University of Nevada Cooperative Extension

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NEVADA PESTICIDE APPLICATOR'S CERTIFICATION WORKBOOK

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Material presented in this Nevada's Pesticide Safety Education Program (PSEP) workbook is designed to help the reader prepare for the various pesticide certification examinations. General information shall be supplemented by reading the National Pesticide Applicator Certification Core Manual.

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General Knowledge: Pesticides and the Law

Pesticides And The Law Learning Objectives

After studying this section you should be able to:

- ✓ **Describe terms and definitions in the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).**
- ✓ **Describe unlawful acts and penalties listed in FIFRA.**
- ✓ **Describe other laws and regulations (non-FIFRA) related to pesticides.**
- ✓ **Discuss requirements of the Worker Protection Standard (WPS), including the 2015 update to the WPS.**
- ✓ **Discuss provisions related to pesticides in Chapter 555 of the Nevada Revised Statutes.**
- ✓ **Discuss the differences between Licensed Applicators, Government Licensed Applicators and Certified Applicators in Nevada.**
- ✓ **Discuss new provisions in NRS Chapter 586.**

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 as it pertains to certified applicators. The complete Nevada statutes and the administrative code can be accessed at http://nv.gov.

State law may be more restrictive than Federal law, but not less.

I. Federal Law

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) passed in 1972, and was last amended in 2012 by the Pesticide Registration Improvement Act (PRIA). FIFRA regulates the registration, manufacturing, transportation, distribution and use of pesticides.

FIFRA, the Federal Insecticide, Fungicide, and Rodenticide Act, is administered by the U.S. Environmental Protection Agency.

A pesticide is any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest or any substance or mixture of substances used as a plant regulator, defoliant, or desiccant.

Pesticide labeling includes the printed material attached to the pesticide container and all supplemental pesticide information that may not be attached to the pesticide container. It is the law to read, understand and follow all pesticide labeling.

FIFRA Section 1: Administration

- The United States Environmental Protection agency (EPA) administers FIFRA.

FIFRA Section 2: <u>Definitions:</u>

- <u>Certified Applicator:</u> 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.
    - <u>Private Applicator:</u> 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).
    - <u>Nonprimary Principle Commercial Applicator:</u> a certified applicator who applies or supervises the application of a restricted-used pesticides, except as part of a business of pest control, and does not qualify as a private applicator (EXAMPLES: HOA employees, private golf clubs, hotels/casinos/resorts, restaurants, homeowners)
- <u>"Under the Direct Supervision of a Certified Applicator"</u>: unless otherwise prescribed by its labeling, a restricted-use pesticide may be 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.
- <u>Person:</u> any individual, partnership, association, corporation, or any organized group of persons whether incorporated or not.
- <u>Pest:</u>
    - any insect, rodent, nematode, fungus, weed or
    - 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.
- <u>Pesticide:</u>
    - any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest,
    - or any substance or mixture of substances used as a plant regulator, defoliant, or desiccant; does not include "new animal drugs."
- <u>Label and Labeling:</u>
    - <u>Label:</u> the written, printed, or graphic matter on, or attached to,

the pesticide, container, device or wrapper.

- Labeling: all labels and all other printed or graphic matter accompanying the pesticide or device.
- Any additional information to which reference is made on the label or the literature accompanying the pesticide or device. For example, if the pesticide label directs you to a website, the information on the website is considered part of the label.

- 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:
  - Applying a pesticide at any dosage, concentration or frequency less than that listed on the labeling.
  - Applying a pesticide against any target pest not on the labeling if the application is to a crop, animal, or site that is listed.
  - Use any equipment or method of application that is not prohibited by the labeling.
  - Mix a pesticide or pesticides with a fertilizer, if the labeling does not prohibit the mixture.

FIFRA Section 3: Registration of Pesticides

- 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.
  - All states must accept all EPA registered restricted-use pesticides.
  - A state may restrict any EPA registered general use pesticide.
- 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").
- 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).
- Classification of pesticides and their uses by the EPA is based upon "risk assessment":
  - potential for poisoning humans
  - type of formulation
  - the way the pesticide is used
  - site of application
  - potential for environmental harm

General Use Pesticides (GUP) are those that are less likely to harm humans or the environment. They are available to everyone.

Restricted Use Pesticides (RUP) are those that could cause harm to humans or the environment if not applied properly. Applications of these pesticides must be done by a certified applicator or a licensed applicator.

- EPA will assign each registered pesticide a registration number. (EXAMPLE: Reg. No. 012S001).

FIFRA Section 5: Experimental Use Permits

- Issued to accumulate the necessary information and data required to register a new pesticide.
- Permit period shall not exceed one (1) year, and is not required for areas less than 10 acres per pest for terrestrial pests or less than one acre per pests for aquatic pests.
- 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.

FIFRA Section 7: Registration of Establishments

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

FIFRA Section 11: Certification of Restricted Use Pesticide Applicators

- 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.
- 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.

FIFRA Section 12: Unlawful Acts

- It shall be **unlawful** for any person in any state to distribute, sell, offer for sale, deliver, etc., to any person:
  - any pesticide not registered by the EPA.
  - any registered pesticide whose composition or claims differ from those made in connection with its registration.

The Nevada Department of Agriculture, in cooperation with the University of Nevada Cooperative Extension, conducts training and testing sessions for certification.

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.

- any pesticide that is "adulterated" or "misbranded" or any device that is misbranded.

- "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.
- "Misbranded": a pesticide is misbranded if:
  - labeling bears any statement, design, graphics, etc., relative thereto or to its ingredients that is false or misleading.
  - the package, container, or wrapper does not conform to specific EPA standards.
  - it imitates or is offered for sale under the name of another pesticide.
  - its label does not bear an EPA Establishment Registration Number.
  - 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.
  - the label does not contain a cautionary statement that adequately protects health and the environment.
- It shall also be **unlawful** for any person:
  - to detach, alter, deface, or destroy, in whole or in part, any labeling.
  - 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.
  - to advertise a restricted-use pesticide without giving the product's classification.
  - 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.
  - to use any registered pesticide in a manner inconsistent with its labeling, or any experimental use permit contrary to the provisions of such permit.
  - to knowingly falsify any required application for registration, record, information, or report; or failure to file reports required by this Act.
  - to add, or take, any substance from any pesticide to defeat the

It is unlawful for any person to refuse to keep required records, or to refuse to allow the inspection of any records or establishment.

It is unlawful to use any registered pesticide in a manner inconsistent with its labeling.

purpose of this Act.

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

FIFRA Section 14: Penalties

- 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.
- 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.

FIFRA Section 18 – Exemptions of Federal Agencies

- 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.

- 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.

FIFRA Section 19 – Storage, Disposal and Transportation

- 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.
- 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.
- EPA will provide advice and assistance to the Department of Transportation (DOT), in functions relating to the transportation of pesticides and hazardous wastes.
  - 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.

FIFRA Section 24(c): Authority of States (Special Local Need – SLN).

- Allows a state, under certain conditions, to register additional uses for a federally registered pesticide.
- These registrations may involve adding (a) application sites; (b) pests; or (c) alternate control techniques to those listed on the federally registered label.
- Provisions:
  - Registrant must provide supplemental labeling for each SLN registration.
  - 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.
  - 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.

FIFRA Section 26: State Primary Enforcement Responsibility

- For the purposes of this act, a state shall have primary enforcement responsibility for pesticide use violations.

For more information on transporting pesticides:

University of Nevada Cooperative Extension and Nevada Department of Agriculture, Safe and Legal Transportation of Pesticides, https://www.unce.unr.edu/publications/files/ag/2001/sp0109.pdf

U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, Transporting Agricultural Products Safely, https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/agbrochure_10_02_07.pdf

Nevada Department of Transportation, http://www.nevadadot.com/

For more information about The Food Quality Protection Act (FQPA), EPA's implementation of the law, and opportunities for public involvement, go to https://www.epa.gov/laws-regulations/summary-food-quality-protection-act

II. Other Laws and Regulations

<u>Food Quality Protection Act of 1996</u> (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.

<u>Federal Aviation Administration (FAA)</u>

- Oversees aerial applications, including those made by unmanned aerial vehicles (UAVs), more commonly known as drones.
- Judges the flying ability of pilots and the safety of their aircraft.

Title III of the Superfund and Reauthorization Act of 1986 (SARA):
<u>Emergency and Community Right-to-Know Act</u>

- <u>Subtitle A</u> – stipulates procedures for emergency planning in states and localities.
- <u>Subtitle B</u> – 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.
- <u>Subtitle C</u> –trade secret protection, citizen petitions, and information availability.

Endangered Species Act (ESA)

- Sets up pesticide restrictions, beginning in 1991, for growers, applicators, and dealers designed to protect endangered plant and animal species.
- Developed to bring FIFRA into compliance with the Endangered Species Act.
- U.S. Fish and Wildlife Service (FWS) is the final authority for the interpretation of the ESA.
- 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. The label will also direct the pesticide user to follow all the measures contained in the Endangered Species Bulletin for the county in which they are applying the product. To obtain the Bulletin, go to https://www.epa.gov/endangered-species and click on Bulletins Live! Two.
    - Select your intended application area.
    - Select the application month.
    - You can enter the active ingredient, product name or product registration number. The default is a search for all products and active ingredients.
    - Hit "SEARCH"
    - If a Pesticide Use Limitation Area (PULA) occurs within the selected area of intended pesticide use, click on the PULA to select it. This will activate the results tab with the associated limitation. Click the "Printable Bulletin" button for a pdf you can print or save.
    - If no PULA occurs in your selected area, click the "SEARCH" button. This will activate the "No Limitations" screen. Click the "Printable Bulletin" button for a pdf you can print or save.

Chemical Hazard Communication Standard part of the Occupational Safety and Health Act (OSHA) – workers right-to-know

- Employer must inform employees of chemical hazards.
- Safety Data Sheets (SDS), formerly Materials Safety Data Sheets (MSDS), must be available.
- Written training program must be implemented.
- Labeling must be attached to all chemical and service containers (not application devices).
- The EPA has not adopted the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) for pesticides. The GHS has two categories of signal words: Warning and Danger. The

U.S. Fish and Wildlife Service (FWS) is the final authority for the interpretation of the Endangered Species Act.

Information on endangered species can be found at the EPA's Endangered Species Protection Bulletins Website. at https://www.epa.gov/endangered-species click on Bulletins Live! Two

ESA Bulletins are provided only six months in advance and you must use the bulletin for the area you are applying product and the month you are applying the product.

EPA still has three signal words: Caution, Warning and Danger. Be advised that the signal words on SDS (Safety Data Sheets) may not match the signal word on the pesticide label.

The Worker Protection Standard (WPS) seeks to protect workers on farms, nurseries, greenhouses and forests.

The WPS requires employers to take steps to reduce the risk of pesticide related illnesses.

A WPS reference statement will appear on agricultural pesticide products that require employers to provide pesticide handlers and agricultural workers with all WPS protections.

Worker Protection Program

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.

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 pesticide 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 Agricultural Use Requirement statement under the "Directions for Use" section of the pesticide labeling. An example is shown in the box on the next page.

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.

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.

In 2015 the EPA revised the WPS; the new regulations became effective January 1, 2018. These most recent changes are outlined below:

- Mandatory **annual** training to inform employees about the required protections, including instructions on reducing take-home exposure from pesticide work clothing.
- Requirement that only certified applicators or an individual that completes an EPA-approved "train the trainer" program are authorized to conduct the mandatory training.
- Anyone under 18 years of age is prohibited from being a pesticide handler or doing early-entry work during a REI.
- Expanded mandatory posting of no-entry signs for outdoor production if the REI is greater than 48 hours.
- New application exclusion zones of up to 100 feet surrounding pesticide application equipment.
- If the label requires a respirator, the employer must provide a medical evaluation, fit testing and respirator training in compliance with the Occupational Health and Safety Administration (OSHA) respiratory protection standard.
- If the label requires protective eyewear, the employer must provide water for emergency eye washing at pesticide mixing/loading sites.
- Mandatory record-keeping to improve states' ability to follow up on pesticide violations and enforce compliance.
- Anti-retaliation provisions comparable to the U.S. Department of Labor's.

If it is necessary for you to meet the requirements of the WPS, you will need to obtain a copy of the "How to Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides" at http://pesticideresources.org/wps/htc/htcmanual.pdf

In 2015 the EPA revised the WPS. For more information go to "How To Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Employers Need to Know" at http://pesticideresources.org/wps/htc/htcmanual.pdf

State pesticide laws can be more restrictive or stringent, but may not negate or reduce the federal law.

It is unlawful for any person to sell, distribute, transport or use a restricted-use pesticide in the state of Nevada that is not registered with the Nevada Department of Agriculture.

All restricted-use pesticide dealers must keep and maintain for two (2) years a record of all sales of restricted-use pesticides

III. Nevada Revised Statutes (NRS) Chapter 555

The use and application of restricted-use pesticides is governed by both federal and state laws. The federal law serves as an umbrella, determining the minimum regulations and standards. State laws can be more restrictive or stringent, but may not negate or reduce the federal law. For more information on federal law, see Chapter 2 in the National Pesticide Applicator Certification Core Manual. The following is an explanation of the Nevada State law, Nevada Revised Statutes (NRS) Chapter 555 (See www.leg.state.nv.us/NRS/NRS-555.html)

A) The purpose of the statute is to regulate, in the public interest, the application of pesticides. Although these restricted use pesticides are valuable for the control of pests, they may seriously injure man, animals and crops over wide areas, if not applied properly.
B) Licenses and certificates issued fall into three main categories, detailed in Table 1.
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.

Table 1. Types of licenses and certificates issued			
	LICENSED FOR HIRE Applicators	**Licensed GOVERNMENT Applicators**	**CERTIFIED applicators**
DEFINITION	Licensed: to apply pesticides for hire	License to apply general use and restricted use pesticides	Certified: to apply-RUP's (restricted-use pesticides).
CREDENTIAL TYPES	Primary Principal*, Principal, Operator, Agent, Consultant, Demonstration and Research Specialist,	Licensed Government Applicator	Non-Primary Principal Commercial, Private *Primary Principal automatically certified by meeting license requirements
EXAMPLES	Pest control business owners and their licensed operators doing custom pesticide applications, commercial landscapers,	Employees of: BLM, USFS County, State, City or other Municipality, School District, Mosquito, Weed Control and Conservation Districts, Cooperative Weed Management Areas	Nurseries, greenhouses, farmers, ranchers, residential landscaper, hotels, casino, resorts, Home Owner Association (HOA) employees, private golf clubs, tribes, mine staff
EDUCATION/ EXPERIENCE	Principal: 2 years of experience or 6 months experience plus 16 college credits in biological sciences Operator, Agent, Consultant, Demonstration and Research Specialist: None	None	None
EXAMS			
Number of Questions	General test: 50 questions for Principal; 100 questions for Operator; Category tests: 50 to 100 questions each	General test: 50 questions, Category tests: 20 to 25 questions each; Must take general test and at least 1 category exam	General test: 50 questions, Category tests: 20 to 30 questions each; Must take general test and at least 1 category exam
Passing Grade	70% for Principal 65% for Operator and Agent, Consultant, Demonstration and Research Specialist	70%	60%
Exam Fees	$50.00 initial exam, $35 each subsequent exam	$50 per exam session	$50.00 per exam session

Table 1. Types of licenses and certificates issued

	LICENSED FOR HIRE Applicators	Licensed GOVERNMENT Applicators	CERTIFIED applicators
LICENSE/CERTIFICATE			
Additional Annual Fees	$250.00 per Business License, $50 each Primary Principal, Principal, Operator, Consultant, and Demonstration and Research Specialist $350 per Agent $50 inactive license	None	None
Renewal	Annual, by December 31 of each year	Every 4 years	Every 4 years
Testing	Testing by appointment only: Reno 775-353-3712 Elko 775-738-8076 Las Vegas 702-668-4545	Testing by appointment only: Reno 775-353-3712 Elko 775-738-8076 Las Vegas 702-668-4545	Tests given at end of some trainings. Testing by appointment also: Reno 775-353-3712 Elko 775-738-8076 Las Vegas 702-668-4545
Retest Period	Principal: 10 days*;Operator, Agent, Consultant, Demonstration and Research Specialist: 7 days* *6 months if caught using an unauthorized testing aid.	7 days* *6 months if caught using an unauthorized testing aid	5 days* *6 months if caught using an unauthorized testing aid
CONTINUING EDUCATION	6 total hours each year for Principals* and Operators. Agents, no continuing education needed, must retest each year. *1 of the 6 hours must include laws	12 total hours during a 4 year period, 2 of the 12 hours must be in laws	12 total hours during a 4 year period, 2 of the 12 hours must be in laws
REPORT	Pesticide usage report must be submitted each month for aerial and agricultural licensees. All pest control companies must submit annual pesticide usage report.	Annual pesticide usage report	None
RECORDS	Keep and maintain for 2 years Wood-destroying Pest Inspection Reports kept for 3 years	Keep records for 2 years for all Restricted Use Pesticides (RUPs)	Keep records for 2 years for all Restricted Use Pesticides (RUPs)

Definitions:

Agent: A person licensed to only solicit business on behalf of a pest control company.

Commercial Applicator: see Non-Primary Principle Commercial Applicator

Consultant: A person who publicly holds him or herself as being in the business of identifying pests or recommending pesticides for the purpose of detecting, preventing, controlling or exterminating pests.

Demonstration and Research Specialist: An industry representative or other person who publically holds himself or herself out as being in the business of conducting field research for experimental purposes using pesticides not registered in the State or demonstrations using registered pesticides for the purpose of detecting, preventing, controlling or exterminating pests.

For Hire: Any pesticide application performed for hire, including such activity when performed by a government agency.

Government Pest Control License: Application of pesticides classified for general use and restricted use on government managed lands. Includes, but is not limited to, highway maintenance, weed control, or structural pest control.

GUP: General Use Pesticide

Non-Primary Principle Commercial Applicator: Application of pesticides as part of job duties on a property where they work. NOT for hire.

Operator: A person licensed to apply pesticides without the immediate supervision of a principal.

Primary Principal: The licensee responsible for the daily supervision of the pest control business

Principal: Owner, officer partner, member or technician of a pest control business who has qualified by examination in one or more categories of pest control.

Private Applicator: Application of pesticides on a property that they own.

RUP: Restricted Use Pesticide

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 Nevada Department of Agriculture.

NDA has a list of pesticides not illegal to use on marijuana or medical marijuana at http://agri.nv.gov/Plant/Environmental_Services/Pesticide_Use_on_Medical_Marijuana/

IV. Nevada Revised Statutes (NRS) Chapter 586: Pesticide Registration

- Registrations require an annual renewal
- $125.00 for each pesticide registered

- It shall be unlawful for any person to distribute, sell, or offer for sale in this State any pesticide:
  - Not registered in the State
  - Unless it is in the registrants or manufacturers unbroken immediate container and there is affixed to such container the required information.
- 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 Nevada Department of Agriculture.
  - Restricted-use pesticide Dealer registrations expire on December 31, and are renewable annually at a fee of $25.00.
  - All licensed dealerships are required to submit RUP sales reports on or before the 15th day of each month (even if that dealer has not sold any RUP's during that previous month), and maintain a record of all RUP sales for two (2) years showing:
    - date of sale or delivery
    - name and address of person to whom the product is sold
    - brand name and EPA registration number of the pesticide
    - amount of pesticide sold
    - certification / license number
    - expiration date
    - certification / license categories
- A marijuana establishment or medical Marijuana establishment may use a pesticide in the cultivation and production of marijuana, edible marijuana products, marijuana products and marijuana-infused products if the pesticide:
  - Is exempt from registration (25b) product or is allowed to be used on Crop Group 19, hops or unspecified crops or plants
  - Has a label that allows the pesticide to be used at the intended site of application
  - Has a label that allows the pesticide to be used on crops or plants intended for human consumption.
  - The Nevada Department of Agriculture (NDA) will establish and publish a list of pesticides not illegal to use on marijuana or medical marijuana. NDA will accept requests from pesticide manufacturers

and marijuana establishments to add pesticides to the list. This list is updated periodically and can be found at http://agri.nv.gov/Plant/Environmental_Services/Pesticide_Use_on_Medical_Marijuana/

V. Nevada Administrative Code (NAC) Chapter 555: Certified Applicator Regulations

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. Note: these categories are show as listed in NAC Chapter 555. The number and letter designations shown do not correspond the numbers on the chapters in this manual or the category numbers used by the Nevada Department of Agriculture.

NONPRIMARY PRINCIPAL COMMERCIAL APPLICATORS. Standards for competency for nonprimary principal commercial applicators are:

1) Agricultural Pest Control
   a) 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.
   b) 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, nontarget injury and community problems resulting from the use of restricted-use pesticides in agricultural areas.
2) 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

The agricultural-plant category is for applicators using pesticides in agricultural cropland. This includes insect, weed and rodent control.

The aquatic pest control category is for applicators using pesticides in and near aquatic sites, such as rivers, creeks, ditches and ponds.

Applying fumigants requires certification in a fumigation category

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.

3) Chemigation: Applicators must demonstrate practical knowledge of pesticides, safety procedures, environmental concerns, and methods and equipment for the application of pesticides through chemigation systems.
4) 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.
5) 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.
   a) Commodity fumigation
   b) Rodent burrow fumigation
   c) Soil fumigation
   d) Structural fumigation
6) 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.

7) 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.

8) 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.

9) 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.

10) Predatory Pest Control/M-44: This category is only available to USDA Wildlife Services employees and now requires a Licensed Government Applicator certification. 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 nontarget species, and knowledge of special laws and regulations governing the use of poisons to control predators on private and public lands.

11) 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.

12) 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

The ornamental and turf pest control category is for applicators who apply pesticides in parks, golf courses or other similar settings.

If the applications are made on public lands, they are now required to be made by a Licensed Government Applicator.

Predatory Pest Control category is only available to USDA Wildlife Services employees and now requires a Licensed Government Applicator certification.

The right-of-way pest control category is for applicators who apply pesticides along roads, railroads or utility rights-of-way.

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.

13) 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.

14) 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. Study manuals are available from the pesticide manufacturers.

15) 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.

PRIVATE APPLICATORS. The categories of private applicators are:

1) Agricultural Pest Control:
    a) Animal:
        (1) 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.
        (2) 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.
        (3) Poultry pest control: The control of any pest in, on, or around poultry, including, but not limited to, chickens, turkeys and ducks, and including places on or in which poultry are confined, including, but not limited to, coops and pens. This category excludes fumigation.

b) Plant
   (1) Forage, grain, pasture and range pest control: The control of any pest in, on, or around the production of forage, grain, pasture and range. This category excludes fumigation.
   (2) Row crop pest control: The control of any pest in, on, or around row crops. This category excludes fumigation.
   (3) Seed crop pest control: The control of any pest in, on, or around seed crops. This category excludes fumigation.

c) Specialty Crops
   (1) 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.
   (2) 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.
   (3) 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. This category excludes fumigation.
   (4) 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. This category excludes fumigation.

2) Chemigation: The control of any pest through the application of pesticides by injection of the pesticides into irrigation water. This category excludes fumigation.
3) 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.
4) Fumigation: The control of any pest by fumigation with poisonous and lethal gases in any habitat, including, but not limited to, structures and soil.
   a) Commodity fumigation: The control of any pest which infests raw agricultural and processed commodities, animal feeds and

Specialty Crop categories exclude fumigation. Applying fumigants requires certification in a fumigation category

Applying fumigants requires certification in a fumigation category

commodity storage facilities where they are held or stored and are subject to infestations of insects, rats, mice, fungi and bacteria. Sites for commodity fumigations included, but are not limited to, grain elevators, rail cars, truck trailers, vans, shipholds, air and sea containers, other static sealable enclosures, food processing plants with raw or processed commodities, tarpaulin fumigations with raw or processed commodities, prepared bins with raw or processed commodities, warehouses or other areas where raw or processed commodities are stores, beehives and other beekeeping equipment.

b) Rodent burrow fumigation: Outdoor applications for the control of non-protected or non-endangered burrowing rodents and moles, including, but not limited to, fumigants applied to underground burrow systems for the control of marmots, woodchucks, Norway rats, roof rats, house mice, ground squirrels, moles, voles, pocket gophers and chipmunks and excluding structural fumigation.

c) Soil fumigation: The control of any soil pest when present in the soil at the time of treatment, including, but not limited to, plant-parasitic nematodes, soil-borne disease causing organisms, weeds and insects.

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

Originally published in 1987 Pesticides and the Law, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

General Knowledge: Guidelines for the Safe Use of Pesticides

Guidelines for the Safe Use of Pesticides Learning Objectives

After studying this section you should be able to:

- ✓ **Define what a pesticide is, and the different types of pesticides.**
- ✓ **Identify the routes of entry for pesticides into the body.**
- ✓ **Describe and follow the components of a pesticide label.**
- ✓ **Give examples of protective clothing and personal protective equipment (PPE) for use by pesticide applicators.**
- ✓ **List the steps necessary to avoid heat stress during pesticide applications.**
- ✓ **Explain procedures for safely mixing, disposing, storing and transporting pesticides.**
- ✓ **Explain what to do in the event of a poisoning.**
- ✓ **List record-keeping requirements for pesticide applications.**
- ✓ **Describe calibration and equipment used to apply pesticides.**

Introduction to Guidelines for the Safe Use of Pesticides

No one really knows what would happen if farmers were denied the use of pesticides. 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 commercially produce 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 as well as domestic and wild animals, and damage the environment.

Pests not only adversely affect agricultural productivity, but they impair the health of humans as well as domestic and wild animals, and damage the environment.

Pesticides are an important management tool and we must use them wisely, properly and safely.

Pesticide labeling includes the printed material attached to the pesticide container and all supplemental pesticide information that may not be attached to the pesticide container. The law requires that you read, understand and follow all pesticide labeling.

Pesticides efficiently control most public health pests. Scientists estimate that about 30 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.

Pesticides aid in the commercial production of food, feed, and fiber. They 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 critically important. Too much of a chemical may damage or kill the plants or animals it was intended to protect, while too little may not provide adequate pest control. Many desirable plants and animals, including humans, can be harmed by the incorrect or careless use of pesticides. We must use them wisely, properly and safely.

Pesticides must be used in strict accordance with the instructions on the product label, which is the printed material that is attached to the container. In some cases the label may require that applicators refer to additional instructions that are not attached to the container. The label will instruct users where to find the information. The pesticide label and information it references are legal documents according to federal and state laws. Any deviation from the label directions 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.** 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 structures or personal property, injure ornamental plants, damage livestock or pets, or transmit diseases to people or animals. Pests include animals such as insects, spiders, ticks, mites, rats, birds, snails, slugs, and nematodes, or plants such as weeds, or fungi, such as 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:** Control pest birds.
- **Algicides:** Control algae in lakes, canals, swimming pools, water tanks and other sites.
- **Antifouling agents:** Kill or repel organisms that attach to underwater surfaces, such as boat bottoms.
- **Antimicrobials:** Kill microorganisms, such as bacteria and viruses.
- **Attractants:** Materials that attract pests; for example, by luring an insect or rodent to a trap or bait. Food is not considered a pesticide when used as an attractant.
- **Bactericides:** Destroy bacteria.
- **Biopesticides:** Biopesticides (also called biorational pesticides) are a certain types of pesticides derived from natural materials such as animals, plants, bacteria and certain minerals.
- **Biocides:** Kill microorganisms.
- **Disinfectants and sanitizers:** Kill or inactivate disease-producing microorganisms on inanimate objects.
- **Fumigants:** Produce gas or vapor intended to destroy pests in buildings or soil.
- **Fungicides:** Kill fungi, including blights, mildews, molds and rusts.
- **Herbicides:** Kill weeds and other undesirable plants that are growing where they are not wanted.
- **Insecticides:** Kill insects and other arthropods, such as ticks, spiders or centipedes.

A pesticide is any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest or any substance or mixture of substances used as a plant regulator, defoliant, or desiccant.

General Use Pesticides (GUP) are those that are less likely to harm humans or the environment. They are available to everyone.

Restricted Use Pesticides (RUP) are those that could cause harm to humans or the environment if not applied properly. Applications of these pesticides must be made by a certified applicator or under the direct supervision of a certified applicator.

- **Miticides (also called acaricides):** Kill mites that feed on plants and animals.
- **Microbial pesticides:** Microorganisms that kill, inhibit, or outcompete pests, including insects or other microorganisms.
- **Molluscicides:** Kill snails and slugs.
- **Nematocides:** Kill nematodes (microscopic, worm-like organisms that feed on plant roots).
- **Ovicides:** Kill eggs of insects and mites.
- **Pheremones:** Biochemicals used to disrupt the mating behavior of insects.
- **Piscicides:** Control pest fish.
- **Predacides:** Control vertebrate pests.
- **Repellants:** Repel pests, including insects, such as mosquitoes, and birds.
- **Rodenticides:** Control mice and other rodents.

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

- **Defoliants:** Chemicals that cause leaves or foliage to drop from a plant, usually to facilitate harvest.
- **Desiccants:** Chemicals that promote drying of living tissues, such as unwanted plant tops.
- **Insect growth regulators:** Chemicals that disrupt the molting, maturity from pupal stage to adult stage, or other life processes of insects.
- **Plant-growth regulators (PGRs):** Substances (excluding fertilizers and other plant nutrients) that alter the normal or expected growth, flowering, or reproduction rate of plants.

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 may take more than 10 years.

Pesticides can be categorized by their chemical "family" or by the method used in their production.

Types of Pesticides

Pesticides are often categorized by the type of pest they control, as shown above. Another way to categorize pesticides is to consider the production source or method. Some of the most common types of pesticides are listed below.

<u>Chemical Pesticides:</u> Many chemical pesticides are derived from a common source or production method. The most common are:

- **Organophosphate Pesticides:** These pesticides affect the nervous system by disrupting the enzyme that regulates aceylcholine, a neurotransmitter. Most organophosphates are insecticides. They were developed during the early 19th century but their effects on insects, which are similar to their effects on humans, were discovered in 1932. Some are very poisonous (they were used in World War II as nerve agents). However, they are usually not persistent in the environment.
- **Carbamate Pesticides:** These pesticides also affect the nervous system by disrupting the enzyme that regulates aceylcholine, a neurotransmitter. The enzyme effects are usually reversible. There are several subgroups within the carbamates.
- **Organochlorine Insecticides:** These substances were commonly used in the past, but many have been removed from the market due to their health and environmental effects and their persistence in the environment (examples are DDT, chlordane).
- **Pyrethroid Pesticides:** These pesticides were developed as synthetic versions of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system.

<u>Biopesticides</u>: Biopesticides are those derived from natural materials, such as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products. Biopesticides fall into three major classes:

- **Microbial pesticides:** These pesticides have a microorganism (bacterium, fungus, virus or protozoa) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pests. For example, there are fungi that control certain weeds, and other fungi that kill specific insects.
- **Plant Incorporated Protectants (PIPs):** These are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the

Biopesticides, although "natural," can still be just as harmful to humans, animals, plants and the environment as chemical pesticides.

Even slightly toxic pesticides can be hazardous to man, non-target animals and the environment, if used in a manner inconsistent with the label directions.

The lower the LD 50 or LC 50 of a pesticide product, the greater the toxicity of the material to people and animals.

plant itself, are regulated by the United States Environmental Protection Agency (U.S. EPA).

- **Biochemical pesticides:** These are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances such as insect sex pheromones that interfere with mating. This group of pesticides also includes various plant extracts that attract pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, the U.S. EPA has established a special committee to make such decisions.

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:

- oral toxicity, in which the chemical is fed to test animals;
- dermal toxicity, in which the skin is exposed to the chemical and the absorption through the skin and accumulation in the bloodstream is measured; and
- inhalation toxicity, in which 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 or 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 acute 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 label directions.

Pesticide products are categorized on the basis of their LD 50 or LC 50 values. Those pesticides that are classified as having high 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 symbol prominently displayed on the package label. Effective December 31, 1984, the Spanish equivalent for the word 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 such a material could be fatal to a 150-pound person.

Pesticide products classified as having 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:

- through the skin (dermal)
- through the lungs (inhalation)
- through the 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. To protect yourself, keep pesticides away from the underarms and groin. Don't sit on pesticide containers or

The three most common routes of entry of pesticides into the human body are:

- **Dermal – through the skin**
- **Inhalation – through the lungs**
- **Oral – through the mouth**

After applying pesticides, always wash your hands and face before eating, drinking or smoking.

Protect your eyes and cover any open wounds when handling pesticides to prevent pesticides from entering the body through these routes.

It is your legal responsibility to read, understand and follow pesticide label directions.

contaminated seats. These areas absorb pesticides 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, and 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 fitted correctly. 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 you eat, drink, or smoke with contaminated hands, or you rub your mouth on contaminated clothing, or you lick your lips. Since the intestinal tract rapidly and completely absorbs many pesticides, always 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 can absorb surprisingly large amounts 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, desirable plants and the environment. Most pesticide accidents result from careless use. Lack of knowledge about pesticides and improper handling 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 information on the label is a legal requirement. Read and make sure that you understand the information presented on a product label before you use it. Explore alternatives to applying pesticides and select the least toxic methods available. If pesticides are necessary, select the least toxic products first.

Pesticide manufacturers are 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 formula 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, re-entry 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.

Nine Required Parts of a Pesticide Label

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 (other) ingredients. Labels 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 the 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.

Explore alternatives to applying pesticides. If pesticides are necessary, select the least toxic products first.

The nine required parts of a pesticide label are:

1. **Ingredient statement**
2. **Name, brand or trademark**
3. **Precautionary statements**
4. **Directions for use**
5. **Name and address of manufacturer**
6. **Net contents**
7. **EPA registration number**
8. **EPA establishment number**
9. **Use classification**

Certain information MUST appear on the <u>front panel</u> of a pesticide label:

- **Brand name**
- **Use classification**
- **List of ingredients**
- **"Keep Out of Reach of Children" statement**
- **Signal word**
- **First aid statement**
- **Net contents or net weight**

Unfortunately, there is no absolute standard for <u>where</u> on the front panel of the pesticide label this information is to be placed.

READ THE LABEL CAREFULLY

Hazard statements help the user apply the pesticide correctly. Precautions must include signal words to reduce hazards to humans as well as child hazard warnings. They 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 more than 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:
   i. Signs and symptoms of poisoning
   ii. First aid
   iii. Antidotes
   iv. 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:
   a. How much of the product to use and when to use it (MORE IS <u>NOT</u> BETTER!).
   b. The crop, animal or site the product claims to protect.
   c. The proper equipment to be used for the application.
   d. Mixing directions, if they apply.

   e. 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 indicate 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 that indicates 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: The EPA classifies pesticides as either "General Use" or "Restricted Use." Restricted use pesticides may 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 legal basis 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 the lowest rate that is effective. It is against the law to exceed the maximum 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 pesticides to avoid injury or damage to themselves, other persons, and the environment. Failure to follow the instructions on a pesticide label can result in serious pesticide accidents and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document. The user is

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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

Formulation of a pesticide is the mixing of an active ingredient with some type of carrier or diluent, either a liquid or solid material. Pesticides are available in a wide variety of formulations. It is not uncommon to find some active ingredients formulated in several different ways. 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). Undiluted active ingredients are rarely 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.

Never attempt to puncture or burn aerosol cans because they may explode and produce shrapnel.

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. **Never attempt to puncture or burn aerosol cans because they may explode and produce shrapnel.**

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 the 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. Domestic animals and wildlife may be killed by these formulations. In order to protect non-target species, any bait used for rodent control must be applied below ground in rodent burrows or in bait stations. 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 as well as phytotoxicity (toxicity to plants) of EC materials may occasionally be problems. Most liquid concentrates of this type can cause rubber hoses, gaskets, and pump parts to deteriorate, and some formulations are detrimental to painted surfaces.

Because of the high concentration of active ingredient(s) in Emulsifiable Concentrates (EC) formulations, there may be considerable hazard to the applicant and other persons if the product is accidentally spilled on the skin or consumed.

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,

Fumigants are nonselective and can penetrate into any area that is not airtight.

They are the most hazardous of all pesticide formulations.

granaries and greenhouses. Fumigants 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. All fumigants are classified as Restricted Use Pesticides.

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-concentrate formulations usually contain less than two pounds active ingredient 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 dusts, they may be hazardous to workers who breathe in the concentrated dust during mixing. Wettable powder suspensions need to be agitated constantly to avoid settling of the particles. Wettable powders also cause problems by clogging sprayer screens and nozzles. They are 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 as much as 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. Glass containers have been replaced by plastic and corrosive chemicals are no longer put in metal containers. Pesticide recognition by container packaging is helpful, but the final authority on the nature of the contents is the product label itself. Keep the label with the product.

Be sure to always store pesticides in their original containers. The original packaging includes the pesticide label, as required by law. Keep additional labeling brochures or leaflets with the pesticide.

This ensures easy access to the information you need to mix, apply, store and dispose of the pesticide and empty pesticide containers properly.

Protective Clothing and Personal Protective Equipment (PPE)

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.

Protective clothing and Personal Protective Equipment requirements may be different for mixing the pesticide versus applying the pesticide.

Read the pesticide label carefully!

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.

Maintain all your protective equipment clean and in good operating condition.

Replace worn and cracked equipment promptly.

Heat stress is an illness that occurs when the body builds up more heat than it can cope with.

At 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. Maintain all your protective equipment clean and in good operating condition. Replace worn and cracked equipment promptly.

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
- scheduling

Heat and Workload

High temperatures, high humidity and bright sunlight increase the likelihood of heat stress. Air movement from wind or 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 increase 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

High temperatures, high humidity and bright sunlight increase the likelihood of heat stress.

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.

A person can become overheated quickly when wearing Personal Protective Equipment (PPE). Generally, the more protective the equipment is, the more it adds to the heat load.

The PPE specified on the label is the MINIMUM PPE required.

Drink plenty of water before, during and after work during heat stress conditions.

Schedule the 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.

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 the 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. 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 and 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 the victim immediately. Brain damage and death may result if treatment is delayed.

Mixing Pesticides Safely

The concentrated form of many pesticides is relatively poisonous when absorbed through the skin. Always use rubber gloves and eye protection when mixing the concentrated form of any pesticide. For very toxic

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- **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)**

Take immediate action to cool down if these symptoms appear.

Severe heat stress (heat stroke) is a medical emergency! Cool victim immediately. Get medical help right away.

When mixing pesticides, put water in the spray tank until it is about half-full before adding the chemical.

Wash all measuring utensils thoroughly after each use and store them with the pesticides. Never use these utensils for other purposes.

Make sure the water supply hose does not come into contact with the pesticide spray preparation to prevent back-siphoning of the pesticide into the water source.

If two or more products are equally effective, select the least toxic material whenever possible.

materials, wear a chemical-resistant apron, a respirator, gloves and a face shield 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. Accurately measure the proper amount of chemical according to the instructions on the label. Keep all measuring utensils (spoons, cups, etc.) in the areas where pesticides are stored. Wash the utensils thoroughly after each use. Never use these utensils 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 into contact with the spray preparation. This prevents contamination of the hose and avoids the possibility of back-siphoning of the pesticide into the water source.

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

Applying Pesticides Safely

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 whenever 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 which they are registered. Spraying 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.

Carry fresh water, soap and paper towels with you in a container, protected from the pesticide spray, in case you accidentally spill the chemical 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 influencing drift are 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, 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 into 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 a crop. If, while spraying, you have 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.

Temperature plays an important role in pesticide applications. Generally, the pesticide label will specify a range of temperatures that are best for pesticide applications or the label will specify a minimum and maximum application temperature range. For example: Do not apply below 50 degrees F or above 85 degrees F. At 40 to 50 degrees F, most pesticides will show reduced activity. Applying them at these low temperatures will be a waste of time and money as they will not be effective. At temperatures of 85 degrees F or above, many pesticides will volatilize, increasing the potential for drift and decreasing their effectiveness.

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.

Cover all livestock and pet feed and water containers before applying pesticides.

Check the pesticide label for the proper temperature for application. Below 40 to 50 degrees F many pesticides show reduced activity. Above 85 degrees F many pesticides will volatilize, increasing the potential for pesticide drift.

Never re-enter a recently sprayed field or greenhouse when the foliage is still wet unless you are wearing proper protective clothing and equipment.

DON'T STOCKPILE PESTICIDES. Registrations change and new chemicals may be better than old ones.

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 every ten gallons of water.
3. Drain and flush with clean water.

Never re-enter a recently sprayed field or greenhouse when the foliage is still wet unless you are wearing proper protective clothing and equipment. Pesticide labels list re-entry interval times. These intervals should be strictly observed unless applicators or field personnel are properly protected against residues. 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 that an application has been made to a field and the length of the restricted re-entry interval (REI).

Immediately following application and cleaning of equipment, applicators should wash thoroughly and change to clean clothing. All 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 emulsifiable concentrates (ECs) 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, when 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 crop or site listed on the label.

If you must dispose of a surplus mixture, dispose of it 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. 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 the rinsate back into the sprayer and spray out according to the label directions. 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 trash burning 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 as the smoke may contain toxic vapors. The practice of burning containers is being discontinued in most areas.

Large metal drums must be disposed of according to label instructions. Never reuse empty pesticide containers for any other purpose.

If a leak or spill occurs, contain the spill and exclude entry to the spill area. Clean up the spill immediately. Scatter sawdust, pet litter or some other absorbent material over the spilled pesticide. Sweep up the material, 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. Clean up thoroughly and change into clean clothing after handling or disposing of pesticides.

If you have a serious accident or have problems during the cleanup phase, 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 the handling of pesticides, including spills and accidents.

If you must dispose of a surplus mixture, do so according to label directions.

Follow disposal instructions on the pesticide label and use adequate safety equipment and proper clothing when disposing of pesticide wastes and empty containers.

If a leak or spill occurs, clean it up immediately.

If you have a serious accident or have problems during the cleanup phase, 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.

Always store pesticides and other chemicals in their original containers with the label attached and the lid closed securely.

The label should be readable. All supplemental labeling should also be stored with the pesticide.

Keep all pesticides out of the reach of children, pets and irresponsible people. LOCK all chemicals in a building or cabinet. Limit access to those who are qualified to use the pesticides.

Do not store pesticides near food, pet feed or livestock feed.

Store all herbicides separately from other pesticides to limit cross-contamination.

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 away from 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.

Never store pesticides in well houses or near water sources. Never store pesticides in rooms with floor drains.

Herbicides should be stored separately from other types of pesticides as 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. Place extremely heavy containers 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 amount of 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 ensure 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 a pesticide. *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 firefighters. The fire department must be properly prepared in the event of an agricultural chemical fire.

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

Never store respirators, PPE, or other safety equipment in the same room as pesticides to prevent possible contamination.

Check stored pesticide containers often for leaks or cracks.

The pesticide label will specify the acceptable temperature range for storage.

Post the name of your physician, hospital and nearest poison control center in a prominent location in the storage facility.

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 by 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 the 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 may 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 on the label.

If you use pesticides or reside near areas where pesticides are used, 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.

Never transport pesticides inside the passenger compartment of any vehicle.

Secure pesticides in the trunk of a car or in the back of a truck to minimize the potential for breakage or leaks.

Know how to recognize the symptoms of pesticide poisoning. Symptoms may include:

- **Headache**
- **Giddiness**
- **Sweating**
- **Blurred vision**
- **Cramps**
- **Nausea**
- **Vomiting**
- **Diarrhea**
- **Numbness**
- **Changes in heart rate**
- **General muscle weakness**
- **Difficulty breathing**
- **Pinpoint pupils**
- **Rashes**
- **Allergic reactions**

Contact your local hospital, physician, University of Nevada Cooperative Extension office, or Nevada Department of Agriculture office 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 never 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, as the victim's life may depend on it. Usually it is best to void the swallowed poison quickly. 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.

If a pesticide has been spilled on the skin or clothing, remove all clothing immediately and thoroughly wash the skin with soap and water.

If the pesticide has been inhaled, get the victim to fresh air.

If the pesticide has been swallowed, identify the pesticide to determine whether or not to induce vomiting.

<u>Never induce vomiting if:</u>

- **the victim is unconscious or having convulsions**
- **the victim has swallowed petroleum-based products**
- **the victim has swallowed a poison that is corrosive, strongly acidic or strongly alkaline**

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

Certified applicators that use restricted-use pesticides are required to keep records for two years.

More detailed information about record keeping requirements can be obtained from the Nevada Department of Agriculture, http://agri.nv.gov/Resources/Forms/Environmental_Svcs/

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 a first aid measure 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 the vomit 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 vomit for the doctor, as it may be needed 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.

Keeping Records

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

1. date and time of the application
2. location of the application
3. type of equipment used
4. name of the pesticide used
5. the EPA registration number
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. pest 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. 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 at http://agri.nv.gov/Resources/Forms/Environmental_Svcs/.

The best way to avoid the potential hazards of pesticide use is to read, understand and follow all pesticide label directions.

Conclusion

The best way to avoid the hazards of pesticide use 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 associated with using pesticides, they would be more apt to **READ THE LABEL** and follow the instructions closely.

Merely reading the label does not ensure safety. You must follow all instructions. 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 which 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 intended 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

Various types of equipment are available for applying pesticides, and applicators must select the proper equipment in order to achieve good results. Equipment must be set up, used and maintained properly. When selecting pesticide application equipment, consider the size of the area to be treated, the crop and site of the application, the accuracy desired, and the cost of the equipment. This section summarizes the most common types of application equipment.

Hand operated sprayers:

Hand operated sprayers may be used indoors or outdoors and are most often used for applying pesticides to small sites. They are useful in locations that are inaccessible to larger equipment. These sprayers have a manually operated air pump that must be physically pumped, usually with a hand lever. Some are equipped with a small motor that compresses air into the tank and pressurizes the spray mixture. Commonly referred to as buildings and grounds (B & G) or backpack sprayers, this type of equipment generally has small tanks (3 or 4 gallons) and operates at low pressures of 50 psi or less.

Motorized sprayers:

Motorized systems may be mounted on tractors, trucks, trailers or aircraft. Motor-powered sprayers are capable of delivering large volumes of spray mix over large areas. This equipment is also capable of driving agitation systems for pesticide formulations that require agitation.

Boomless sprayers:

Motorized boomless sprayers are systems that supply spray mix to a hand gun or hand-held boom with several nozzles. Operators are able to cover larger areas than with a hand-operated sprayer. Hand guns are useful for spot treatments and treating small areas. This equipment is suitable for use in rough areas and along fence lines and roadsides.

Boom sprayers:

Boom sprayers have spray nozzles spaced at regular intervals on a boom. An example is a horizontal boom used on tractor-driven sprayers to apply pesticides to field-grown crops. This type of equipment is also used on aircraft. Good coverage and uniformity is possible when constant spray pressure and travel speed is maintained. In field crops, good coverage is relatively easy to achieve where the target foliage is small and close to the nozzles.

Airblast sprayers:

It is difficult to achieve good coverage in fruit trees, especially large trees, with conventional sprayers. With airblast sprayers, a powered fan forces air through an opening, resulting in high air speeds. The opening is adjustable and directs the air stream that carries the pesticide to the target.

Granular applicators:

Equipment used to deliver granular pesticides includes hand-operated systems that use gravity to spread granules or pneumatic applicators that use a stream of air to carry granules through delivery tubes. The potential for pesticide drift is much lower when granular formulations are used.

Aerial applicators:

An advantage of aerial applicators, such as airplanes and helicopters, is that pesticide applications can be done quickly over large areas and in locations where ground equipment cannot operate, such as wet fields or large expanses of range or forest land. While pesticide drift is possible with any type of application equipment, drift is one of the main disadvantages of applying pesticides through an aircraft.

Chemigation:

Chemigation is the process of applying pesticides through an irrigation system. Drip and sprinkler irrigation systems are the most common methods used to chemigate. Chemigation has some advantages over applying pesticides with field sprayers, including less damage to plants. Pesticides may be applied to crops or soil when conditions prohibit entry into the field with other spray equipment. Chemigation also has disadvantages: if not done properly, pesticides may backflow into the water source, either groundwater or surface water, resulting in significant environmental damage. To prevent backflow, several specific devices must be installed in the chemigation system. This hardware is required by the pesticide label. The Nevada pesticide certification program has a specific category just for chemigation (Category 14).

Injection:

Injections and implants that place pesticides, usually systemic insecticides, directly inside of ornamental and forest trees are becoming more common. Tree injections have advantages over sprays because they use lower volumes of pesticides, there is less equipment needed and application may be done in adverse weather conditions. In addition, the potential for drift onto a non-target site is eliminated. Pesticide labeling does not allow systemic injected pesticides to be used on trees that produce fruit or nuts that will be consumed.

Types of pesticide mix tanks:

Pesticide mix tanks are tanks attached to application equipment where pesticide formulations and concentrates are mixed with water and other additives, such as adjuvants, surfactants, anti foaming agents or drift reducers. Tanks may be constructed of a variety of materials including stainless steel, fiberglass or plastic.

Some pesticide product labels do not allow for the product to be mixed in tanks made of certain materials. Therefore, it is essential to read product labeling in order to determine whether your tank is acceptable for the specific pesticide you wish to apply.

Pesticide spray nozzles:

Pesticide spray nozzles are an integral part of pesticide application equipment. Good uniformity of the application is dependent on proper nozzle selection. Nozzles help control the amount of pesticide applied and the size of droplets. Droplet size depends not only on the nozzle but on the pressure as well. Droplet size decreases with high pressure and increases with low pressure. The bigger the droplet, the less likely it is to drift.

Nozzles may be constructed of a variety of materials, including stainless steel, nylon, aluminum, brass or ceramic. Some materials are very durable, such as stainless steel. Nozzles made from brass wear out quickly, especially when using wettable powders.

Some basic nozzle types include:

- **Fan or flat fan nozzles:** These nozzles are used for herbicide and insecticide applications. They put out the spray in a fan-shaped pattern with less material applied at the edge of the pattern, so the spray pattern must overlap in order to obtain uniform coverage.
- **Hollow cone nozzles:** These nozzles produce a cone-shaped spray pattern, with the liquid on the outside of the cone. Hollow cone nozzles generally produce the smallest droplets and are used when penetration and coverage are critical.
- **Full cone nozzles:** This type of nozzle produces a cone-shaped spray pattern with liquid being applied throughout the cone. They are often used for soil-applied herbicides.

Other equipment:

- **Site gauges** are necessary if you can’t see the level of pesticide mix in your tank.
- **Pressure gauges and pressure regulators** allow for management of pressure during application.
- An **unloading valve** may be used for quick unloading of chemicals.
- **Strainers** located in the supply line and in individual nozzles remove debris and prevent clogging of nozzles.
- **Control valves** are used for on and off operation.
- **Hoses, pipes and tubing** must be corrosion-proof, capable of withstanding high pressure, and U.V. light resistant. Changing hose diameter will increase or decrease pressure.

Drift

Pesticide drift is defined as the airborne movement of pesticide spray droplets, vapor or dusts away from the application site. Pesticide dust or droplets can be carried away by wind, temperature inversions and other factors resulting in accidental exposures of people, animals and plants. Pesticide drift is most often associated with agricultural and landscape pesticide applications. However, drift may also occur indoors. Air currents caused by forced-air heating and cooling systems can result in pesticide drift indoors. Drift is illegal and can cause injury to people, animals, and plants. **Controlling drift is the responsibility of the pesticide applicator**.

Pesticides applied in an upwards direction, for example, spraying trees or spraying under the eaves of structures, and applications made by aircraft are more likely to result in drift than pesticide applications directed toward or close to the ground.

Minimizing pesticide drift:

- Droplet size is one of the most important factors affecting drift. Small droplets are more likely to drift than large droplets. For sprays, use formulations which give large diameter (150 - 200 microns or larger) spray droplets.
- Using solid cone or fan spray nozzles will produce larger droplet sizes than hollow cone nozzles.
- Don't apply pesticides under windy or gusty conditions. Read and follow drift management instructions on the pesticide label. Use a wind meter to determine wind speed, and monitor for gusts.
- Use a buffer zone to ensure drift does not occur off the target area.
- Select an application method and a formulation that is less likely to cause drift. Pesticide granules are far less likely to drift than pesticide sprays.
- When appropriate, use drift control or drift reduction agents.
- Don't spray when weather conditions favor thermal inversions. This occurs when the air closest to the ground is cooler than the air above it.
- Avoid spraying at temperatures above 90° to 95°F, ideally not over 85°F.
- Be familiar with your surroundings. Determine the location of sensitive areas near the application site, including cropland, homes, schools, hospitals, day car parking facilities, surface water, water treatment facilities and honey bee colonies.
- Service and calibrate your equipment regularly.
- Check your spray system for leaks. Small leaks under pressure can produce very fine droplets.
- When chemigating, use drop booms instead of upwardly directed nozzles and turn off the end gun.
- Everything that you have done to manage drift will be a waste if you don't determine and consider wind direction.

Equipment Calibration

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. Applying pesticides is NOT a case where "*if a little is good, a lot is better*," especially with herbicides. Accurate application rates are essential for best results.

Calibration information is often presented using many mathematical calculations, which tends to impress us only with the difficulty of the calibration process. In order to simplify the process, the method described below has minimal math needed. This section is subdivided into sections based on the application method used:

- Boom sprayer equipment
- Backpack sprayer equipment
- Granular application equipment
- Chemigation equipment
- Stationary sprinkler system calibration

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.

Calibrating Boom Sprayer Equipment

Calibration information provided in this section is designed to be used with tractor or pickup-mounted application equipment when applying emulsifiable concentrates or other liquid pesticide formulations.

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 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 the gear that will be used in the 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 measured in step 2. Because of variability among nozzles, it is best if each nozzle is collected separately. Record the amount of spray collected in each container from each nozzle and add the numbers together. Divide 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 until all the measurements are within 10 percent of the average.
4. Convert the total amount collected in step 3 to gallons per acre. Multiply the distance in feet originally measured (traveled) by the width of the spray pattern in feet to obtain the area of the plot sprayed in square feet. 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.

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 fluid ounces of 2,4-D to your 100-gallon sprayer tank. (2.3 fl. oz. X 100 = 230 fl. oz. Use the handy conversions below to convert ounces to gallons, quarts, etc.)

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
32 ounces = 1 quart	1 gallon = 16 cups

1 acre = 43,560 square feet

Table 3: Volume of pesticide at 4 lbs. active ingredient per gallon to mix in one gallon of water*

Spray Water Volume (gallons per acre)	Desired application rate of pesticide per acre			
	1 quart	2 quart	3 quart	4 quart
10	3.3 fluid oz	6.5 fluid oz	9.5 fluid oz	12.3 fluid oz
15	2.0 fluid oz	4.0 fluid oz	6.2 fluid oz	8.5 fluid oz
20	10.0 tsp	3.2 fluid oz	4.8 fluid oz	6.3 fluid oz
30	6.0 tsp	2.0 fluid oz	3.2 fluid oz	4.2 fluid oz
40	4.8 tsp	1.6 fluid oz	2.3 fluid oz	3.2 fluid oz
50	3.8 tsp	1.2 fluid oz	2.0 fluid oz	2.5 fluid oz
60	3.2 tsp	6.3 tsp	1.6 fluid oz	2.0 fluid oz
70	2.8 tsp	5.5 tsp	1.3 fluid oz	1.8 fluid 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 contain 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., divide the pesticide mixture number (oz or tsp.) shown on the chart by 4 and 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.

Refill Method Sprayer Calibration:

<u>Acre-Volume Method:</u>

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):

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

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

Area-Volume Refill Method:

1. Stake out the test area (1,000 feet 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 and measure the amount of water it takes to refill the tank sprayer to the original mark.
8. Record the amount of water used.
9. Calculate the rate of application.

To Find Area Sprayed:

$$\frac{\text{Width of Swath X Length of Run}}{\text{Square Feet per Acre}} = \frac{\text{16-foot Boom X 1000 Feet}}{43{,}560\ ft^2\text{/acre}} = \text{0.37 Acres}$$

To Find Application Rate (assuming 8 gallons used to refill tank):

$$\frac{\text{Gallons Used to Refill Tank}}{\text{Number of Acres Sprayed}} = \frac{\text{8 Gallons}}{\text{0.37 Acres}} = \text{22 Gallons/Acre}$$

To Find Acres Per Full Spray Tank:

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

To Determine the Final Spray Mixture:

Liquid Formulation:

From the Label: 4 Quarts/100 Gallons

Sprayer Tank = 175 Gallons

Final Spray Mixture (Liquid Formulation) $= \frac{\text{4 Quarts}}{\text{100 Gallons}} \text{ X 175 Gallons} = \frac{700}{100} = \text{7 Quarts/Tank}$

Dry Formulation:

From the Label: 2 Pounds per Acre

Sprayer Tank = 100 Gallons

Rate of Application = 22 Gallons/Acre

$$\frac{\text{Gallons per Spray Tank X Lbs. Material/Acre (from label)}}{\text{Gallons per Acre Applied Desired (From Label)}} = \text{Pounds of Material to Add to Sprayer Tank}$$

Final Spray Mixture = 100 Gallon Tank X 2 Lbs./Acre = 9 Pounds of Material Per Tank
(Dry Formulation) 22 Gallons/Acre

To Vary the Output (may require recalibrating your equipment)

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

Calibrating Backpack Sprayer (or similar) Pesticide Application Equipment

This section is designed to be used when calibrating individual backpack sprayers or other hand-carried application equipment used in applying emulsifiable concentrates or other liquid pesticide formulations. Because equipment and walking speed varies by individual, EACH PERSON must calibrate their application equipment before using hand sprayers for pesticide applications. This ensures 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 (number of seconds recorded above) it took you to spray the plot. 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. Repeat the first three steps two more times and average the results for increased accuracy.
5. Determine the amount of herbicide you will need 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, do the additional math described at the bottom of the chart.
   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, 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, convert ounces to another unit of measurement using the conversions below.

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

Spray Water Volume	Desired application rate of pesticide per acre			
	1 quart	2 quart	3 quart	4 quart
10	3.3 fluid oz	6.5 fluid oz	9.5 fluid oz	12.3 fluid oz
15	2.0 fluid oz	4.0 fluid oz	6.2 fluid oz	8.5 fluid oz
20	10.0 tsp	3.2 fluid oz	4.8 fluid oz	6.3 fluid oz
30	6.0 tsp	2.0 fluid oz	3.2 fluid oz	4.2 fluid oz
40	4.8 tsp	1.6 fluid oz	2.3 fluid oz	3.2 fluid oz
50	3.8 tsp	1.2 fluid oz	2.0 fluid oz	2.5 fluid oz
60	3.2 tsp	6.3 tsp	1.6 fluid oz	2.0 fluid oz
70	2.8 tsp	5.5 tsp	1.3 fluid oz	1.8 fluid 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 contain 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., divide the pesticide mixture number (oz or tsp.) in the chart by 4 and multiply the answer by the number of pounds of a.i. per gallon listed on your product label. Mix that quantity 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
32 ounces = 1 quart	1 gallon = 16 cups

1 acre = 43,560 square feet

Calibrating Granular Pesticide Application Equipment

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.

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

Example: The product has a broadcast rate of 40 pounds per acre. Your band width is 7 inches, with 36 inches between rows (the row spacing).

$$\frac{\text{7-inch band width}}{\text{36-inch row spacing}} \times \text{40 pounds per acre broadcast rate} = 0.194 \times 40 = 7.77 \text{ or } 7\tfrac{3}{4} \text{ Pounds per Acre}$$

For band applications at different row spacings:

Many granular insecticide recommendations are based on an acre of 40-inch rows, or 13,068 feet of row. Row widths less than 40 inches require more granular material per acre, but the calibration in the row stays the same. Narrow rows will take more granular material per acre than wider 40-inch rows. Use Table 5 to calculate the amount used **per acre** for different row spacings.

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

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

1. Attach a paper or plastic bag or granular calibration tube to the bottom of each row delivery tube.
2. While operating the applicators, drive a distance equal to 1/20 of an acre. Determine the distance by this formula:

   $$\frac{\text{43,560 Square Feet per Acre}}{\text{Row Width in Feet} \times \text{Number of Rows on Applicator} \times 20} = \text{Distance to Drive in Feet}$$

   Example: to calculate the distance to drive (in feet) with a 4-row applicator set to a 36-inch (3-foot) row spacing:

   $$\frac{43{,}560\text{--}}{3 \times 4 \times 20} = \frac{43{,}560}{240} = \text{181.5 feet (the required distance to drive for the calibration)}$$

3. After driving the required distance, remove sacks or tubes and weigh or measure the contents of each. Contents of each 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.

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 of the product (80 ounces, or 5 x 16) contains 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 (there are 4 rows on the applicator).

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 applications, use a similar calculation using this formula:

$$\frac{\text{43,560 square feet per acre}}{\text{Applicator Width in Feet} \times 20} = \text{Distance to Drive in Feet}$$

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

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

Weigh the total contents of the bags from each of the applicator tubes. The 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.

Handy Conversions	
1 pound = 16 ounces	1 mile = 5,280 feet
1 yard = 3 feet	1 acre = 43,560 square feet

Calibrating Chemigation Pesticide Application Equipment

Chemigation is the process of applying pesticides through an irrigation system. 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 you must determine the exact irrigation water and injection pump settings for your equipment.

Measuring Equipment:

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

You will need a clear calibration tube that indicates units of volume (a 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 the 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 illustrates the procedure.

1. Area Irrigated:

The area irrigated must be calculated using 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:

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

Where:

r = the wetted radius, in feet (the length of the pivot)

π = 3.1416

For this example:

r = 1,300 ft:

$$\text{Area} = \frac{3.1416 \times (1{,}300 \times 1{,}300)}{43{,}560 \text{ square feet per acre}} = 122 \text{ Acres}$$

The area irrigated becomes increasingly more complex with when there are partial circles, circles with intermittent end guns and other configurations. In many cases, it may be wise to leave the end gun off because the water pattern is easily distorted by wind. If an end gun shutoff 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, 1 quart of chemical is required per acre:

Chemical required = 122 Acres irrigated 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.

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:

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

Circumference = 2 X π X r

r = the distance in feet from the pivot point to outer wheel track
π = 3.1416.
For this example, r = 1280 feet

Circumference = 2 X 3.1416 X 1280 = 8042 Feet

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

Revolution time is calculated by dividing the circumference in feet by the 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:

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

Determining these amounts in gallons per hour (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 using 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 63.09 or can be converted to ounces/minute by multiplying gph X 2.133.

- If the calibration tube is in milliliters, 1.48 gph X 63.09 = 93 ml/minute.
- If the calibration tube is in ounces, 1.48 gph X 2.133 = 3 oz/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 of 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.

Pump is rated at 4 gph max.

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

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 that you can inject the chemical at any time during the irrigation process. An herbicide may be injected midway through the irrigation period to allow additional water to be applied for incorporation. A foliar insecticide, in contrast, will usually be applied near the end of the irrigation cycle 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.

   $$\text{Area Irrigated} = \frac{800\text{ ft} \times 40\text{ ft} \times 10}{43{,}560\text{ ft}^2/\text{acre}} = 7.3\text{ Acres}$$
2. Determine the amount of formulated chemical needed per acre by consulting the 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 Chemical = 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 the product label.
   Example: The 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 capture and measure the flow for 1 minute in a pail or graduated measuring device. 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 by using 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 (sprinkler flow) 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 (S_1) X 40 ft (S_m)

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

Another method to determine the water application rate is to determine the sprinkler nozzle size (usually stamped on the nozzle) and discharge pressure, 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) = 0.80

   Net irrigation = 1.0 in.

   $$\text{Gross Irrigation Amount} = \frac{1.0\ \text{inch}}{0.80} = 1.25\ \text{inches}$$

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

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 of 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 at the midpoint of the irrigation time.

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

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 cycle, 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.

Determining Irrigated Acreages

Formulas for calculating acreages in fields and irregular portions of fields are shown below. For irregular fields, sum the areas of the parts of the field using the closest approximations.

1. Area of a square.

   Area of a square = L X L = L^2

   "L" is the length, in feet, of one side of the square

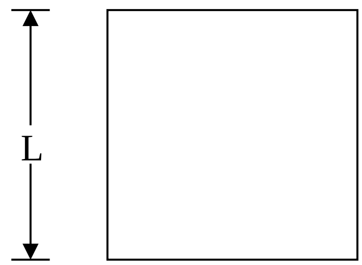
   If L = 2640'

   L^2 = 2640 X 2640 = 6,969,600 ft^2

   Area = 6,969,600 sq. ft

   $$\text{Acres} = \frac{\text{Area (in ft}^2)}{43{,}560\ \text{ft}^2/\text{acre}}$$

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



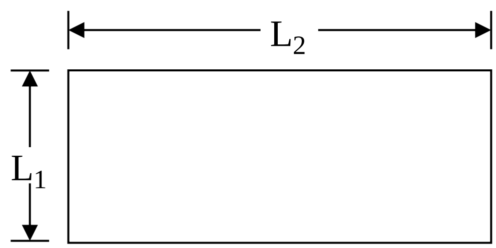
2. Area of a rectangular field.

   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

   $$\text{Acres} = \frac{13{,}939{,}200\ \text{sq. ft}}{43{,}560\ \text{ft}^2/\text{acre}} = 320\ \text{Acres}$$



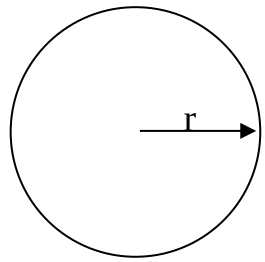
3. Area of a circle.

   Area = r^2 X π where r = the radius and π = 3.1416

   If r = 1300'

   Area = 1300^2 X 3.14 = 5,309,291 sq. ft

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



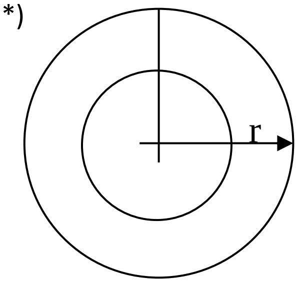
4. Area of part of a circle.

Area = (r^2 X π) X $\frac{<°}{360°}$ (this is the number of degrees in the partial circle*) (this is the total number of degrees in a circle)

If r = 1300 and <° = 270°

Area = (1300^2 X 3.1416) X $\frac{270°}{360°}$ = 3,981,978 ft^2

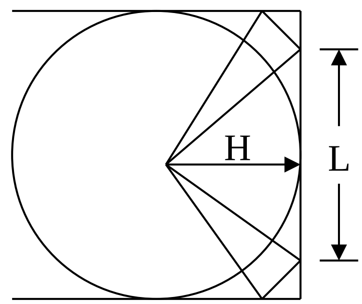
Acres = $\frac{3{,}981{,}968\ ft^2}{43{,}560\ ft^2}$ = 91.41 Acres



* <° = Number of degrees, measured with a protractor

5. Area of a triangle.

Area = $\frac{H\ X\ L}{2}$



If H = 1300 ft and L = 1900 ft

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

Acres = $\frac{1{,}235{,}000}{43{,}560\ ft^2/acre}$ = 28.4 acres

"H" is the same as system length and is equal to the "radius"

"L" is length of the base in the triangle

NOTE: To 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.

Originally published in 1987 as Guidelines for the Safe Use of Pesticides, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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General Knowledge: Pesticide Use and the Environment

Pesticide Use and the Environment Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the chemical characteristics that control pesticide movement in the environment.**
- ✓ **Describe the different ways pesticides can move in the environment.**
- ✓ **Describe the different types of pesticide drift and the factors that can affect pesticide drift.**
- ✓ **Explain why it is important to protect water resources, especially groundwater resources, from pesticide pollution.**
- ✓ **List the different methods pesticide applicators can use to reduce or prevent surface water and groundwater contamination.**
- ✓ **Explain potential pesticide effects on non-target organisms and methods to reduce or prevent these potential effects.**
- ✓ **Describe the Endangered Species Act and how it applies to pesticide applications.**

Pesticide Use and the Environment

After a pesticide is applied, whether to a plant, an animal, the soil, inside a structure, out-of-doors or to any other site, it has been introduced into the environment. Applicators need to ask themselves a few important questions:

1. Will the pesticide remain where it was applied or will the pesticide become mobile in the environment?
2. How long will the pesticide remain viable or effective?
3. What effect could the pesticide have on non-target plants, animals, or other things in the environment?

To answer these questions, you must understand how pesticides move in the environment and the chemical properties that control movement. There are

Once applied, all pesticides are considered to have been introduced into the environment.

Four basic chemical characteristics control pesticide movement:

<u>Solubility</u> is the ability of a pesticide to dissolve in a solvent, usually water.

<u>Adsorption</u> is the ability of a pesticide to bind with soil particles.

<u>Persistence</u> is the ability of a pesticide to remain in its original active form and not break down into an inactive form.

<u>Volatility</u> is the ability of a pesticide to turn into a gas or vapor.

four basic chemical characteristics that control pesticide movement in the environment: solubility, adsorption, persistence and volatility.

Solubility is a measure of the ability of a pesticide to dissolve in a solvent, usually water. The greater the solubility, the more readily the pesticide dissolves. Pesticides that are easily dissolved in water can move with water. Highly soluble pesticides are more likely to move through the soil and into groundwater or into surface waters, causing harm to unintended sites, plants and animals, including humans.

Adsorption is the ability of a pesticide to bind with soil particles. Adsorption occurs because the pesticide has an electrical attraction to the surface electrical charge of a soil particle, generally organic matter or clay particles. A pesticide that adsorbs to soil particles is less likely to move from the application site.

Persistence is the ability of a pesticide to remain in its original form, active and viable, before breaking down chemically to become inactive. A common measure of persistence in chemicals is referred to as the half-life. Half-life is the time it takes for half the original amount of chemical applied to break down. The longer the reported half-life of a chemical or pesticide, the more persistent the chemical or pesticide is in the environment. Sometimes, persistent pesticides are desirable because they will provide long-term pest control and reduce the need for repeated applications. However, persistent pesticides can also cause later problems to unintended sites, plants, animals or humans if the persistent pesticides are also mobile in the environment. If you are using a persistent pesticide, it is very important to prevent unintended consequences due to improper handling, drift, runoff, erosion or leaching.

Volatility is a measure of the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. Pesticides tend to volatilize more readily when temperatures are high, winds are high, and relative humidity is low at the application site. Pesticide movement as a gas or vapor is also known as “drift” and will be discussed in the next section.

Pesticide degradation occurs in three basic ways:

- Microbial action: chemical breakdown or degradation of pesticides by soil microorganisms, such as fungi, bacteria, etc.
- Chemical degradation: Breakdown of pesticide chemical components by inorganic methods (not by living organisms).
- Photodegradation: breakdown of pesticide chemical components by reaction with sunlight. This is why many pesticide application

instructions require incorporation of the pesticide in the soil, away from direct sunlight.

How do Pesticides Move in the Environment?

It would be ideal if pesticides always remained on the target site, whether single plants, farm fields, road sides, soil, or structures. However, pesticides are capable of moving in the environment and under certain conditions they do not always remain on the target site. Pesticides can move in the air, in water, and through the soil resulting in environmental damage and exposure to nontarget plants and animals. Applicators are responsible for damages resulting from off-target pesticide movement.

Pesticide Drift

Pesticide drift is the movement of pesticides through the air away from the intended target site. When pesticide drift occurs, it can damage crops and expose humans, domestic animals and wildlife. Drift can contaminate soil and water.

Pesticide movement in water usually is the result of either **runoff** from the application site to an unintended site or water body or **leaching** from the soil by water, moving outward and/or downward in the soil. This can cause unintended harm to plants or animals or contaminate surface water or groundwater.

Movement on or in objects includes such things as:

- Pesticide **residues** on equipment or clothing used by pesticide applicators. These residues can affect unintended plants, wildlife, livestock, pets and people.
- Pesticides that have adsorbed on soil particles that are subsequently moved to an unintended site by wind or water **erosion**.
- Pesticide **residues** on plants that are removed from site. This may be as plant parts, feed, seed or other plant-based products.
- Pesticide **residues** on or in animals that are treated by pesticides and moved to a new site. The residues can be in the meat, milk or fiber used by man, on their fur or skin, in their feces or other waste products, etc.

Minimizing pesticide movement and subsequent unintended application and damage is part of the pesticide applicator's job.

Pesticide degradation occurs in three basic ways:

- **Microbial action**
- **Chemical degradation**
- **Photo-degradation**

Drift is the movement of pesticides through the air to non-target sites.

Pesticide residues are the product's active ingredient(s) or its breakdown product(s) that remain in the environment after application.

Minimizing pesticide movement and subsequent unintended application and damage is part of the pesticide applicator's job.

There are two types of drift: vapor drift (chemical volatility) and particle drift.

Vapor drift is the movement of pesticide vapors from the target area, carried by air.

Particle drift is the movement of small spray droplets or dust from the target area, carried by air.

Temperature influences the volatility of pesticides.

The size of the spray droplets determines how fast the droplets fall and how far the pesticide might drift. Small, lightweight droplets fall more slowly and have more time to drift.

Types of Pesticide Drift

There are two types of pesticide drift: particle drift and vapor drift. Drift may occur outdoors during agricultural and pesticide applications or indoors, moving on air currents through ventilation systems.

Vapor drift occurs when pesticide surface residues change from solids or liquids to gases or vapors after the application of a pesticide has occurred. This process is called volatilization. Once airborne, volatile pesticides can move long distances from the site of application. Fumigant pesticides used to treat soil before planting and to treat structures such as homes or storage bins are especially volatile.

Not all pesticides are volatile. The potential for volatilization increases as the temperature increases. At higher temperatures, more product will be converted to the volatile form. Pesticide labeling describes precautions to take in order to avoid damage from volatile pesticides.

Particle drift is made up of small pesticide spray droplets or dust carried by air movement from the target area during application.

Factors Affecting Drift

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

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). Droplets that are smaller than 50 microns are highly susceptible to drift under normal conditions. The ideal range of spray droplet diameters for general ground spray application is 80 to 150 microns. The fall rate and lateral drift of different spray droplets is summarized in the table on the next page.

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.

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	2 minutes	1,110 feet
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

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.

Wind velocity or speed is another factor 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, the potential for drift increases. Winds 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. Also take into account the direction of the wind before applying pesticides. Do not apply pesticides when the wind is blowing toward an adjoining susceptible crop, water body, sensitive site, etc.

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 a liquid increases, 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

As droplet size increases, the potential for drift decreases.

The greater the wind speed during a pesticide application, the greater the risk of pesticide drift.

Consider wind direction when planning a pesticide application. Do not apply pesticides when the wind is blowing towards a susceptible crop, water body or other sensitive site.

Winds are generally calmer in early morning or early evening. These are better times of day to apply pesticides.

may reduce weed control. Always follow the label directions regarding the use of any spray additives.

- 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. 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 occurs when there is cool air 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 during temperature inversions since small spray droplets or vapors will be suspended in the cool air layer at crop height for long periods of time.

Low relative humidity and/or high temperature increase the evaporation rate of spray droplets.

- Humidity and temperature: Low relative humidity and/or high temperature increase the evaporation rate of water spray droplets. Evaporation reduces droplet size, and 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.

Spray drift is usually greater from aerial applications than from ground applications.

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.

- Spray nozzles: Pesticide spray nozzles are an integral part of pesticide application equipment. Good uniformity of the application depends on proper nozzle selection. Nozzles help control the amount of pesticide applied and the size of the droplets. Droplet size depends on both the nozzle and the pressure. Droplet size decreases with high pressure and increases with low pressure. The bigger the droplet, the less likely it is to drift.

Nozzles may be constructed of a variety of materials, including stainless steel, nylon, aluminum, brass or ceramic. Some materials are very durable, such as stainless steel. Nozzles made from brass wear out quickly, especially when using wettable powders.

Some basic nozzle types include:

- Fan or flat fan nozzles: These nozzles are used for herbicide and insecticide applications. They put out the spray in a fan-shaped pattern with less material applied at the edge of the pattern, so the spray pattern must overlap in order to obtain uniform coverage.
- Hollow cone nozzles: These nozzles produce a cone-shaped spray pattern, with the liquid on the outside of the cone. Hollow cone nozzles generally produce the smallest droplets and are used when penetration and coverage are critical.
- Full cone nozzles: This type of nozzle produces a cone-shaped spray pattern with liquid being applied throughout the cone. They are often used for soil-applied herbicides.

- Spray pressure: 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.

Proper nozzle selection helps maintain uniform application by controlling both the amount of pesticide applied and the size of the pesticide droplets.

Spray pressure influences the size of the droplets formed. Increased pressure produces smaller droplets, which are more susceptible to drift.

Water Resources

The water cycle or hydrologic cycle is one of the oldest recycling systems on earth. No new water is ever created. Instead, the water cycles through a complex system fueled by the sun that continually replenishes water supplies. The hydrologic cycle moves water among Earth's land, atmosphere and oceans.

The major processes moving the water are evaporation, transpiration, condensation and precipitation. **Evaporation** occurs when the sun's energy turns liquid water on the Earth's surface into water vapor, which enters the atmosphere. Water vapor leaves plants in a process called **transpiration**. Collectively, these two processes are referred to as **evapotranspiration**. When the water vapor in the atmosphere cools and forms clouds, it is called

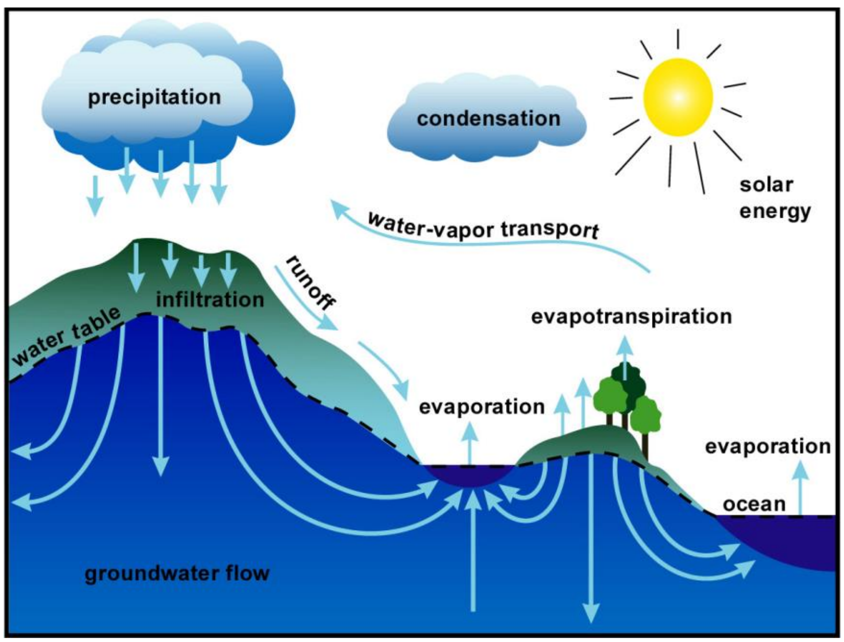
An aquifer is a geologic formation from which groundwater can be drawn. It can be a layer of sand, gravel or other soil materials, or a section of bedrock with fractures through which water can flow.

Groundwater is widely used for household and irrigation water supplies.

condensation. When the water in the atmosphere falls back to Earth as rain or snow, it is called **precipitation**. Rainfall and snowmelt contribute to the surface water in streams, rivers, lakes, ponds, etc.

Precipitation also soaks into the ground or infiltrates, replenishing the water in the soil. Some of this water continues to infiltrate below the soil. This subsurface water accumulates within cracks in bedrock or fills 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. Groundwater is the source of water for wells and springs, which are the source of drinking water for many communities.



The Water Cycle

Groundwater: Water entering the soil gradually percolates downward or laterally to become groundwater. This hydrologic process is referred to as **recharge**. 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. Groundwater may eventually discharge (exit) through springs or seeps into surface water bodies such as streams or lakes.

Groundwater is usually very clean because it is filtered as it squeezes through porous spaces in the rock. When groundwater becomes contaminated, fixing the problem is difficult and is prohibitively expensive. The degradation of pesticides in groundwater is extremely slow because of the low temperatures, low microbial activity, and absence of light.

Surface Water: Surface water resources include water in oceans, rivers, lakes, streams and ditches. Surface water is linked to groundwater by recharge through water bodies such as streams and lakes. Most agricultural and urban areas drain into surface water systems, making surface water especially vulnerable to pesticide contamination. When pesticides enter surface water, they can be transported downstream and spread throughout rivers, streams, lakes and oceans.

Pesticide Contamination and Water Resources

Pesticides can contaminate surface water and groundwater from both point sources and non-point sources. Point sources are from specific locations such as spill sites, disposal sites, pesticide drift during applications, and application of pesticides to control aquatic pests. Nonpoint sources are currently the major contributors to surface water and groundwater contamination and may include agricultural and urban runoff, erosion, leaching from application sites, and precipitation that has become contaminated by upwind applications. Pesticides typically enter surface water when rainfall or irrigation exceeds the infiltration capacity of soil, or the soils ability to absorb the water. Resulting runoff then transports pesticides to streams, rivers and other surface-water bodies.

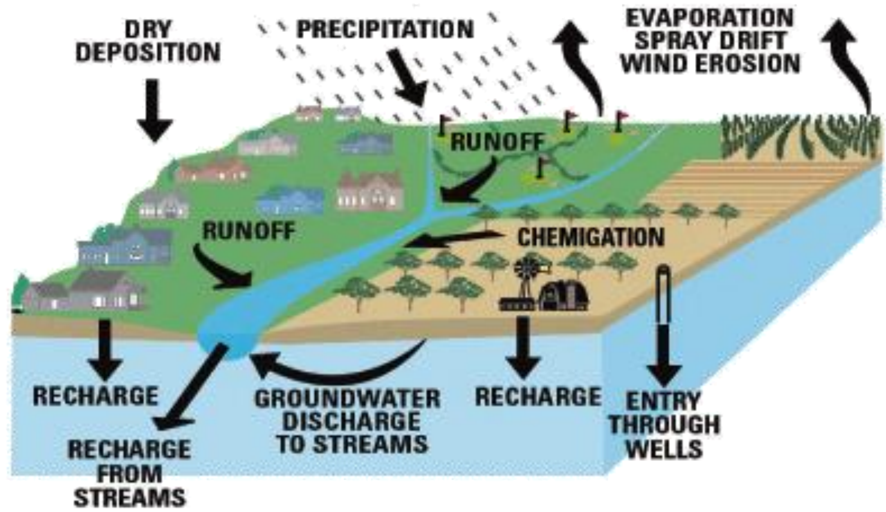
Pesticides also enter surface waters through drift. Contamination of groundwater may result directly from spills near poorly sealed wellheads and from pesticide applications made using improperly designed or malfunctioning irrigation systems. Groundwater contamination also may occur indirectly by the percolation of agricultural and urban irrigation water through soil layers into groundwater and from pesticide residues in surface water, such as drainage ditches, streams and municipal wastewater.

The diagram below illustrates routes of pesticide introduction into streams and groundwater. (Modified from Gilliom and others, 2006.)

Once groundwater is contaminated, it is difficult and expensive to decontaminate.

Pesticides can contaminate surface water and groundwater from both point sources and nonpoint sources.

Chemicals on the ground surface can become groundwater contaminants if they are carried downward by recharge water.



Leaching is the term for transport of pesticides downward or sideways through soil.

The risk of groundwater contamination is greater when pesticides are applied to gravelly or sandy soils.

The closer the water table is to the land surface, the greater the possibility of contamination.

Runoff and erosion moves pesticides into surface water bodies, such as streams or lakes.

Leaching is the term for the transport of pesticides downward or sideways through 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 risk of groundwater contamination is greater when pesticides are applied to gravelly or sandy soils than to other soil type.

The potential for pesticide movement in the soil varies according to the nature of the pesticide, the properties of the soil, the application practices used, irrigation and precipitation. The closer the water table is to the land surface, the greater the possibility of contamination. Pesticide labeling describes environmental hazards and may include groundwater advisory statements. These are instructions that may prohibit the product's use in areas where groundwater is vulnerable to pesticide contamination. As an example, some product labels will advise users not to apply the pesticide to sand or loamy sand soils in areas where the water table is close to the surface.

Runoff is the process of water moving across the soil surface or other hard surfaces when it arrives faster than it can soak into the soil. Runoff is usually produced by rain, melting snow, or irrigation water. Some pesticides eventually end up on soil or on paved surfaces. As water runs off and the soil erodes, the pesticides are carried along with the water and soil particles. Runoff and the erosion it causes move pesticides downhill into streams, rivers, ponds and lakes.

Runoff can occur from all types of sites, including agricultural areas, rangeland, compacted soils and roadside rights-of-way. Pesticides applied in urban areas to structures, and landscapes can be a significant source of surface water contamination. According to U.S. EPA, because of impervious surfaces such as rooftops and pavement, a city block produces nine times more runoff than a wooded area of the same size. When urban runoff enters storm drains it can carry pesticide pollutants with it directly to streams and rivers.

Protecting Water Resources

Preventing water contamination by pesticides is the responsibility of every pesticide applicator. Follow these pesticide application guidelines

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, danger, 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. Pesticide labels contain information on protecting water resources and preventing contamination.

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

- **Measure pesticides 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.
- **Direct pesticide applications to the target site.** Avoid overspraying the ground to prevent the possible introduction of the pesticide into water. 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

Preventing groundwater contamination is the pesticide applicator's responsibility

Always read, understand and follow directions and precautions on the product label.

Use pesticides only when and where necessary and only in amounts adequate to control pests.

There are both civil and criminal penalties for using pesticides in a manner inconsistent with label directions.

Read, understand and follow the information and instructions on the pesticide label regarding disposing of pesticides and storing pesticides safely.

Maintain records of pesticide applications, as required.

Additional groundwater protection methods, such as timing of irrigation, avoiding irrigation runoff and regularly inspecting and maintaining water wells, can help prevent groundwater contamination.

pesticide disposal to avoid groundwater contamination. Triple-rinsed or pressure-rinsed pesticide containers to prepare them for disposal. Pour the rinse water back into the spray tank and use it 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.

- **Store pesticides 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. Store pesticides in a cool, well-ventilated, secured (locked) location away from wells, pumps, or other water sources. Seal pesticide containers tightly and periodically check them for leakage, corrosion breaks, tears, etc.
- **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.
- **Use additional water protection methods,** such as carefully timing irrigation, avoiding runoff, and inspecting wells, to prevent groundwater contamination by pesticides.
    - **Time irrigation:** If it is practical, delay irrigation for one or more days after a pesticide application. A delay in irrigation gives the plants 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. This reduces the chances of the pesticide reaching the groundwater.
    - **Avoid irrigation runoff.** This reduces soil erosion and decreases the chances of the pesticide entering surface water and groundwater. Extra care should be taken when irrigating and applying pesticides on clay soils because they are especially susceptible to runoff.
    - **Inspect wells 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. Proper well construction can prevent groundwater contamination. Locate wells 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 from the ground surface to a depth of at least 50 feet with neat cement.

Proper maintenance of existing wells helps prevent groundwater contamination. Inspect wells and pumps regularly for leaks and to ensure the seal is adequate to prevent pesticides from entering the groundwater. Check irrigation pipes for leaks that could lead to contamination of the groundwater.

Chemigation

Chemigation is the application of agricultural chemicals through an irrigation system. Particular care should be used when practicing chemigation. The irrigation may carry the pesticides downward through the soil to groundwater. Devices must 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. Chemigation systems must include the following:

- 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 also 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 metering pumps, such as a positive displacement injection pumps (e.g., diaphragm pumps) effectively designed and constructed of materials that are compatible with pesticides and

Chemigation is the application of agricultural chemicals, both pesticides and fertilizers, through a sprinkler system.

For further information on Chemigation, see Category 14, Chemigation in this manual.

Phytotoxicity: poisonous toplans, a chemical that causes damage or death to plants.

Be aware of bee activity when applying pesticides.

Before applying pesticides that are toxic to bees, notify beekeepers in the area.

Use insecticides that are relatively non-hazardous to bees whenever possible.

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 "Calibration of Chemigation Equipment" under the "Guidelines for the Safe Use of Pesticides" section for information on calibrating chemigation equipment. See Category 14, Chemigation for further information.

Pesticide Effects on Non-Target 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, pets, livestock, and wildlife may be affected.

Pesticide 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** refers to 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 injuries are due to herbicides that are persistent at the site of application. Persistent products may also injure succeeding crops.

Damage to crops or other plants in adjacent areas is most often due to drift, although damage may sometimes be a consequence of surface runoff, particularly from sloping areas.

Pesticide effects on bees

Bees pollinate many fruit, vegetable and field crops. Always monitor for bee activity prior to applying pesticides. Prevention of bee harm or loss is the joint responsibility of the applicator, 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. In addition, take the following steps to protect bees:

- 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 pesticide 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 or other pesticides that are relatively nonhazardous 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.
- Be aware that airplane applications are more hazardous to bees than ground applications.

Pesticide 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 beneficial insect numbers as effectively as those of the pests themselves. This allows the resurgence of the pest population to be faster and greater because the beneficial predators have been eliminated or are slower to rebound.

Pesticide effects on pets

Keep pets out of treated areas during applications and cover pet food and water bowls. After walking through treated areas, pets may lick their paws and become exposed to the chemical, so it is advisable to keep pets out of the treated areas until the pesticide has completely dried.

Apply rodenticide baits in bait stations and insect baits in locations where pets can't get to them. Information about bait stations and bait placement can be found on the pesticide labels.

Some pesticides are manufactured specifically for use on pets. Read, understand and follow label directions carefully. It is especially important to use these types of products only for the species of animals they are actually labeled for. For example, do not use products labeled for dogs on cats.

Pesticide effects on livestock

Livestock poisoning by pesticides occurs as a result of contaminated feed or forage and contaminated drinking water. This is often due to carelessness, and may result from improper transport, storage, handling, application or disposal of pesticides.

Applying a pesticide to a forage crop that is not listed on the label and then feeding the forage to livestock may result in illness or death of the animals.

Some pesticide labels list grazing restrictions, which are periods of time that livestock must be excluded from the treated area after treatment. Grazing

Apply pesticides in the evening or early morning, when bees are not actively foraging.

Beneficial insects, other than bees, can also be harmed by pesticides. Survey the insect population and use caution when applying pesticides.

Keep pets out of treated areas during applications and cover pet food and water bowls.

Applying a pesticide to a forage crop that is not listed on the label and then feeding the forage to livestock may result in illness or death of the animals.

restrictions prevent adverse effects to livestock and livestock products from occurring as a result of pesticides used on pasture and range sites.

Pesticide effects on wildlife

Pesticides can affect wildlife in many ways. They may kill wildlife, weaken wildlife, kill their food source or interfere with reproduction.

Adverse effects of pesticides on wildlife can differ widely. For example, rodenticides applied in a manner that is not consistent with label instructions can kill non-target species, such as birds and mammals. Some pesticides, especially insecticides, are very toxic to fish and other aquatic life. When these products drift or run off into waterways, aquatic species may suffer adverse effects. Insecticides kill important insects that are a vital part of the food chain. Herbicide use can eliminate habitat that is valuable for insects, birds and mammals.

Insecticides and rodenticides are sometimes intentionally misused to kill nuisance wildlife. **This is a violation of pesticide labeling**. It is also a serious violation of state and federal wildlife laws and regulations.

Lethal effects are those that cause death directly by exposure to pesticides.

Insecticides and rodenticides are generally more toxic than herbicides to wildlife. Few acute or chronic effects on wildlife are currently known to be connected with herbicide use.

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**.

Sublethal effects are those that do not kill outright, but those that interfere with survival and reproduction.

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 **sublethal effects**.

Insecticides also can affect wildlife indirectly by killing insects other than crop pests. Insects are very high in protein, which 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.

Bioaccumulation or bioconcentration is the accumulation of persistent pesticides in the bodies of animals.

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 properties account for most of the environmental problems associated with their use. As a result, EPA has 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." For example, birds might eat insects, and then larger birds might eat smaller ones. 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 (ppm), it reached a concentration of 141 ppm in earthworms and 444 ppm in robins.

Biomagnification is the accumulation of persistent pesticides in increasing concentration in animals as it moves up the food chain.

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.

Any application method or farming practice that allows considerable drift or runoff is potentially harmful to wildlife.

Granular insecticides and rodenticides are attractive to birds. Some birds can die from swallowing even a single granule of some of these products.

By following the best management practices outlined in this study guide, you can minimize pesticide impacts 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 wetlands or other natural areas.
- 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 run off into the water. Pyrethroids are a good alternative in upland areas because they have low toxicity in birds and mammals.

For additional Endangered Species information:

Nevada Natural Heritage Program, Department of Conservation and Natural Resources
901 South Stewart Street, Suite 5002
Carson City, NV 89701-5245
Phone: 775-684-2900
Fax: 775-684-2909
http://heritage.nv.gov

Nevada Department of Agriculture
405 South 21st Street
Sparks, NV 89431
Phone: 775-353-3600
http://agri.nv.gov/

University of Nevada Cooperative Extension
4955 Energy Way
Reno, NV 89502
Phone: 775-784-4848
Fax: 775-784-4881
http://www.unce.unr.edu

- Avoid draining wetlands for planting and avoid cultivating and using pesticides on 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 and may be 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 alternating untreated swaths with treated swaths.

Protecting Endangered Species

The Endangered Species Preservation Act was passed by Congress in 1966 and amended to the Endangered Species Act (ESA) in 1982. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service are the designated federal agencies that are responsible for administering the law.

The ultimate goal of the ESA is to maintain the natural diversity of plants and animals and the ecosystems upon which they depend. As of 2010, the U.S. Fish and Wildlife Service endangered species list contained more than 1,060 species of plants and animals. An additional 317 species of plants and animals are listed as threatened. Of these, 40 species of plants and animals are federally listed as endangered or threatened in Nevada.

Once listed as endangered or threatened, a species has full legal protection under the Endangered Species Act. All Federal agencies are required to undertake programs for the conservation of endangered and threatened species. They are prohibited from authorizing, funding, or carrying out any action that would jeopardize a listed species or destroy or modify its "critical habitat:" the limited area where an endangered species lives.

The ESA program is concerned about the impact pesticide use limitations or restrictions have on the people who use pesticides. To minimize these impacts, the EPA emphasizes lower pesticide application rates rather than complete prohibition of use in areas where endangered or threatened species and their habitats could be affected by pesticides. The use of lower rates reduces the exposure of endangered and threatened species to potentially harmful pesticides.

The program requires some pesticide manufacturers to place a generic statement on the label. This statement instructs the pesticide's users to determine if any use limitations exist by visiting the U.S. Environmental Protection Agency's Endangered Species "Bulletins Live" website, https://epa.gov/endangered-species. If use limitations are listed, the user is required to understand the information and adhere to its restrictions. The bulletins contain habitat location maps, which pinpoint species habitat locations. The maps can help pesticide users determine if a pesticide application has the potential to impact a threatened or endangered species. The EPA is working with U.S. Fish and Wildlife Service, U.S. Department of Agriculture, the Natural Heritage Program and state agencies to ensure the accuracy of the maps. Contact the Environmental Protection Agency's Endangered Species Hotline, 1-800-447-3813, to find out which counties nationwide are currently included in the program.

Because EPA's Endangered Species Protection Program is constantly changing, check regularly with the Nevada Department of Agriculture for changes in pesticide use restrictions and to learn which bulletins are available. **Remember, if you use pesticides, you are responsible for knowing if an endangered or threatened species or their habitat may be affected by pesticide use in your area.** Read each pesticide label carefully, get the additional information you need, and then observe any necessary limitations that apply to endangered species or their habitats. When you fulfill your responsibilities as a pesticide applicator, you help ensure that the benefits of pesticide use outweigh the risks.

The Nevada Natural Heritage website, http://heritage.nv.gov, lists all the endangered and threatened species in Nevada. Check the website regularly for updates. Endangered and threatened species are also protected in Nevada by the Nevada Revised Statutes (NRS) 501 Fauna (animals), NRS 527 Flora (plants) and the Cactus and Yucca Law (with the exception of the Warner sucker in Washoe County, which is not listed by the state of Nevada).

Conclusion

Use care when applying pesticides. Read, understand and follow label directions. Read the entire label. Do your best to limit pesticide drift. Be aware that pesticides may adversely affect non-target plants and animals. Pesticides may also contaminate surface and ground waters if not applied correctly. Use pesticides carefully and thoughtfully.

Parts of the water resources section were adapted from:

Thodal, C.E., 2009, Monitoring for pesticides in groundwater and surface water in Nevada 2008: U.S. Geological Survey Fact Sheet 2009-3093, 4 p.

Originally published in 1987 as Pesticide Use and the Environment, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

U.S. Environmental Protection Agency Pesticides: Protecting Endangered Species from Pesticides, https://www.epa.gov/endangered-species

U.S. Fish & Wildlife Service, Endangered Species Program, https://www.fws.gov/endangered/

Remember, if you use pesticides, you are responsible for knowing if an endangered or threatened species or their habitat may be affected by pesticide use in your area.

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General Knowledge: Integrated Pest Management (IPM)

Integrated Pest Management (IPM) Learning Objectives

After studying this section, you should be able to:

- ✓ **Define the concept of Integrated Pest Management (IPM).**
- ✓ **List the principles of IPM.**
- ✓ **Describe IPM Action Thresholds and explain how they are used.**
- ✓ **List the five major groups of IPM control strategies and provide several examples of how each would be used in an IPM program.**

What is Integrated Pest Management (IPM)?

Integrated Pest Management (IPM) combines prevention, cultural, mechanical/ physical, biological and chemical pest control methods to formulate effective pest management plans.

Integrated Pest Management (IPM) is a long-term management strategy that uses a combination of tactics to reduce pests to tolerable levels with the lowest cost to the pest manager and minimal effect on the environment. IPM integrates prevention, cultural practices, mechanical and/or physical pest controls, biological pest controls **and** chemical pest controls 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. IPM is based on and uses scientifically sound strategies. Problems associated with widespread pesticide use, such as pest resurgence, pest resistance and secondary pest outbreaks, are minimized by using IPM.

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, presents special challenges. Urban IPM, or pest control programs that incorporate reduced use of pesticides in homes, private and commercial landscapes, golf courses and structural

Principles of IPM

- **Identify the pest.**
- **Monitor the pest population.**
- **Establish an action threshold.**
- **Evaluate control options.**
- **Implement control options.**
- **Monitor results.**

For identification help, go to http://www.manageNVpests.info

Select tactics that will be most effective, most economical and have the least impact on non-target species and the environment.

settings, is an expanding field with increased support from university and industry research.

Principles of Integrated Pest Management (IPM)

1. **Pests, their hosts and beneficial organisms must be positively identified.** The pest problem and associated plant or animal species must be correctly identified. If you can't identify the pest, collect samples and submit them to University of Nevada Cooperative Extension or the Nevada Department of Agriculture for identification. Our website, www.manageNVpests.info, also contains photo galleries of common weeds and insect pests, beneficial insects and exotic invasive insects. Once the pest is identified, determine the pest's life cycle, growth cycle and reproductive habits. Pest managers should also be able to identify all life stages of beneficial organisms, such as the lady bird beetle, an insect predator.

2. **Establish monitoring guidelines for each pest species.** Routine monitoring of both pests and natural enemies (beneficial species) is a critical part of IPM. Methods of monitoring include visual inspection, pheromone and sticky traps, and sweep nets. Document and track both pest and beneficial organism population numbers. The ratio of natural enemies (usually insects) to pests should be taken into account before a pesticide is applied.

3. **Establish an action threshold for the pest**. A fundamental concept of IPM is that a certain number of individual pests can and should be tolerated. Thresholds may be based on many things, such as pest numbers or percent damage. Will the pest cause unacceptable damage to the value or appearance of the plant, crop or animal? When working with structural pests, how will the pest affect the structure and those who use the structure? **What will happen if no action is taken?** These types of questions help to establish the action threshold for a particular pest in a given situation. Action thresholds are usually divided into three categories: economic, aesthetic and emotional.

   The **economic threshold** is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density, or population level, at which a control application should be made. Economic thresholds are commonly used in agricultural crop production. 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. In an agronomic setting, a single crop is grown over a large area with a 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 and whether or not the presence of a pest presents a health or safety issue. The aesthetics and healthful condition of an individual plant or animal, a whole landscape or a structure may be affected by pests. The presence of pests and their damage, though not serious, may be intolerable or annoying to some, yet readily accepted by others. Urban IPM strategies are developed with less emphasis on economic thresholds, unless the soundness of the structure or liability concerns for a client are involved. It is often the appearance of a pest or the damage it causes that triggers control actions. This is called the **aesthetic threshold**. The aesthetic threshold varies from person to person, making it difficult to establish control criteria for most landscape pests.

Sometimes, the action threshold is based solely on the emotions of the property owner. This is referred to as an **emotional threshold**. For many people, a single mouse, cockroach or spider is unacceptable. Many people fear pests and this triggers their need to implement control actions.

Action thresholds are low when human health and safety are at risk. The action threshold for poisonous black widow spiders would likely be lower than the threshold for other spiders. Action thresholds are likewise low for arthropods that transmit disease, such as ticks that transmit Lyme disease or mosquitoes that transmit West Nile virus.

4. **Evaluate and implement control tactics.** Select tactics that will be most effective, most economical and have least impact on non-target species and the environment. In agriculture and urban landscapes decisions based on action thresholds should also take into account the presence of natural enemies. Select controls that will impact beneficial organisms as little as possible while suppressing the pest. If a pesticide is the selected management tool, beneficial enemies (usually insects) will likely also be killed.
5. **Monitor, evaluate and document the results.** This allows you to make adjustments to improve the effectiveness of future pest control strategies.

Pest Thresholds:

- **Economic:** Point at which the pest infestation causes enough economic damage to justify the cost of treatment.
- **Aesthetic:** Point at which the infestation causes enough visual damage to justify treatment.
- **Emotional:** Point at which the pest infestation causes enough emotional trauma to justify treatment.

Integrated Pest Management (IPM) Methods

Integrated Pest Management (IPM) uses a wide range of pest control methods that will provide control in a cost-effective manner. IPM also seeks to minimize potential risks to humans, animals (pets, livestock and wildlife), and the environment. Most effective pest control plans include two or more control methods. Control methods can be divided into five basic groups: prevention, cultural controls, mechanical or physical controls, biological controls and chemical controls.

Prevention: Prevention strategies seek to prevent pest infestations or minimize the conditions that contribute to pest infestations.

For plants, one of the most effective prevention strategies is to select plant varieties that are adapted for and will flourish in Nevada's challenging climate. Plants that are not subject to environmental stresses are less susceptible to disease or other pest problems. If a poorly adapted plant is selected for a landscape, it will be difficult to overcome the stresses imposed on the plant or control the pest problems that arise as a result. Choosing plants that will do well in existing site conditions can help to prevent pest problems.

Another prevention strategy for plants is to choose pest-resistant plant varieties. Selecting plants based on their resistance to pests is essential 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. Box elder bugs do not prey on Norway maples, but both the silver maple and box elder trees are preferred hosts for the bug.

Before purchasing or planting, inspect all new stock to make sure diseases, insects, weeds and other pests are not present. Do not purchase and refuse to accept plant material with obvious disease, insect or cultural problems. Remove weeds from nursery containers *before* you place them in a landscape.

Rotating crops can help disrupt disease or insect infestation cycles. Choosing disease, weed, and other pest-free plants, seed, mulch and other garden amendments will also aid in preventing a pest problem.

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

Successful pest control management considers all the potential control methods:

- **Prevention**
- **Cultural**
- **Physical/ mechanical**
- **Biological**
- **Chemical**

Prevention is generally the least expensive control strategy

Cultural practices: Cultural practices are the strategies we use to grow and maintain healthy plants and animals. Cultural practices such as proper fertilizer application, appropriate watering, soil management, sanitation and site selection can influence the health of plants, and therefore the frequency and severity of pest problems. Good sanitation practices are imperative to prevent many insect and vertebrate infestations in homes, warehouses and other structures. Livestock operations require the animals be maintained in healthy conditions with adequate food and water. Healthy animals, like healthy plants, are better able to resist pest infestations. Relatively small changes in cultural practices can have significant impacts on pest populations.

Proper fertilization and appropriate watering can promote healthy plant growth, which makes plants less susceptible to pest problems. Improper fertilizer and watering, either too much or too little, can stress plants and may actually encourage pests. Managing soil to improve water- and nutrient-holding capacity and maintain pH within the range from 6.0 to 8.0 will also aid plant health. Healthy plants are less susceptible to pest problems. Selecting appropriate planting sites also helps to ensure plants will survive and thrive. A plant under stress is more susceptible to pest problems.

For crops or gardens, rotating plantings can help break the pest cycle. Diseases and insect pest cycles can be disrupted by this simple, time-honored cultural practice. The use of companion plantings can also interrupt the pest cycle, acting as a barrier to protect the desired crops or plantings.

Another cultural practice that can aid plants is to avoid unintended injury. 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 insects and diseases. 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 creates wounds that may attract egg-laying females.

Good sanitation can help to prevent many pest infestations. Remove disease- or insect-infested plant materials from the vicinity of susceptible plants. Pick up fallen fruit, as diseases and/or insect pests may overwinter in them, leading to re-infestation the following year. Prune out dead or diseased plant parts or remove entire diseased plants before pests spread to adjacent plants. Regular cleaning and disinfecting of gardening equipment, particularly pruning tools, is also recommended to prevent the spread of some landscape diseases.

Proper fertilization and appropriate watering promotes healthy plant growth, reducing the plant's susceptibility to pest infestation.

Good sanitation can prevent many pest infestations.

Changing the environment is another method to discourage or eliminate pests. All animals need three things to survive: food, water and shelter. Insect, rodent and bird pests are no different than other animals. Manipulating the environment can prevent or discourage them. This approach is most appropriate when dealing with pests in and around homes, agricultural buildings and other facilities, such as schools and hospitals. Good sanitation within and around structures is critical in controlling pests. This eliminates habitat and food sources for most pests. Good sanitation, especially manure management, aids in reducing the incidence of pest infestations in or on animals.

Eliminate food and water sources for pests:

- Regularly empty trash cans and replace liners to reduce insect and rodent pest problems.
- Store seed and pet and livestock feed in secure pest-proof containers.
- Routinely sweep and mop kitchen floors and food preparation areas.
- Repair leaking pipes.
- Wring out and dry floor mops.
- Clean out rain gutters to allow proper drainage.
- Keep floor drains clean.
- Destroy crop residues to reduce insect and disease pests.
- Empty containers that collect rain or irrigation water.

Eliminate shelter sites for pests:

- Seal entry points including holes, cracks and other openings where insects and rodents enter structures.
- Use door sweeps to prevent pests from entering under doors.
- Keep doors closed.
- Eliminate clutter, including trash, brush and debris or leaf piles where pests hide and nest.
- Install bird spikes, netting or other barriers to prevent birds from nesting, feeding or roosting.
- Empty containers that collect rain or irrigation water.

Changing the temperature, light or humidity are cultural factors that can reduce the incidence of pest infestations in storage structures, greenhouses and other facilities.

Physical/mechanical practices: Physical or mechanical control strategies are those methods that reduce pest infestations by disrupting the pests or providing a physical barrier to prevent the pest from infesting an area.

One of the simplest methods of physical or mechanical pest control is hand-picking insects or hand-pulling weeds. This removes the pest from the host plant or site. This method works best in those situations where the pests are visible and easily accessible.

Physical or mechanical disruption of pests also includes such methods as mowing, hoeing, tilling or cultivating. Another method of physical disruption is washing. A strong spray of water may interrupt the life cycle of many insect pests while causing little damage to the host plants or the surrounding environment. In many cases, reducing pests by mowing, cultivating, hoeing or trimming can provide an 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.

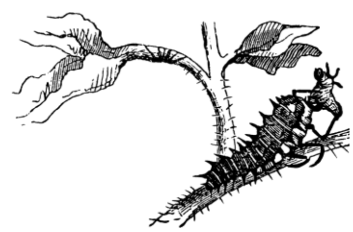
Physical barriers, such as fences, netting, sticky barriers, plastic mulches, row covers, plant cages and paper or plastic tree collars, can help prevent or at least deter pests. Caulking around windows, doors and utility line access holes, and screening entrances, vents and access ports does much to keep structural pests out of a building. Do not bring pest-laden items, such as storage boxes, old furniture, plants and soil, stored products, etc., into a structure without first inspecting them for pests and controlling them.

Traps are another physical or mechanical method used to control pests. Types of traps include mechanical traps, such as mouse traps, sticky traps and light traps. Some traps contain pheromones that attract and trap pests using scents. Another method uses trap crops. These are crops intentionally planted to attract pests away from economic crops or desired plants. The trap crop is sacrificed to protect the other crops.

Biological Control: Biological pest control is the use of a living organism to control another living organism. The importance of using biological control agents to control insect and disease pests is often overlooked. Biological agents of landscape pests include:

- **Predators:** Common arthropod predators of insects include lacewings, predatory mites, minute pirate bugs, lady bird beetles and spiders. Either the adult and/or immature stage may prey on insect pests, so it is important to properly identify all the life stages of predator arthropods. Some predatory arthropods have greater impacts on pest populations than others. Vertebrate pest management should include the use of natural enemies. Examples include predators, such as hawks, owls and coyotes,

Trap crops are planted to attract pests away from economic crops or desired plants.



Lady bird beetle larva

Biological control may be obtained by conservation, augmentation or importation of the control species.

For further information on biological controls, go to USDA-APHIS Plant Health Biological Control Program, https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs

that prey on rodents. Natural enemies can be found in all habitats including landscapes, aquatic sites, crop land and surrounding areas.

- **Parasites:** The life cycle of insect parasites develops in or on an insect host. The parasite feeds on body fluids or organs, usually killing the host. Common parasites include wasps, flies and nematodes. Most are specialized in their choice of a host.
- **Weed Feeders:** Insects, grazing animals, and some fish, such as grass carp, consume plant leaves, stems, seeds, flowers and fruits. Insects are often specific to a single species of weed, while grazing animals and fish feed on a broader array of vegetation. Weed feeders seldom eradicate an infestation. However, they are useful in slowing the spread of weeds.
- **Pathogens:** Weeds, arthropods and vertebrate pests can be infected by pathogens, including viruses, bacteria and fungi. When environmental conditions are favorable for the pathogen, a disease outbreak can occur which may decimate the pest population. This same principle applies to disease outbreaks in all species, including humans. Most pathogens are specific to certain groups of plants or animals. A pathogen commonly found in soil is *Bacillus thuringiensis,* or "Bt". Bt is a bacterial that is effective at controlling insects in their larval stage. It is used commercially to control mosquitoes, black flies and other insects. It is considered safe to humans and other non-target organisms.

Biological control may be accomplished in one or a combination of several ways:

- **Conservation**: This is the process of using, protecting and encouraging existing populations of natural enemies. Examples of conservation include avoiding the use of insecticides when beneficial insect populations are high, or providing nesting or roosting sites for birds of prey. Conservation is the most cost-effective form of biological control.
- **Augmentation:** This occurs when more individuals are added to an already existing population of biocontrols at a site. For instance, many species of predator and weed-feeding insects can be collected in the field or raised commercially, and may be released to increase existing populations to a level where they are effective against the pest.
- **Importation:** This method relies on introducing a population of beneficial organisms not currently present to a given site. This is often done to manage nonnative pest species, such as the noxious weeds saltcedar and leafy spurge, or insect pests like the Russian wheat aphid.

The Nevada Department of Agriculture, in cooperation with USDA – Animal Plant Health Inspection Service (APHIS) and Plant Protection and Quarantine (PPQ) is using biological controls to manage 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 they will contribute to the control of this damaging aphid. Attempts to control the noxious weed leafy spurge (*Euphorbia esula*) have included beneficial insects. 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.

Chemical controls: Chemical controls include pesticides applied to manage pests. More information on types of pesticides can be found in the previous chapter of this manual. 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 or to protect human health. Pesticides are important tools, but they should be used only when necessary and in conjunction with other management tools. The development of a pest problem often signals poor management practices, so a review of the management protocols and cultural practices for a given landscape, field or property should be made prior to applying pesticides.

In the urban environment, the tendency is to use pesticides as preventative measures to ensure "perfect" landscapes. Pesticide use for this purpose is based on perceived threats from pests, but many times no actual pest has been identified and no damage is visible. Not only is this pesticide application philosophy expensive and unnecessary, it may also have significant environmental consequences. For example, overapplication of weed-and-feed-type products on lawns can have serious effects on adjacent ornamental plants, particularly trees planted in or adjacent to turf.

The use of pesticides for structural and institutional pest control must first take into account the potential exposure to the residents of the building as well as potential health effects. When inside a structure, pesticides tend to break down more slowly than when in the outdoor environment, so residual effects must be considered. This limits the number and type of pesticides that are available for such applications. These products are highly regulated.

Why Use Integrated Pest Management (IPM)?

Effective Integrated Pest Management programs have successfully reduced unnecessary pesticide applications as well as the total number of

IPM recognizes that pesticides have a role in pest control strategies, but they are not the only pest control option, and should only be used when other options are not effective.

An effective Integrated Pest Management (IPM) program will help reduce pest resistance, pest resurgence and secondary pest outbreaks.

applications made 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, including pest resurgence, secondary outbreaks and pesticide resistance.

Pest Resistance: When a pesticide is effective against a pest or group of pests, it may be overused. Under these circumstances, the pest population may become resistant to the specific pesticide or pesticides with similar modes of action. This happens because naturally resistant individuals who survive the pesticide application may pass the resistance on to their offspring. The resistant offspring survive while the nonresistant offspring 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 frequencies, which in turn leads to increased resistance and increased environmental hazards due to overapplication of pesticides. Currently, hundreds of pests 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 often found 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 natural enemies may be few in number, when they are present they help to control a certain percentage of the pest population. If the existing natural enemies are destroyed by pesticides, you lose this benefit. Following a pesticide application, pest populations have the ability to rebound much more rapidly than their predators, particularly those with multiple generations per year. Their numbers may quickly outdistance the ability of the predators to help control them. The pest population may quickly increase to greater numbers than before the pesticide application was made. Pest resurgence can result in a "pesticide treadmill," which occurs when applications of pesticides are followed by pest resurgence, followed by pesticide applications made at a higher rate, followed by pest resurgence, and so on. This pattern adds to pesticide resistance problems.

Secondary Pest Outbreaks: An organism that usually does little damage when 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, such as carbaryl, organophosphates or acephate, are used for the control of aphids or coddling moth on apple trees. Along with a decrease in the targeted pest population, there is a decrease in the natural enemies of mites and consequently a serious increase in the mite population. 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. The mites existed before, but were being kept in check by natural enemies. The broad spectrum pesticide releases the secondary pest from control by their natural enemies and allows them to become dominant pests.

Conclusion

Ideally, an Integrated Pest Management program considers all available pest control actions, including *no action*. IPM 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.

Ideally, an Integrated Pest Management program considers all available pest control options, including no action.

Unless otherwise noted, all line drawings are from Clipart ETC, Florida's Educational Technology Clearinghouse, University of South Florida, http://etc.usf.edu/clipart/index.htm.

Originally published in 1987 as Integrated Pest Management, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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General Knowledge: General Pest Problems

General Pest Problems Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the steps in managing a pest problem.**
- ✓ **List abiotic and biotic primary causal agents of plant diseases.**
- ✓ **Describe the primary biotic causal agents of plant disease.**
- ✓ **Describe plant disease management principles and control measures.**
- ✓ **Explain the three components of the plant disease triangle.**
- ✓ **Provide examples of invertebrate pests.**
- ✓ **Describe the two life cycles of insects.**
- ✓ **List and describe the three plant life cycles.**
- ✓ **Define weed management strategies.**
- ✓ **Describe vertebrate pest control practices.**

General Pest Problems

General pest problems fall into four main groups of pests:

- Disease agents or pathogens
- Invertebrate pests, such as insects, arachnids, mollusks and other animals without a backbone
- Plant pests (weeds)
- Vertebrate pests (animals with a backbone)

Certified applicators must have a basic understanding of these four general pest groups. More information about these pest groups can be found in the individual category chapters, which are more specific to pests encountered in the specific sites.

Four groups of pests:

- **Diseases/pathogens**
- **Invertebrates**
- **Weeds**
- **Vertebrates**

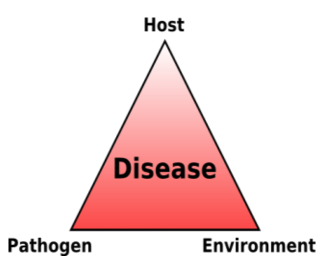
The first step in pest control is proper identification of the pest.

There are two broad categories of primary causal agents: Biotic, or living organisms, and abiotic, or non-living factors.

If the cause is abiotic, modify behavior or cultural practices accordingly.

If the cause is biotic:

- **Identify the pest**
- **Learn the pest's life cycle**
- **Formulate a pest management plan.**



The plant disease triangle

Pest Identification

The first step in effective pest control is proper identification of the pest. Many times, what we observe is the damage caused by a pest, not the pest itself. It is imperative to determine if the damage you see was actually caused by a pest (disease, plant, or animal) or by an abiotic causal agent. Abiotic causal agents are non-living climatic or cultural factors that can affect the growth or life of a plant or animal.

The next step is to learn about the pest's life cycle, and in some cases, its behavior. You can use this information to formulate a pest control plan that will control the pest and be cost- and time-effective. Misidentification or lack of information about a pest can lead to choosing the wrong pest control method or applying the control at the wrong time in a pest's life cycle. This wastes time and money and can allow the pest problem to increase rather than decrease.

There are many resources available to help you identify pests. The Nevada Department of Agriculture and the University of Nevada Cooperative Extension can help in pest identification. Go to www.manageNVpests.info for more information. Many books contain pictures and descriptions of plant diseases, insect pests, weeds and vertebrate pest damage. There is a limit to the amount of information they contain, so it is best to consult sources specific to your geographic area. There is great variability in Nevada's climate. Plants and animals found in southern Nevada can be much different than those in northern Nevada. Not all pests that occur in the Las Vegas area occur at Lake Tahoe, and vice-versa. There is a wealth of information available on pest identification on the Internet, but use caution and only trust information from reputable sources.

Plant Disease

Plant disease is can be thought of as the interaction of three separate factors: a susceptible host plant, a conducive environment for the disease organism, and the presence of the disease organism or pathogen, as illustrated in the plant disease triangle to the left. A plant is considered 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 pathogen) 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 functioning of ornamentals.

The primary causal agents of plant disease occur in two major groups: biotic, or living organisms, and abiotic, or non-living factors.

Biotic primary causal agents are plant pathogens and include:

- Viruses (viroids and virons)
- Phytoplasmas (formerly called Mycoplasma-like organisms)
- Bacteria
- Fungi
- Nematodes
- Parasitic higher order (seed producing) plants

Abiotic primary causal agents are non-infectious agents and include:

- Air pollutants
  - O_3 or ozone
  - SO_2 or sulfur dioxide
  - PAN or peroxyacylnitrate compounds
- Temperature (too high or too low)
- Water (too little or too much)
- Nutrients (deficiencies or excesses)
- Chemical inputs (road salts, excessive or misapplied pesticides, etc.)
- Light (too little or too much)
- Soil issues (compaction, soil texture, poor soil structure, etc.)
- Unintentional mechanical injury (weed whacker or lawn mower injury, etc.)

Abiotic factors can cause disease-like symptoms.

Diseases and pathogens are some of the most frustrating pests to identify. Most of the time, these pests are not visible to the naked eye. Identification of these types of pests requires the use of a microscope or special tests to identify their presence. Careful analysis of damage can be very helpful in identifying the pest. Keep in mind that the damage from a pathogen or disease may be different for different species of infected plants or animals. For example, bacteria in the genus *Erwinia* manifests itself as fire blight in pear and apple trees, Stewart's wilt in corn, and a soft rot of fleshy vegetables. The symptoms of many different diseases are also similar, making identification of the cause of disease difficult.

Plant Pathogens:

Plant pathogens (biotic causal agents) are generally subdivided into the following groups:

- **Viruses (viroids and virons):** These are the smallest of the microscopic pathogens and are not always visible even with a microscope. Viruses reproduce within the plant and may cause strange plant forms, structures or even colors. Viruses can be easily spread from one plant to

Vector: A plant or animal that spreads a disease or pathogen but does not directly cause the disease or pathogen.

Vectors of plant pathogens are usually insects, and disease management is achieved through control or management of the insect vector.

another by vectors. A vector is a plant or animal that spreads a pathogen or disease, but does not cause the pathogen or disease directly. For example, many insects, such as aphids, scales or leafhoppers, will spread a virus as they move from plant to plant while feeding. Even humans can be vectors of a virus. Smokers who touch diseased plant materials (tobacco) can spread the tobacco mosaic virus to susceptible plants they touch. Vectors of plant pathogens are usually insects, and management of the disease is achieved through control or management of the insect vector. Viruses can infect the plant's seed and be passed on to the next generation of plants. Viruses move throughout the plant, affecting and changing its normal metabolism and physiology. The symptoms commonly exhibited by plants with a viral infection are mosaics (light-colored patches or spots with in the green areas of leaves or on fruit), ring spots, leaf curling, leaf rolling, tumors, stem pitting, malformation of plant parts, and overall stunting and reduced growth rates.

- **Phytoplasmas (formerly called Mycoplasma-like organisms):** These microscopic organisms are similar in size to bacteria. Like viruses, they are transferred via a vector from plant to plant, most commonly by an insect. In plants, they tend to invade the food-conducting tissues, which can disrupt normal plant functions. Symptoms of phytoplasma infection or disease are yellowing, leaf curl, twisting of stems and progressive weakening of the plant. These symptoms are similar to virus symptoms.
- **Bacteria:** A microscopic single-celled pathogen that infects plants through natural openings or wounds and rapidly multiplies, forming a bacterial colony. Bacteria can be spread by splashing water and rain, by contaminated tools or clothing (boots, etc.), by contaminated soil or plant debris, or by contaminated transplanted plants. Bacteria can remain dormant for many months in the soil, in plant debris and even within insects that later spread the bacteria when they chew on susceptible plants. Common symptoms of bacterial infection are soft rots of fruits, roots and other storage organs in plants, scabs, vascular wilts, galls and cankers on stems and tree trunks. Some of the most common symptoms are spots on leaves, stems, blossoms and fruits. When these disease symptoms appear rapidly, the disease is often referred to as "blight."
- **Fungi:** Fungi (the plural of fungus) are the largest group of plant pathogens. Almost all plants have some level of susceptibility to fungal infections, and most disease-causing fungi have a wide range of plants they can infect. Once fungi enter plant tissues, they can grow rapidly, producing toxins and enzymes that disrupt normal plant growth and functions. Individual fungi generally grow as fine, thread-like,

microscopic structures called hyphae. The hyphae can form a network, which is called a mycelium. The mycelium can be macroscopic, (visible with the naked eye.) Fungi also form fruiting structures, of which the most commonly recognized are mushrooms. Fungi reproduce by forming spores. Spores are easily spread by wind, water, soil, insects, animals and even humans to provide rapid infection once an infestation is established. Some common fungal infection symptoms are similar to bacterial infection symptoms, such as blights, cankers, galls, leaf spots, leaf curl, root rot, scabs and soft rot. Some symptoms are only found in fungal infections, such as damping off, mold, rusts, smuts, and downy, sooty, or powdery mildew.

- **Nematodes:** These are multi-celled, non-segmented roundworms that are generally not visible with the naked eye. Nematodes have a piercing mouthpart known as a stylet, which they use to pierce plant tissues and secrete an enzyme that digests nutrients stored in the roots or other plant parts. The nematodes then suck up these nutrients. Most nematodes attack plant roots, but some target above-ground plant parts. Generally, nematodes do not kill the host plant, but they weaken it and also cause a wound that acts as an entry for other pathogenic diseases. Nematodes may also act as vectors of diseases, transferring them from one plant to another as they feed. Nematodes can survive for a year or more in the soil as eggs or cysts, waiting for a susceptible host plant to grow. Some common nematode infestation symptoms include root galls, root knots, root lesions, excessive root branching and injured root tips. Nematode infestation decrease the ability of plant roots to take in water and nutrients, resulting in above-ground symptoms of wilting, general stunting, yellowing and distortion of the entire plant. Nematodes can be spread by transfer of infested soils or plant parts.
- **Parasitic higher plants (seed-producing):** These plants cannot produce their own chlorophyll, which means they cannot produce their own food. Through various adaptations, these plants pierce or penetrate the host plant and remove water and nutrients for their own use. The parasitized host plants are weakened and eventually die. These parasitic plants are visible to the naked eye. Dodder, mistletoe and broomrape are the most common parasitic plants in Nevada, and dodder is responsible for the most economic damage of the three. These parasitic plants are spread by animals, contaminated soil and contaminated seed. The seeds from these plants can remain viable in the soil for a number of years, awaiting a susceptible host.

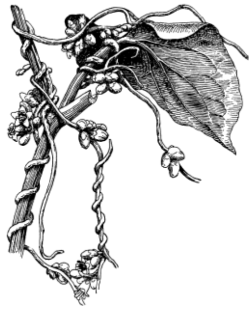
Much of plant disease diagnosis is based upon recognizing the characteristic symptoms that plants express as a result of their abnormal physiology. There are three general types of plant disease symptoms:

Fungi are the largest group of plant pathogens.

Almost all plants have some susceptibility to fungal infections.

Most disease-causing fungi have a wide range of plants they can infect.

Generally nematodes do not kill the host plant, but they weaken the plant and the wounds they cause can provide an entry for pathogens or disease.



Dodder

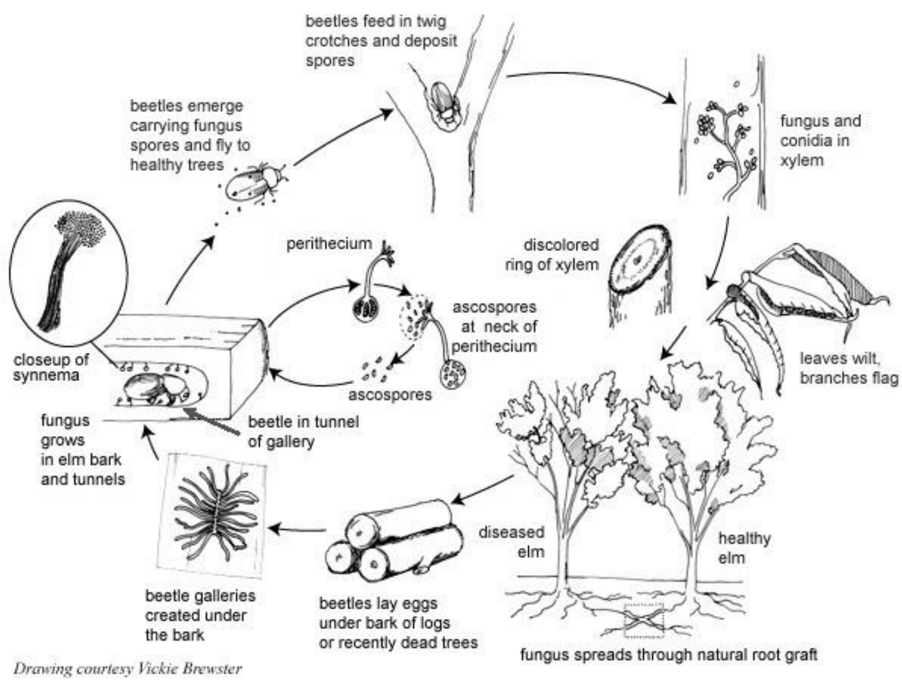
Necrosis: The dead or dying portions of a plant.

Hypoplasia: Stunting of all or specific plant parts.

Hyperplasia: over development of specific plant parts.

- **Necrosis:** Necrotic symptoms are the most common and include dead or dying cells or tissues. Both biotic and abiotic primary causal agents can cause necrotic symptoms to develop in diseased host plants.
- **Hypoplasia:** Hypoplastic symptoms include 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 leaves, short internodes).
- **Hyperplasia:** Hyperplastic symptoms include the over-development of some plant part or process. In many cases, this over-development is caused by abnormal cellular division and/or enlargement and is detrimental to the host plant (galls, canker).

Specific requirements must be met before a 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, humidity, 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 evidence of the pathogen (biotic primary causal agent) that include structures such as mushrooms, conks, bacterial ooze, etc.



Dutch Elm Disease Cycle, APS.net

Plant diseases occur in cyclic fashion depending upon the environment. The sequence of events that develop in plant disease are 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 small population and often can be controlled. 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, such as fungus spores, bacterial cells, etc., are produced from the overwintering stages and are spread by wind, water, insects, man, equipment, etc. onto 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 occurs often give good levels of control. If infection occurs, the pathogen proceeds to colonize the host and reproduce in large numbers. This results in inoculum for secondary disease cycles. 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 an epidemic or epiphytotic development. As energy supplies for the pathogen dwindle and/or the environment no longer supports disease development, the pathogen produces over-wintering structures and the disease cycle is completed.

Infection courts: The place where infection may take place. A plant part, wound, etc.

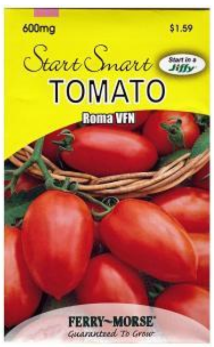
Plant disease management, like most pest management, is based on several important principles. A basic understanding of control principals is necessary in managing plant diseases. The following principals were first described in 1929 and are still used today. Disease control is often not practical or even possible. However, it is possible to reduce the progress of plant disease and keep it at an acceptable level.

Plant disease management principles:

- **Exclusion**
- **Eradication**
- **Protection**
- **Resistance**
- **Therapy**
- **Avoidance**

- **Exclusion:** For plant disease management, exclusion consists of practices designed to keep pathogens, vectors and infected plants out of disease-free areas. The goal of this method of management is to prevent the disease from entering the area where the plants are growing. Plant only disease-free stock. Another method for this type of plant disease management is to establish plants in areas where the pathogen does not occur.
- **Eradication:** For plant disease management, eradication consists of eliminating, destroying or inactivating the pathogen after it has become established. This includes destruction of infected plants, disinfection of storage bins, containers and equipment, and soil disinfection by fumigation, pasteurization, or drenching. Most people recognize that

Row covers
www.msu.edu



Disease resistant tomato seeds
Ferry-Morse.com

Successful plant disease management considers all the potential control methods:
- **Prevention**
- **Cultural**
- **Physical/ mechanical**
- **Biological**
- **Chemical**

absolute eradication is not always possible or economically feasible, so this control method also includes reduction of the pathogen to an acceptable level. Reducing the infestation involves cultural practices such as sanitation, removing diseased plants or plant parts, rotating crops, eliminating weeds or other plants that may be alternate hosts for the disease, and discouraging or preventing insect vectors.

- **Protection**: For plant disease management, protection establishes a chemical or physical barrier between the host and the primary causal agent. There are chemical applications that prevent disease from becoming established, such as fungicidal dusts and nematicides (nematode controls). Row covers that exclude vector insects (see picture to the left), fences and other physical barriers also provide protection from pests.
- **Resistance:** For plant disease management, this method of control consists of planting resistant varieties. Resistance is achieved by altering the genetic system of the host to make it less susceptible to the pathogen. The tomato packet to the right, Roma VFN, is a strain of tomato developed to be resistant to verticillium and fusarium wilt as well as nematodes. 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 used in the development of crop plants. There are many trees, shrubs, and ornamental and vegetable crops with resistant varieties on the market.
- **Therapy:** This method of plant disease management 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.
- **Avoidance:** This method of plant disease management consists of cultural practices that help avoid the potential for infection. Practices such as planting date selection, seedbed preparation and water management are cultural practices that will help avoid disease. Poorly drained soils, shade and other factors can increase the susceptibility of plants to disease. Choose plant placement wisely or remove and replace problem area plants with better-adapted species. Provide adequate irrigation, fertilization and plant spacing. Handle plants carefully to prevent injury, as the injury may later be the access point for a disease.

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

1. Timely and accurate disease identification
2. Consideration of all potential control methods:
   a. physical/mechanical
   b. cultural
   c. biological
   d. chemical
3. Recognition and evaluation of the potential benefits and risks associated with the disease and its management
4. Selection of the most effective, economical and safe methods of control
5. Ensuring the proper use of materials or methods
6. Knowing and following 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. Please review Guidelines for the Safe Use of Pesticides in this manual for more information on pesticide modes of action and formulations.

Invertebrate Pests

Invertebrate pests are those animals without a backbone. They include insects, arachnids (spiders, ticks and mites), and, to a lesser extent in Nevada, mollusks. The most important of these groups are the insects.

As a group, insects are the most successful animals to have evolved. They have been on earth for more than 300 million years, and many species are relatively unchanged from their prehistoric ancestors. 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 and adaptable as a group. This adaptability has led 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.

Insects 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 numbers 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 (predators and parasites) and decomposers. Less than five percent of all the insect species are pests at one time or another in

Invertebrate pests have no backbone and include insects, spiders, snails and slugs.

Current estimates suggest there are more than 11 million insect species in the world and 25,000 species in Nevada.

Insects are an essential part of any ecosystem.

Less than 5% of all insect species are "pests."

Pest populations must be regularly monitored.

Keeping records of pest observations may aid in predicting and preventing future outbreaks.

Pest Thresholds:

Economic: Point at which a pest infestation causes enough economic damage to justify the cost of treatment.

Aesthetic: Point at which the infestation causes enough visual damage to the landscape to justify treatment.

Emotional: Point at which the pest infestation causes enough emotional trauma to justify treatment.

their life cycle.

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 individuals of the previous generation to three or four percent. Causes of insect outbreaks can be divided into five general areas:

- Introduction of a pest into an area with few natural suppression factors (Gypsy moth, invasive weeds).
- Previous use of a chemical to control another pest and subsequent loss of predators and parasites.
- Weather that favors a pest while suppressing its predators and parasites.
- Planting of monocultures of host plants (typical of U.S. agriculture).
- Overuse of a pesticide product leading to 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 passively (baits, lures, pheromones, light, etc.) and actively (sweep nets and visual observations). Accurate records of pest observations can lead to predictions 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, at which point the landscape looks unthrifty and the aesthetic threshold has been reached. Emotionally, some people's tolerance for a cockroach or spider in their kitchen is zero.

As stated previously, it is imperative to identify the pest and ensure that the "pest" is causing the damage observed. Once you have identified that the observed problems are indeed pest-caused and you have identified the specific pest causing the observed problems, the next step is to learn the pest's life cycle, growth cycle and reproductive habits. Use this information to formulate a pest control plan that will control the pest and be cost- and time-effective.

Insect or other invertebrate pest identification is aided by handbooks, field guides and a wealth of information on the Internet. Many books and field guides are of limited scope and may be either too general or too specific to a particular geographic area or land-use type. Make sure the source of information, printed or from the Internet, is reliable. For more accurate identification of the insect, help is available from both the University of Nevada Cooperative Extension and the Nevada Department of Agriculture.

Basic Insect Identification

Insects belong to the Animal Kingdom and are classified in the Phylum Arthropoda. All animals in this phylum have the following characteristics:

- Segmented bodies, with 2 or 3 distinct body regions
- Paired and segmented appendages
- External skeleton of chitin
- Ventral nerve cord
- Open circulatory system, as opposed to a system with enclosed veins and arteries as found in mammals, including humans

Differences between insects and other classes of Arthropods:

<u>Crustaceans</u>

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

<u>Millipedes (Diplopoda)</u>

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

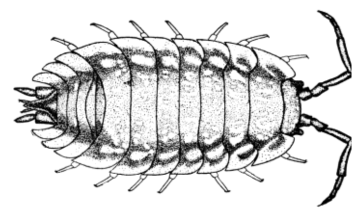
<u>Centipedes (Chilopoda)</u>

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

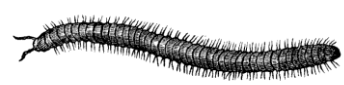
<u>Arachnids</u>

- Araneae are spiders, Acari are mites, Scorpiones are scorpions, Solifugae are wind scorpions, Opiliones are harvestmen or daddy longlegs
- Two body parts
- Four pairs of legs
- No antennae
- No wings

Visit http://www.manageNVpests.info for photo gallery of insect pests and beneficial insects



Crustaceans

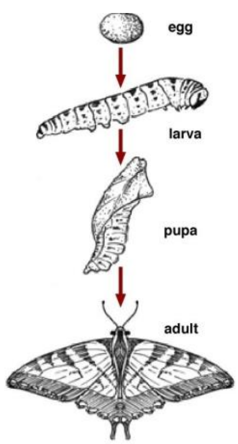


Millipedes

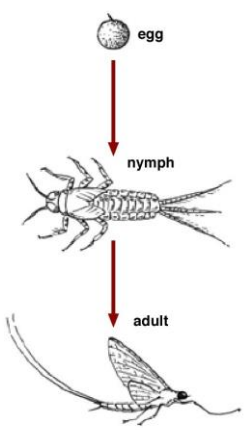
Centipedes

Arachnids

Typical insect



Complete metamorphosis
egg, larva, pupa, adult
UNCE



Incomplete metamorphosis
egg, nymph, adult
UNCE

Insects (Insecta)

- Three body regions, composed of head, thorax and abdomen
- Three pairs of legs
- One pair of antennae
- Often have wings in the adult stage; usually two pair, although a few insects, such as flies, have one pair
- Classes are further divided into orders

Class Insecta (all insects)

The class Insecta is currently divided into 31 orders. This is based on differences such as types of mouthparts (chewing and sucking being the most common); presence, absence and number of wings; wing structure; type of life cycle; and presence of social forms. We will only discuss those orders that contain common insect pests.

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 life cycle. Insects can be divided into two basic groups, based on their life cycle: complete metamorphosis and incomplete or simple metamorphosis. Complete metamorphosis consists of a life cycle of egg-larva-pupa-adult. These insects look very different from the larval to adult stages. Common insects exhibiting complete metamorphosis include butterflies, moths, flies, bees, wasps, ants and mosquitoes.

Incomplete metamorphosis is also referred to as gradual or simple metamorphosis, and consists of a life cycle of egg-nymph-adult. The nymph stage looks similar to the adult stage, but is generally smaller and without wings. Many insects with an incomplete metamorphosis life cycle grow through several nymph stages, called instars, until finally becoming adults, hence the name “gradual metamorphosis.” Common insects exhibiting incomplete metamorphosis include grasshoppers, crickets, termites, cockroaches, aphids and true bugs.

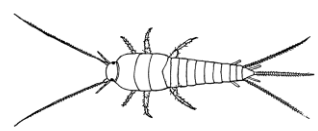
Many insects are only pests during certain stages of their life and often may only be effectively controlled in one or two stages of their life cycles. How they feed may also affect the control measure selected. Without this knowledge, much effort, time and money may be wasted on ineffective control.

Table 6. Distinguishing characteristics of insects among orders

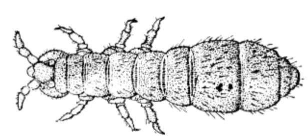
Order	Mouthparts	Life Cycle	Wings
Thysanura	chewing	incomplete	none
Collembola	chewing	incomplete	none
Dermaptera 2pr	chewing	incomplete	none,
Isoptera	chewing	incomplete	2 pr
Othoptera	chewing	incomplete	2pr
Mallophaga	chewing	incomplete	none
Anaplura	sucking	incomplete	none
Thysanoptera none	rasping	incomplete	2pr,
Hemiptera	sucking	incomplete	2pr
Blattodae (Blattaria)	chewing	incomplete	2 pr
Homoptera	sucking	incomplete	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

<u>**Insect Orders**</u>

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

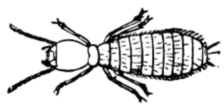


Collembola: Springfoils make up this order. Small, wingless insects without compound eyes, these insects go through a simple life cycle. They get around using a tail-like structure that folds beneath their body and propels them. They habit moist areas and may be a nuisance in homes. Only one is known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

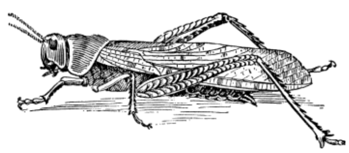


Dermaptera: The earwigs make up this order. They have long slender bodies with or without wings that end in

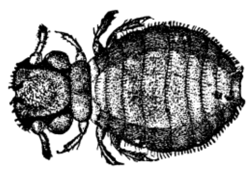
pincer-like cerci. A nuisance pest in homes, they are a minor pest in vegetable and ornamental gardens.



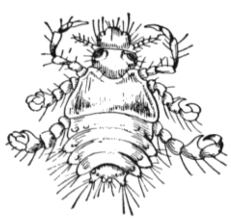
Isoptera: Termites have a broad juncture at the abdomen and thorax, two pairs of similar-sized and -shaped, membranous wings and moniliform (string of beads) antennae. They are pests of wood and require cellulose from wood or other plant tissue for food. They are social insects.



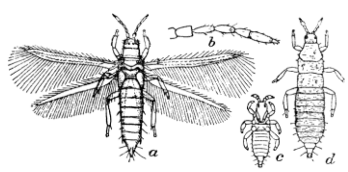
Orthoptera: This order contains the grasshoppers, crickets, praying mantis and walking sticks. Their life cycle is simple. They have strong chewing mouthparts. Their rear wings are membranous and are covered and protected by the front pair. Most are large insects and many are pests.



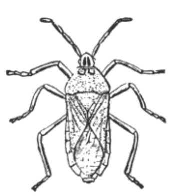
Mallophaga: Chewing lice. Small, wingless, chewing insects, the chewing lice have a simple life cycle spent entirely on the host. The head is wider than the thorax. Most attack birds, domestic fowl and mammals as ectoparasites (external parasites), but not humans.



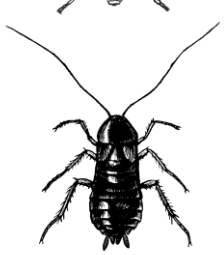
Anaplura: Sucking lice. These small ectoparasites suck blood from mammals, are wingless, and their long, pointed heads are narrower than their thorax. The life cycle of sucking lice is simple. These insects irritate livestock, reducing their vitality. They also transmit diseases to animals and humans.



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.



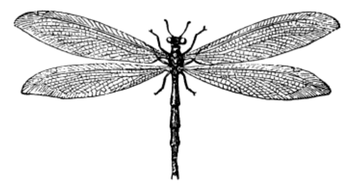
Hemiptera: This order contains the true bugs. They can be recognized by the X formed by the wings. This order includes both pests and beneficial insects. They have piercing-sucking mouthparts and a simple life cycle. These include box elder bugs, leaf footed bugs, stink bugs, assassin bugs, big-eyed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



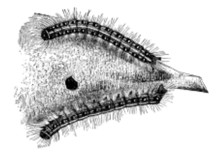
Blattodae: Cockroach family. Cockroaches have an oval brown to black body, two pairs of membranous wings, if present, and long antennae. Their head is bowed down and covered with a pronotum. They run rapidly and hide from light.

Homoptera: Includes 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 such as viruses and phytoplasmas.

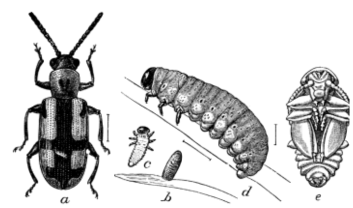
Neuroptera: Antlions and lacewings are in this order. Most of the members of this order are predacious. The adults have wings that have numerous veins, giving them a net-like appearance. Larvae can be destructive. They have chewing mouthparts. They have complete life cycles and many are important aquatic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



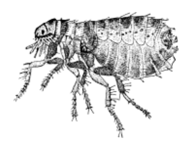
Lepidoptera: This order contains moths and butterflies. The major characteristic of the adults of this group are the scale-covered wings. They have a long tube-like mouthpart for sucking or siphoning, two pairs of wings, and they go through complete metamorphosis. Many serious pests occur in this order.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



Coleoptera: 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.

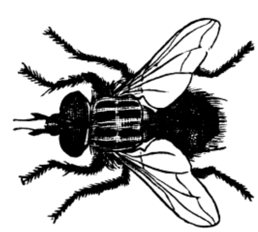


Siphonaptera: This order contains fleas, which are brown, flattened, wingless insects with jumping legs and reaching mouthparts. They have a complete life cycle and are vectors of diseases such as bubonic plague and typhus.



Hymenoptera: This order contains ants, bees, wasps and sawflies. While the order contains many beneficial insects, 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 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.



Integrated Pest Management (IPM) control methods:

- **Prevention**
- **Cultural**
- **Mechanical/ physical**
- **Biological**
- **Chemical**

Trap crops are crops specifically planted to attract pests away from the economic crops or desired plants.

Chemical insect control:
READ THE LABEL

- **Is the insect listed on the label?**
- **Is the site listed on the label?**
- **Is the plant or crop (or animal) listed on the label?**

Insect control strategies

Most effective insect control management plans include one or more control strategies. Using the Integrated Pest Management (IPM) control categories, insect control can be split into five separate categories.

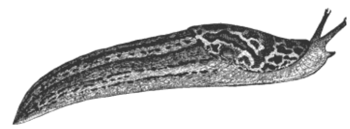
- **Prevention:** Prevention includes such practices as using certified pest-free seed, transplants, amendments and mulches. Prevention also includes removing insect pests before they can lay eggs or become a vector for disease.
- **Cultural controls:** Cultural controls are management practices that reduce the incidence of insect infestations, such as proper planting times and planting rates, planting companion crops, managing fertilization and irrigation to favor desired plants and not insect pests, rotating crops, and planting cover crops or trap crops. Good sanitation, including manure management plans, will help reduce insect pest infestations, such as cockroaches and flies. Changing the environment to discourage insect pests by controlling temperature, light or humidity is another cultural control method.
- **Mechanical/Physical controls:** These are controls such as hand picking the insects and the use of barriers, such as row covers. It also involves using mechanical devices that disrupt the soil and make conditions unsuitable for the survival of insect pests. Other mechanical controls include installing physical barriers, such as window screens and sealing cracks, to exclude insect pests, or trapping insect pests (for instance, with sticky traps).
- **Biological controls:** Biological control is the use of a living organism to control insect pests. Success depends upon selectivity, reproduction, adaptation, and ability of the organism to reach a high level of effectiveness. Predator or parasitic insects that target other insects are a good example. Generally, biological controls will not eradicate the pest, but they will help reduce the pest population to a manageable level. Care must be used to avoid damaging the biological control by using an incompatible chemical control.
- **Chemical controls:** Chemical control is the use of pesticides (insecticides) against a target pest (insect). Many insecticides are available. Know how they are used and how they work before you apply them.
    - Selective insecticides: chemicals that kill a specific insect pest or target a specific life cycle of the pest.
    - Nonselective insecticides: chemicals that kill all insects, pest or beneficial.
    - Contact insecticides: chemicals that kill the insect pest only

where the chemical touches the pest or a site the pest frequents. They require thorough coverage and are quick- acting, but they must contact the pest to be effective.

- Systemic insecticides: chemicals that are absorbed by the plant or animal the insects are targeting. When the insects feed on the plant or animal, they ingest the insecticide and die. They take time to be effective and may be soil or foliar applied for plants and ingested or applied as a surface treatment for animals.

Phyllum Mollusca (Mollusks)

Mollusks are a large group of invertebrates that include snails, slugs, clams, mussels, and many other animals. While slugs and snails are often pest species in wet and humid areas, they pose a little to no risk in Nevada due to the dry climate.



Slug

Quagga and zebra mussels are freshwater aquatic mollusks native to the Black and Caspian Sea. Both species were first detected in the Great Lakes in the late 1980s. It is believed that the mussels were introduced to North America in ballast discharge water from transoceanic ships. Quagga mussels were detected in Lake Mead in 2007. As of 2017, neither species has been detected in Lake Tahoe. Efforts are underway to prevent their spread to Tahoe and other waterways in Nevada. In 2011 the Nevada Legislature passed Assembly Bill 167, requiring an Aquatic Invasive Species (AIS) decal for all motorized and non-motorized vessels capable of retaining water, such as canoes and kayaks. Paddleboards and float tubes are exempt. Go to http://www.ndow.org/uploadedFiles/ndoworg/Content/Wildlife_Education/Publications/AIS-Decal-Brochure.pdf for more information

Mussels

Both species are prolific filter feeders that reduce the microscopic plants and animals which form the base of the food web, ultimately disrupting the ecological balance of entire water bodies. In addition, both species are capable of displacing native mollusk species.

Quagga and zebra mussels attach to surfaces like piers, pilings, water intakes and fish screens. Intake structures become clogged, reducing water flow to municipalities and power plants. The mussels colonize hulls, engines and other parts of watercraft, which negatively impacts recreational boating. Boats and other watercraft are the primary route by which quagga and zebra mussels are moved from infested areas to uninfested areas.

It is important to drain watercraft immediately after leaving a water body to prevent runoff that could contain quagga and zebra mussels from reaching storm drains and uninfested water bodies. Many water bodies now have either voluntary or mandatory “clean, drain and dry” orders for watercraft to prevent the spread of these invasive pests.

A weed is a plant growing where it is not wanted.

Noxious weeds are those plants designated by law as requiring control.

For the latest noxious weed listing, go to http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/.

Sources for Weed Identification:

Nevada Noxious Weed Field Guide, http://www.unce.unr.edu/publications/files/nr/2010/sp1001.pdf

Nevada Nuisance Weed Field Guide, https://www.unce.unr.edu/publications/files/ho/2018/sp1802.pdf.

Weeds are:

- **Competitive**
- **Persistent**
- **Harmful**

Weeds

The term "weed" is an arbitrary word. Basically a weed is a plant growing where it is not wanted, or a plant out of place. A rose bush in a wheat field could be considered a weed, while the same rose bush in an ornamental garden would be considered beneficial and desirable. Generally weeds are plants that are in direct conflict with the well-being of humans and their activities.

The term "noxious weed" is applied to a plant defined by law as being particularly troublesome, undesirable and difficult to control. This legal designation also requires control of the weed. On public lands, the responsibility falls to a government entity. On private land, control of noxious weeds falls to the property owner. Property owners are legally responsible for removing noxious weeds from their property and for preventing the spread of noxious weeds to adjacent properties.

All weeds share common characteristics.

- **Competitive:** They are competitive, growing in spite of interference from other plants. They successfully compete with the native vegetation for water, nutrients, light and space. Many noxious weeds are not native plants, but were introduced from another continent (Asia, Europe, etc.). They may not have any natural enemies, such as animals, insects or diseases that prey on them and keep them in check, as they do in their native land. As a result, they can outcompete the native plants, invading into new areas.
- **Persistent**: Weeds are very skilled at spreading and multiplying, whether through seed production or by spreading by roots and shoots (vegetatively). Many noxious weeds can spread both by seed and vegetatively, so they persist and spread year after year, gradually choking out the native plants and forming a monoculture (single species) plant community. Weeds may also form seeds that are easily spread. Barbs, prickles or sticky surfaces on seeds adhere to animals, allowing them to be transported long distances. Other seeds have adaptations that allow them to be easily transported by wind or water. Weed seeds can remain viable in the soil seed bank for tens to hundreds of years, awaiting the right conditions to sprout and begin spreading.
- **Harmful**: Weeds can be economically undesirable as well as aesthetically unpleasing. In addition to reducing crop and pasture production, they can choke waterways, ruin recreational lands, reduce native forage for livestock and wildlife, and reduce the value of both residential and commercial lands.

Stages of Plant Development

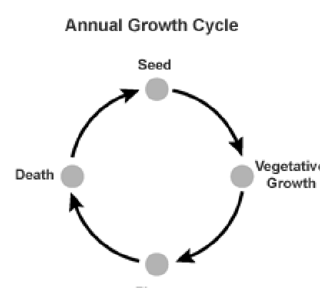
Weeds have the same needs as all plants: light, water, nutrients and space. Like most plants, weeds go through four stages of plant development:

- **Seedling:** At this stage the plant is small and vulnerable. The water and nutrient requirements are small. The roots are very small and not very deep. The leaves are small and not very thick or tough. Many seedling leaves have not yet developed hairs, waxy coatings or any other protection. This is the best time to control a weed: they are small and the roots and leaves are tender. They are easy to pull or hoe. They require little chemical to kill.
- **Vegetative:** At this stage, the plant is growing up. The uptake of water and nutrients is rapid. The plant develops vigorous roots, stems and leaves. Control is more difficult at this stage.
- **Reproductive:** This is the stage where the plant flowers and produces seed or fruit. At this stage, most of the plant energy is directed toward fruit and seed development.
- **Maturity (death or dormancy):** At this stage, the plant is mature, it has formed seed and it either dies or goes dormant for the winter. The plant has little or no water and nutrient uptake and produces little energy. The plant "dries down."

Most plants go through these four stages of development. The time it takes them to do so is another way plants are subdivided.

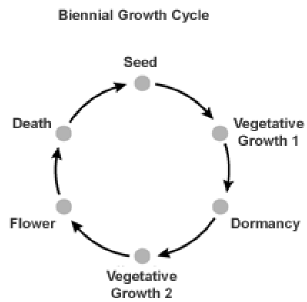
Seedling

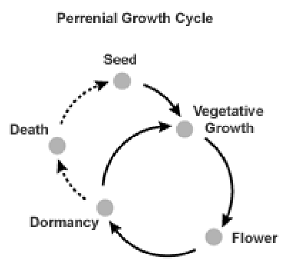
Mature plant



Plant Life Cycles

- **Annuals** are those plants that go through all four stages of growth in one year, hence the name annual. That is, they germinate, form a seedling, grow, flower, form seed, mature, die and drop seed all in one growing season or year. Reproduction in annuals is entirely from seed. Annuals are often split into two categories: summer annuals and winter annuals.
  - Summer annuals: Germinate and grow in the spring, flower and produce seed in the summer and die in the fall. Examples are lambsquarters, foxtail, pigweed and crabgrass.
  - Winter annuals: Germinate and form a seedling in the fall. The seedling overwinters and begins growth in the early spring. In spring or summer, it flowers, forms seed and dies. Winter annuals are particularly competitive plants, since they start growing in the early spring before many other plants have germinated or started to grow. Examples are shepherd's-purse, mustards, cheatgrass and annual bluegrass.
- **Biennials** are those plants that take two growing seasons to go through all four stages of development.
  - First year, the seed germinates and forms a seedling. The





Cattails

seedling begins vegetative growth, with large root development and low-growing leaves (a rosette).
    - Second year, the plant continues vegetative growth, flowers, produces seed and dies.
    - A cold winter period is necessary to complete life cycle.
    - Examples are wild carrot, mullein and bull thistle.
- **Perennial** plants live more than two years. They may go through all four stages in the first year and then through vegetative, seed set and maturity stages each year thereafter. They can spread through seed production and vegetatively by roots and rhizomes (underground stems). Obviously, plants that can reproduce by so many methods can be very competitive and more difficult to control. Most noxious, invasive weeds are perennial plants.
    - Simple perennials are those that reproduce by seed and pieces of roots. Examples are dandelion, plantain, and trees.
    - Bulbous perennials are those that produce seed, bulblets and bulbs. Examples are wild onion and wild garlic.
    - Creeping perennials are those that reproduce by seeds, rhizomes or stolons, or creeping roots. Examples are Johnsongrass, Bermuda grass and Canada thistle.

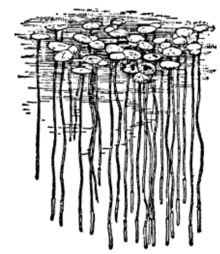
Plants can be classified, categorized or grouped using many different criteria. Life cycle is one classification method, as we just discussed. Plants can also be categorized by physiology, poisonous potential, or legal status. Habitat, or where the plants grow, is a logical way to subdivide plants that grow in Nevada.

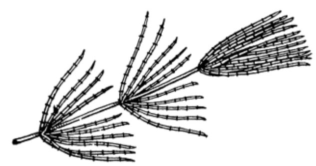
<u>Classification by Habitat</u>

- **Aquatic plants** are those that can survive submersed in water for all or most of the time. These plants have special adaptations that allow them to survive immersed in water. They are divided into two major groups: Vascular plants and algae.
    - **Vascular aquatic plants** have roots, stems and leaves. These plants are most often perennials.
        - Emergent plants are those that have most of the plant above the water surface. Examples are cattails, purple loosestrife, reeds and rushes.
        - Rooted floating plants are those that have all or part of the plant on the water surface while being rooted in the soil. An example is the water lily.
        - Free-floating plants are not rooted in the soil. They get their nutrients directly from the water. These plants are usually very small and have leaves and flowers on the

water's surface. An example is duckweed.
    - Submersed plants are those in which the entire plant is below the water surface. Examples are elodea and Eurasian watermilfoil.
  - **Algae** is the second group of aquatic plants. These plants have no true leaves or vascular systems. Algae plants do not have roots, stems, leaves or flowers. There are three main groups of algae:
    - Plankton-type algae are very small and can be microscopic. This is the type of algae that causes blooms of growth in waters, giving it a split-pea-soup appearance.
    - Filamentous algae have long, thin strands or strings that are attached to rocks or bottom sediments. It is sometimes referred to as moss or slime or even pond scum. Examples are *Cladophora* or *Spirogyra.*
    - Macroscopic algae, those that are visible to the naked eye, are attached to bottom but do not have roots. Examples are *Chara* and *Nitella*. *Chara* has a brittle texture and can be confused with vascular plants.
- **Terrestrial plants** are plants that grow on land. They can be further subdivided by climatic factors, water needs, etc. Terrestrial plants can be subdivided on the basis of botanic classification (see below.)


Water lily


Duckweed


Chara

<u>Botanic Classification of Terrestrial Plants</u>

- **Grasses:** These plants are monocots and have one seed leaf. They grow narrow, upright leaves. The leaves grow in pairs and have parallel veins. Grasses have fibrous roots. The growing points of the above-ground portion of the plants are covered or protected early in the life cycle. The low growing points allow grasses to be grazed or mowed without damaging the ability of the plant to grow. Grasses can be annuals or perennials.
- **Sedges:** These plants have triangular stems and three rows of leaves, which distinguishes them from grasses. They like wet places, but are not considered aquatic plants. Sedges are usually perennials.
- **Broadleaves:** These plants are dicots and have two seed leaves. They have broad leaves, as the name implies, and the leaves have net-like veins. Broadleaf plants generally have a coarse tap root. The growing points of broadleaf plants are at ends of stems and in the leaf axils. They also have growing points on roots and below-ground stems. They can be annuals, biennials or perennials.


Grass plant

Broadleaf plant

Chemical weed control:
READ THE LABEL

- **Is the weed listed on the label?**
- **Is the site listed on the label?**
- **Is the plant or crop listed on the label?**

Weed control strategies

Most effective weed control management plans include two or more control strategies. Weed control can be split into five separate categories.

- **Prevention:** Prevention includes such factors as using certified weed-free seed, hay, transplants, amendments and mulches. Cleaning equipment to prevent the spread of weed seed and weed plant parts from one area to another is another prevention tactic. Prevention also includes removing weeds before they can form seed heads or spread by other methods. It is more difficult to prevent weed seeds from blowing in from an adjoining property.
- **Cultural controls:** Cultural controls are management practices that reduce the incidence of weed infestations. Cultural controls include using proper planting times and planting rates, planting companion crops, managing fertilization and irrigation to favor desired plants rather than weeds, rotating crops and planting cover crops.
- **Mechanical/Physical controls:** These controls include tillage, hoeing, mowing, flooding, burning, hand-pulling, etc.
- **Biological controls:** Biological control is the use of a living organism to control a pest. Success depends upon selectivity, reproduction, adaptation, and ability of the organism to reach a high level of effectiveness. Some examples: the saltcedar leaf-eating beetle *Diorhabda carinulata*, Dyers woad rust fungus, grass carp, livestock that feed on weeds, etc.
- **Chemical controls:** Chemical control is the use of pesticides, in this case, herbicides, against a target pest (weeds). Many herbicides are available. Know how they are used and how they work before you apply them.
    - <u>Selective herbicides</u>: Chemicals that kill <u>specific</u> types of plants.
    - <u>Nonselective herbicides</u>: Chemicals that kill <u>all</u> types of plants.
    - <u>Contact herbicides</u>: 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.
    - <u>Systemic herbicides</u>: 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. Systemic herbicides are effective against most plants and are recommended for perennials. They take time to be effective and may be soil or foliage applied.
    - <u>Soil applied materials</u> may be selective or nonselective, depending upon the rate of application.

How Herbicides Work

The effectiveness of herbicides depends on a number of factors:

- **Herbicide uptake rate and quantity:** Herbicides are applied either to the soil, where they interact with the roots, or applied to the foliage of the plant (the aboveground stems, leaves, etc.)
    - Pesticide application rates influence the effectiveness of an herbicide application. Different weed species and stages of growth may require different rates for the product to be effective. Pesticide labels list the rate requirements. Read and follow them.
    - Equipment must be properly calibrated in order to deliver the proper amount of herbicide to the target plant.
    - Soil-applied materials generally dissolve in the soil water and enter the plant through the plant's roots. Pre-emergence herbicides are examples of soil-applied herbicides. They must be incorporated in the soil, either mechanically or by irrigation or precipitation. Applications are usually planned for a time of year when precipitation will serve to incorporate the herbicide prior to weed seed germination. Absorption of the herbicide takes place across the cell walls of the root hairs. The plant must be actively growing for this to occur, so non-germinating seeds are not affected by these herbicides. The soil must not be disturbed or the herbicide barrier will be disrupted and the soil-applied herbicide will not be effective.
    - Foliar-applied herbicides, also known as post-emergence herbicides, are applied to the aboveground portion of the plant. Thorough coverage is important. Plants produce natural barriers to herbicide uptake. The major barrier is the cuticle, a waxy covering found on all leaves. The thickness of this waxy coating varies for each plant species and can be thicker within the same species on plants growing in dry, hot climates. Many plants also have leaf hairs, which may keep spray droplets from reaching the leaf surface. Both leaf cuticle and leaf hairs can cause herbicides to bead up and run off or evaporate, reducing the effectiveness of the herbicide. The addition of wetting agents or oils can help the herbicide solution spread out, cover the foliage and penetrate the cuticle, but they add to the cost of the application. Often the wetting agents or oils are already included in the formulated product you purchase. If they are not included, follow label instructions when adding them.
    - Spray volume can alter the effectiveness of an herbicide application. Adjust the spray volume to minimize spray runoff or drift while maximizing coverage and penetrating the crop canopy.
    - The amount of foliage or shoot growth can affect the effectiveness

To prevent new weed infestations:

- **Plant certified weed-free seed.**
- **Restrict movement of contaminated mulch, bark, and other products.**
- **Clean vehicles and equipment.**
- **Do not move weed-infested soil, sand or gravel.**

To be effective, herbicides must reach a living site to disrupt a vital process or structure.

of an herbicide application. There must be enough foliage to intercept the spray application. For grasses, this generally means waiting until there are three to five blades. For broadleaf plants, it means waiting until the leaves are one-half inch to 1 inch in diameter.
    - Herbicides must remain in contact with the plant for a period of time in order to maximize absorption. Do not apply herbicides during the rain or when rain is expected. Time herbicide applications so they do not conflict with irrigation schedules.
- **Herbicide movement in the plant:** To be effective, herbicides must come in contact with the plant, be absorbed, and move through the plant to a location where they affect plant growth by disrupting a vital plant process. Herbicides are classified in a number of ways. The classification is based on how the herbicide moves through the plant, the type of plants the herbicide controls, the timing and location of the herbicide application and the metabolic activity in the plant that the herbicide affects. The total process is called the herbicide mode of action.
    - Selective herbicides: Chemicals that kill specific types of plants, such as grasses or broadleaf plants.
    - Nonselective herbicides: Chemicals that kill all types of plants.
    - Contact herbicides: These herbicides have little or no movement in plants. They kill plants quickly after they are absorbed and require thorough coverage. They kill only the plant parts they touch, so leaves and stems will be affected, but not roots. For this reason, they are more effective against annual weeds. Correct timing of application and full coverage to prevent seed production is essential. If only the lower parts of the plant are treated, the upper parts may continue to grow and produce seed. Contact herbicides are not very effective against biennial or perennial weeds, since the roots remain and will produce more aboveground plant parts at a later date.
    - Systemic herbicides: Chemicals that are absorbed through the leaves or roots and move freely (translocate) throughout the plant. Application to part of the plant may be sufficient to kill the entire plant. Systemic herbicides are effective against most plants and are recommended for perennials. They take time to be effective and may be applied to soil or foliage. These types of herbicides can move through the plant tissues in two basic ways: through the water-conducting tissues or through the food-conducting tissues.
        - Systemic herbicides that move through water-conducting tissues, called apoplastic movement: Water movement in most plants is upward only. Water generally is not absorbed by the

Contact herbicides have limited movement in plants. They are generally applied to foliage.

Systemic herbicides move through plants, either in the water conducting tissues or the food conducting tissues. They may be applied to the soil or foliage.

leaves and transmitted down to the roots, but it moves from the roots up to the leaves. These herbicides are most often applied to the soil. If applied to foliage, the herbicide will act as a contact herbicide, only killing the plant parts it touches. The older leaves are affected first.

    - Herbicide movement through the food-conducting tissues, called symplastic movement: These types of herbicides move through the plant to the points of active growth. They are generally applied to the leaves and move through the plant to the roots. A few are soil-applied. They are very effective at killing the roots and can be used on annual, biennial and perennial weeds.

  - Pre-emergence herbicides are applied to the soil and must be incorporated either mechanically or by irrigation or precipitation. Timing is especially important. Most pre-emergence herbicides are applied at a time of year when precipitation will help incorporate the herbicide and weed seeds are likely to germinate.

- **Herbicide mechanism of action** refers to the way the herbicide affects a vital metabolic process in the plant. There are a number of mechanisms of action and they occur at the tissue or cellular level in the plant. Using the same herbicide over and over again can allow a weed population to develop resistance to that herbicide. In order to prevent resistance, it is important to alternate herbicides with different mechanisms of action.
  - <u>Synthetic auxins</u> interfere with cell division and cell enlargement. The symptoms of these types of herbicides include downward twisting and curving stems, and puckered, twisted or curling leaves. The plant dies as growth stops and mature tissues undergo cell division that chokes the vascular tissues. While the symptoms may appear within hours, the plant dies slowly, usually in three to four weeks. Synthetic auxins are translocated throughout the plant and are usually applied to the foliage. Control occurs at low volumes of spray. Drift is a concern with these herbicides, as even very low volumes can cause damage to other plants. Synthetic auxins are more effective at controlling broadleaf weeds and trees than grasses. They are persistent in the soil.
  - <u>Photosynthesis inhibitors</u> cause the plant leaves and stems to stop producing food. The plant turns white and dies. They may be applied in the soil or directly onto foliage. They do not appear to affect the roots. Photosynthesis inhibitors can persist in the soil, depending on the formulation.
  - <u>Cell membrane disruptors</u> cause the cell contacts to leak. Plants wilt, dry, yellow and eventually die. Most of these herbicides are nonselective contact herbicides. Good coverage is required for

If more than one application of herbicide is required to control a weed infestation, it is imperative to use herbicides with different mechanisms of action to reduce the possibility of developing herbicide resistance.

Many chemicals that are effective on 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.

Without drift control, damage may occur to nontarget plants in nearby watersheds, the herbicide may contaminate water, and private property may be damaged. Always read and follow the instructions on the label.

control. Injury can be visible in few hours to a few days, depending on the formulation.

- Cell division disruptors inhibit new cell formation. This causes the plant to stop growing and prevents the development of seed heads, which prevents reproduction. These herbicides do not readily translocate from the leaves to which they are applied. They are not persistent in soils.
- Root and shoot inhibitors prevent the growth of roots and shoots or germinating seeds and small seedlings by disrupting cell division. These herbicides have a very limited ability to translocate in plants, so they do not control established weeds. They are generally soil-applied and have limited mobility in the soil. They require precipitation or irrigation water to activate in the soil.
- Bud development inhibitors prevent bud development when applied to woody plants late in the growing season, but before leaves start changing color. The effects are not seen until the following spring, when the woody plants do not resume growth. These herbicides move only from the leaves to the buds, so they do not translocate in the plants. They have no soil activity and do not injure grasses at normal application rates.
- General metabolic inhibitors are those herbicides that interfere with enzyme production or activity. The enzymes normally help in amino acid production, which in turn form proteins in the plants. The elimination of protein production eventually kills the plant. It may take a week or longer for symptoms of these herbicides to be visible in the targeted plants. Some of these types of herbicides have residual soil activity and some do not.
- Pigment inhibitors cause the destruction of chlorophyll in the plants. Plants die because the leaves can no longer produce food. These herbicides are sometimes applied as pre-emergence herbicides and have limited soil mobility. They are considered nonselective herbicides, but may not control deep-rooted, established plants due to limited soil mobility.

- **Herbicide resistance** occurs when a population of weeds no longer responds to the proper application of an herbicide. Repeated applications of the same herbicide may result in a weed population that is resistant to the active ingredient. Resistance reduces herbicide choices and increases weed management costs. The following tactics are used to manage and prevent herbicide resistance:
  - Rotate herbicides with different mechanisms of action.
  - Tank-mix herbicides with different mechanisms of action.
  - Don’t apply herbicides at rates below the recommended label rate.

- Use IPM. Use other management methods when appropriate, including mechanical or physical removal of weeds.

- **Herbicide fate in the environment** plays an important role in herbicide effectiveness. Herbicides are applied either to foliage or to the soil. They are absorbed into plant tissues or adsorbed onto soil particles. They then combine with plant tissues and disrupt plant functions. As the plants die, the herbicides may break down or they may remain viable in the plant residues or the soil. Herbicide breakdown is also referred to as degradation. Sometimes degradation is desirable. For example, herbicides that do not remain in plant residues or soil allow replanting. Other times, rapid degradation is not desirable, as the herbicide may not persist long enough to be effective. Degradation is measured as the half-life of the product, or the time it takes for half of the amount applied to break down. **Pesticide degradation** occurs in three ways:
    - <u>Microbial action</u>: Chemical breakdown or degradation of pesticides by soil microorganisms, such as fungi, bacteria, etc.
    - <u>Chemical degradation</u>: Breakdown of pesticide chemical components by inorganic methods (not by living organisms).
    - <u>Photodegradation</u>: Breakdown of pesticide chemical components by reaction with sunlight. This is why many pesticide application instructions require incorporation of the pesticide in the soil, away from direct sunlight.

The greatest concern is herbicides that become residues on plants, in animals, or in the soil can contaminate air, surface water or groundwater. Problems with herbicide applications can be avoided by:

- Reading, understanding and following herbicide label directions.
- Calibrating equipment.
- Evaluating site conditions and making appropriate adjustments to reduce the possibility of drift.
- Using the right herbicide for the target site and pest.
- Making the application during the most effective time in the pest's life cycle.

<u>Factors affecting chemical weed control</u>

- **Stage of growth**
    - <u>Seedlings:</u> Very susceptible; all life cycles (annual, biennial and perennial) can be controlled.
    - <u>Vegetative:</u> Less effective for annuals and biennials; chemical control of perennials is poor.
    - <u>Flowering:</u> Nearly impossible to control annuals and biennials at this stage of growth; very effective on perennials, particularly at bud or early flowering.

Pesticide degradation occurs three ways:

- **Microbial action**
- **Chemical degradation**
- **Photodegradation**

The ideal time to control all types of plants is at the seedling stage.

For annuals and biennials, a second opportunity occurs during the vegetative stage. After that, chemical control is ineffective.

For perennials, if the seedling stage is missed, the next best time of control is at the bud to early flowering stage. If you miss this opportunity, be sure to control the regrowth.

Plant factors affecting chemical control:

- **Growing points**
- **Leaf shape**
- **Leaf surface wax and cuticle**
- **Leaf hairs**
- **Herbicide resistance**

  - Maturity: Plant is in a dry-down state; annuals and biennials are not affected by chemicals; perennials only partially controlled.
- Stage of growth summary:
  - The ideal time to control all types of plants is at the seedling stage.
  - For annuals and biennials, a second opportunity occurs during the vegetative stage. After that, chemical control is ineffective.
  - For perennials, if the seedling stage is missed, the next best time of control is at the bud to early flowering stage. If you miss this opportunity, be sure to control the regrowth.
- **Time of year**
  - Spring seeded crops: Treat at seedbed preparation time or pre-emergence. Can treat after harvest if the following crop is a winter annual or fall-seeded perennial.
  - Fall-seeded crops: Pre-plant cleanup with tillage is often effective. Biennials and winter annuals can be partially or totally controlled.
  - Established crops: Fall application is ideal and ecologically safe. There are broad-spectrum selective materials available. Fall application of herbicides stresses 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.
- **Plant factors affecting chemical weed control**
  - Growing points: These areas are protected in grasses until near flowering, 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.
  - Leaf shape: Narrow vertical leaves of grasses deflect chemical sprays. Leaves of broad-leafed plants retain spray solution longer and are an easier target.
  - Leaf surface wax and cuticle: These materials are present on every leaf. The thickness of the wax may vary among species. The waxy cuticle is a barrier to herbicide absorption.
  - 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.
  - Herbicide resistance: The repeated use of the same herbicide to the same weed on the same site will eventually lead to herbicide-resistant weed species. It is believed that within weed populations, a small percentage of plants are naturally resistant or may tolerate a given herbicide. Individual plants that survive herbicide applications produce seed, and the resistant population grows. Tank mixing and using herbicides with different modes of action

help to prevent herbicide resistance.

- **Soil factors affecting chemical weed control**
  - Adsorption: Soil particles may have a surface electrical charge, particularly clay particles and organic matter. Herbicides vary from being highly charged to uncharged. Highly charged herbicides can become stuck or adsorbed to clay or organic particles in the soil and are not then easily removed by plant roots. Herbicides that adsorb strongly are held in the soil and do not leach readily. Herbicides that do not adsorb much leach easily through the soil, away from the roots, making them ineffective and risking groundwater contamination.
  - Solubility: Solubility refers to the degree to which the herbicide dissolves in water or another solvent. Herbicides vary from highly soluble to insoluble. Insoluble materials remain where they are placed and will kill weeds when plant roots come into contact with them. Soluble materials are effective weed killers but can be quite mobile and may be leached below the root zone, potentially contaminating groundwater.
  - Leaching: Soil texture is important. Sandy soils are coarse and do not adsorb pesticides readily. Consequently, herbicides may leach (move) rapidly through sandy soils. More adsorption occurs in clay soils, and it is more difficult for water to move through them, so little leaching occurs. Silt is intermediate in size between sand and clay. Organic matter has many charged sites that help to adsorb and retain herbicides. Some herbicides may not be used on sandy soils because they move into groundwater readily, polluting the water. Certain pesticide labels contain groundwater advisory statements. These statements advise users not to apply the product in areas with permeable soils. You must follow all advisories.
- **Climatic factors**
  - Rainfall or irrigation: If either occurs immediately following a foliar application, it may reduce the herbicide's effectiveness by washing it off the leaf. Excess water can move herbicide below root zone of weeds or erode herbicide-laden soils offsite, polluting the area. Note that for soil-applied materials, a half-inch of rainfall or irrigation is necessary to activate them.
  - 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.
  - Temperature: Herbicide activity increases or decreases with temperature extremes. Do not apply volatile materials during warm days or they may drift onto adjacent plants and cause damage. Hot

Soil factors that affect chemical weed control include:

- **Adsorption**
- **Solubility**
- **Leaching**

Pesticide drift is defined as the air-borne movement of pesticide spray droplets, vapors or dusts away from the application site.

dry weather accelerates evaporation, causes wax layers to harden and the cuticle to thicken, and cause stomates (leaf pores) to close.
  - Wind: Applying pesticides under windy conditions can cause spray drift. Aerial applications should not occur if wind speeds are greater than 5 mph. Never make ground applications if wind speeds are greater than 10 mph

- **Reducing drift**
  Pesticide drift is defined as the air-borne movement of pesticide spray droplets, vapors or dusts away from the application site. Increased wind speeds and increased temperatures contribute to pesticide drift, which can damage desirable plants, pets, livestock, wildlife and, most importantly, humans. To reduce drift:
  - Droplet size is one of the most important factors affecting drift. Small droplets are more likely to drift than large droplets. For sprays, use formulations which give large diameter (150 - 200 microns or larger) spray droplets.
  - Use solid cone or fan spray nozzles to produce larger droplet sizes than is possible with hollow cone nozzles. Larger droplets are heavier and will fall ont
    than evaporating, volatilizing or being carried off target by wind.
  - Reduce spray pressures.
  - Angle nozzles of ground rigs toward the ground, slightly forward in the direction of travel.
  - Use less volatile formulations, e.g. the amine form of 2,4-D instead of the ester formulation.
  - Don't apply pesticides under windy or gusty conditions. Read and follow drift management instructions on the pesticide label.
  - Use a buffer zone to ensure drift from the target area does not occur.
  - Select an application method and a formulation that is less likely to cause drift. Pesticide granules are far less likely to drift than pesticide sprays.
  - When appropriate, use drift control/drift reduction agents.
  - Don't spray when weather conditions favor thermal inversions. This occurs when a layer of warm air above traps cool air close to the ground. Avoid spraying at temperatures above 90°-95°F, ideally not over 85°F.
  - Be familiar with your surroundings. Determine the location of sensitive areas near the application site, including cropland, homes, schools, hospitals, day car parking

facilities, surface water, water treatment facilities and honey bee colonies, and protect them from drift
   - Service and calibrate your equipment regularly.
   - Check your spray system for leaks. Small leaks under pressure can produce very fine droplets.
   - Everything that you have done to manage drift will be a waste if you don't determine and consider wind direction.

Vertebrate Pests

Vertebrate pests are those pest animals that have backbones. Specific control measures vary for different species and are discussed in the sections for individual species.

Common vertebrate pest control practices

- **Exclusion:** Exclusion is the practice of keeping the pest out or away from crops, ornamental plants, buildings, etc. Using barriers like fencing and durable materials to plug entrances into buildings are examples of exclusion practices.
- **Sanitation:** This is especially important for areas like kitchens, residences and areas where animals are kept. Eliminate food and water sources. Store food and animal feeds, grain and seed in rodent-proof containers. Repair leaky pipes.
- **Trapping:** There are several types of kill traps and live traps available for most vertebrate pest species. Choosing the proper trap and learning the correct way to use it is critically important. Live trapping and releasing is not acceptable or legal. Individuals who release live trapped animals are moving the pest problem and sometimes diseases like rabies, distemper or plague along with them. Live trapping followed by an approved method of euthanasia is recommended. The American Veterinary Medical Association has specific guidelines for euthanasia.
- **Repellents:** Repellants may be applied to valuable vegetation or can be used in areas where pests are known to frequent. They often don't work the way people expect them to work. Sunshine can break down the repellent, and sprinklers and rain can wash away the product. New growth on plants must be retreated and animals may simply get used to the repellent.
- **Rodenticide Baits:** Baits like seeds, grains and vegetation treated with rodenticides are used to control several types of vertebrate pests. Most baits must be applied in bait stations or underground within animal burrows to lessen the risk of killing of non-target species. Pesticide labels describe methods for applying the bait. Pesticides used include strychnine, zinc phosphide and various anticoagulants. Strychnine may only be applied underground.

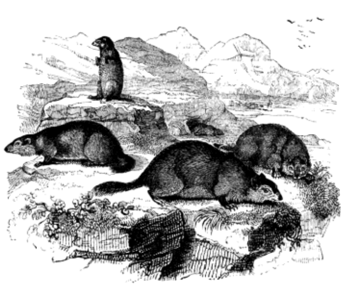
Common vertebrate pest control practices:

- **Exclusion**
- **Sanitation**
- **Trapping**
- **Repellants**
- **Baits**
- **Fumigants**

Strychnine may only be applied underground

Ground squirrel

Rodenticide baits should be used in bait boxes to limit unintended injury or death to non-target species



Marmots

- **Fumigants:** Smoke bombs and internal combustion engines produce poison gases, including carbon monoxide that can be used as fumigants. To be effective, all burrow entrances must be blocked. When using smoke bombs, avoid areas near structures, hay stacks, etc. Aluminum phosphide fumigants are available either as tablets or pellets. When applied in rodent burrows, they produce phosphine gas, which is deadly. Applied improperly, aluminum phosphide has resulted in numerous human deaths. To purchase, apply or supervise the use of this pesticide, applicators must successfully pass the state rodent burrow fumigation certification category.

<u>Specific Vertebrate Pests</u>

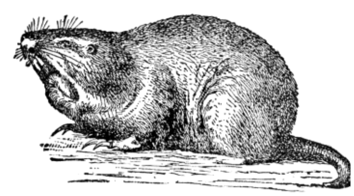
- **Ground Squirrels:** Four species cause problems to crops and ornamental plants in Nevada: Richardson's, Belding's, Townsend's and California ground squirrels. They may also damage irrigation lines by chewing or damage landscape and buildings by burrowing. The best time for control is after emergence from hibernation in early spring. At this time of year, there is little green vegetation, so the ground squirrels are more likely to accept rodenticide baits. Additionally, at this time of year, they have not yet mated and given birth. If control is postponed until later in the spring, there is green vegetation available and the ground squirrels are less likely to accept rodenticide baits. Advanced planning and preparation are essential. Attempting to control squirrels after they have reproduced can be frustrating, expensive and practically impossible. Rodenticide baits should be used in bait boxes to limit unintended injury or death to non-target species. Live trapping and subsequent euthanasia are also used to control ground squirrels. Check traps often and use caution to prevent unintended injury or death to non-target species. Strychnine cabbage bait, a restricted use pesticide, is well accepted but it may be used underground only to protect non-target species. Acceptance of grain baits is inconsistent, so pre-bait first with untreated grain. As these animals can be carriers of bubonic plague, use care in handling sick or dead animals.
- **Marmots or rock chucks:** Marmots can cause damage by consuming ornamental plants and burrowing. Common along the Eastern Sierra, these animals tend to like areas with large boulders, which provide cover. Many landscaped areas, such as golf courses, provide the perfect mix of vegetative food and boulders for cover. Control is similar to ground squirrels. Use live trapping and subsequent euthanasia, zinc phosphide baits or strychnine bait. Use caution when using strychnine, especially in urban areas. It must be applied underground to reduce the potential for harm to other wildlife and dogs. Strychnine is especially

poisonous to dogs.

- **Meadow Voles:** Meadow voles damage turf with shallow, "half-pipe" tunnels and holes. They may girdle plants when feeding. Voles are active all year long, and they have cyclic populations. Control with zinc phosphide baits. Snap traps work for small areas. Keep turf and weeds mowed to reduce cover.
- **Moles:** Moles are insectivorous and are not a serious problem in Nevada. 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. Soil insecticides may be used to reduce the mole's food supply. This may encourage them to move off a property.
- **Pocket Gophers:** Pocket gophers live underground and damage crops and ornamental plants by feeding on roots and sometimes foliage. Their burrows also cause damage to farm equipment and sprinkler systems. Gopher activity is determined by fresh mounds that are typically horseshoe-shaped. Strychnine grain bait, a restricted use pesticide, is most effectively applied in fall or early spring. The bait must be applied below ground. Hand-apply or use in a burrow builder for large areas. Synchronize application with neighbors for best results. Anticoagulant and zinc phosphide baits are also available. Trapping with kill traps is another commonly used control method for pocket gophers.
- **Wood rats or pack rats:** Wood or pack rats will set up house in sheds, attics, garages and other structures. They are messy and carry disease. Like all rodents, their teeth continue to grow their whole lives. They must gnaw or chew on things to wear away their teeth. They can cause structural damage by chewing both wood and wiring. You can use bait stations and traps, but exclusion is the best control method.
- **Norway Rats and House Mice**: Rats and mice are the rodents most likely to be found in homes or businesses. These rodents eat and contaminate food and animal feed. They also cause structural damage by chewing both wood and wiring. They carry diseases contagious to humans, such as Rickettsial pox, bubonic plague, and leptospirosis. No control method will be successful without excluding subsequent mice and rats from entering the site. Seal any opening over ¼-inch. Use good sanitation practices to remove any food supply that may attract these rodents. Use rodent-proof containers to store all food and animal feed to prevent attracting and feeding these pests. Anticoagulant baits are most commonly used. Use care in placing these anticoagulant baits. Pesticide baits must be applied in approved bait stations. Snap traps can be effective, provided exclusion measures are also put in place. Baits for

Meadow vole

Mole



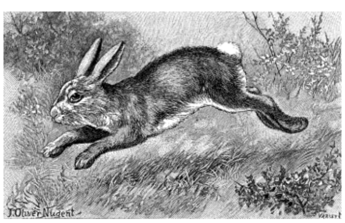
Pocket gopher

House mouse

trapping include peanut butter plus oatmeal, bacon, gumdrops (for mice), nutmeats and dried fruit. Rat and mouse urine fluoresces under UV light. This can be used to locate their trails and commonly frequented areas. Bait and trap in these areas. Check traps daily and use care handling dead rodents.

Deer mouse

- **Deer Mice:** Deer mice can carry hantavirus. Although the chance of infection is low, the mortality rate is high. As with other mice and rats, anticoagulant baits, snap traps and excluding the mice from structures are recommended control measures. Clean up droppings and urine with disinfectant or a 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. Close openings over one-quarter inch in size to exclude further infestation. See the Hantavirus Update chapter in this manual for further information.
- **Blacktailed Jackrabbits:** Jackrabbits cause damage by feeding on crops and ornamental plants. A 45-degree angle cut to stems or branches is typical of rabbit damage. Jackrabbits don't hibernate, so they are active all year long. They have cyclic populations. They will travel long distances for food. The best control is exclusion. Jackrabbits are not easily trapped. Since they generally come in from surrounding rangeland, trapping and removing one simply allows another to take its place. Exclusion fences are recommended around haystacks, small areas, ornamentals and gardens. Repellents can be effective, but must be reapplied on a regular basis and especially after rain or irrigation water washes it away. There are no registered poisons or fumigants for use on rabbits in Nevada. Strychnine (a restricted use pesticide) is no longer registered for jackrabbit control.

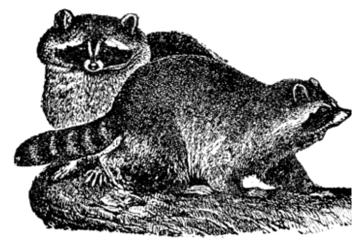


Jack Rabbit

- **Cottontail rabbits and whitetailed jackrabbits:** Cottontail rabbits and whitetailed jackrabbits are usually considered pests in the landscape. Control is similar to that for blacktailed jackrabbits. Exclusion is the best control option. While they can be trapped, trapping is not the best control method, and there are no toxicants registered in Nevada for control of either of these rabbits. The information provided for jackrabbits applies to both of these rabbits as well, with one exception: cottontail rabbits and whitetailed jackrabbits are game species in Nevada. Since they are designated game species, it must be cottontail rabbit and/or whitetailed jackrabbit hunting season to hunt them, and you must have a hunting license.
- **Raccoons:** Raccoons are another vertebrate pest of concern. They are nocturnal and very adapted to urban areas. They can cause structural damage when they nest beneath decks, in attics and in garages. They can

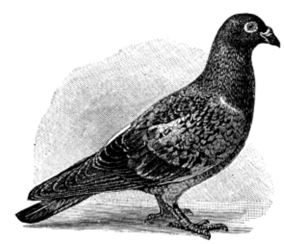
also harm domestic pets. They carry many diseases, some of which are harmful to humans, such as rabies, leptospirosis and raccoon roundworm. The best control method is to discourage them. Exclude them from buildings. Do not feed them directly or indirectly. Indirect feeding might include leaving out dog food overnight or placing tasty scraps of fruit or vegetables in the compost pile. Trapping and subsequent euthanasia is another control option.

- **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 carry diseases that can affect both humans and domestic animals, such as rabies and leptospirosis. Skunks are nocturnal and will make dens in or under buildings. They generally have one litter annually, but may have a second litter. A litter usually consists of five to eight kittens. Exclusion is a key component in skunk control. Seal openings to buildings to prevent their entrance. If a skunk has already set up residence, make sure it is gone before you implement exclusion measures. Do not encourage them by direct or indirect feeding (see raccoon section). Live trapping with subsequent euthanasia is a common control measure, but use a plastic box-style trap to reduce the potential for getting sprayed.
- **Birds:** Droppings, disease potential and consumption of crops and livestock feeds all make pests of certain birds. Caution must be used when dealing with bird pests, as many birds are protected under the Migratory Bird Treaty Act (MBTA). As with all other pests, you must first identify the pest causing your problems. The following common bird pests are <u>not protected</u> by the MBTA.
  - **Pigeons:** These birds are nuisances, roosting and leaving droppings on or around urban and rural structures. Modification of and exclusion from nesting and roosting sites in urban areas has reduced the nuisance. Avitrol used around feedlots and urban areas may cause a flock to leave.
  - **House Sparrows:** These birds consume field crops and pollute livestock feed. Exclude them from buildings. Placing netting over high-value crops may reduce bird damage.
  - **Starlings:** These feedlot pests are also urban pests. Exclude and/or modify urban roosts and nesting sites. Use starlicide around feedlots. To be successful, pre-bait first.
- **Fish Pests:** Fish become pests when they are introduced into waters where they compete with more desirable species. Exotic species such as carp were introduced to North America from Asia. Carp has become one of the most serious fish pests. Also, game fish such as pike, bass, or trout



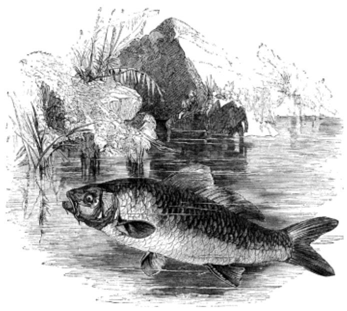
Raccoons

Skunk

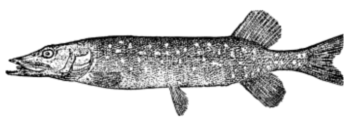


Pigeon

Starling



Carp



Pike

when introduced can compete for food or prey on native, more desirable species.

Physical barriers may be installed in waterways to exclude pest fish. Barriers come with their own set of problems, as they can become clogged with debris and vegetation and impede the flow of water.

It is sometimes necessary to remove some or all fish from a body of water as part of a renovation plan or to carry out a fish management strategy. Piscicides are pesticides that control fish. The most common piscicide is rotenone. Contact the Nevada Department of Wildlife before using rotenone to control pest fish.

Conclusion

The first step in pest control is to properly identify the pest. It is imperative to determine that the damage you see was actually caused by a pest. Consider all control options for managing the pest. Keep records of your management efforts and their success.

Unless otherwise noted, all line drawings are from Clipart ETC, Florida's Educational Technology Clearinghouse, University of South Florida, http://etc.usf.edu/clipart/index.htm

Originally published in 1987 as General Pest Problems, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and
B. Allen and C. Moses, Nevada Department of Agriculture.

General Knowledge: Hantavirus – An Update

Hantavirus – An Update Learning Objectives

After studying this section, you should be able to:

- ✓ **List the rodents responsible for transmitting the different types of hantavirus**
- ✓ **Describe the symptoms of Hantavirus Pulmonary Syndrome or HPS**
- ✓ **Describe how hantavirus is transmitted**
- ✓ **Describe rodent control strategies to prevent HPS disease**
- ✓ **Describe the treatment for HPS disease**

What is Hantavirus?

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. By November 3, 1994, 95 cases of HPS were diagnosed, with some of the cases diagnosed from the saved blood of people who died from unknown causes. Two died in 1959. As of December 31, 2011, 587 cases had been reported in the United States. Unfortunately, of these 587 cases, 36% resulted in death. The virus has been present long enough to differentiate into subtypes or strains. 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.

Hantavirus Pulmonary Syndrome, HPS, is a viral disease caused by a strain of hantavirus known as the Sin Nombre (no name) virus.

To date, 587 cases have been reported in the United States, with a 35% death rate.

Hantaviruses are maintained in nature in a reservoir species, an animal that carries and spreads the virus without being affected by the virus themselves.

In Nevada, the deer mouse is the reservoir species for the Sin Nombre virus, the hantavirus common to our area.

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

There are four rodents that carry different strains of hantavirus in the United States that can affect humans:

- The deer mouse (*Peromyscus maniculatus*) is the reservoir species for the Sin Nombre strain of hantavirus. The deer mouse is a small rodent, 2 to 3 inches in body length and another 2 to 3 inches of tail, with large eyes and ears. While the body color can vary from gray to reddish-brown, the underbelly and feet are always white. The tail is fur-covered and white on the underside. The deer mouse is found throughout North America.
  Deer mice and house mice (*Mus musculus*) are similar looking but have characteristics that enable them to be differentiated. Deer mice have white hair on their belly, legs, and feet. Their tail has short hair that is bicolored, or 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. Deer mice have no odor, whereas house mice have a musty odor. Deer mice have larger ears and eyes than house mice.
- The cotton rat (*Sigmodon hispidus*) is the reservoir species for the Black Creek Canal strain of hantavirus. The head and body of the cotton rat measure 5 to 7 inches long, with another 3 to 4 inches of tail. The fur is long and coarse and can be grayish-brown to grayish-black. The cotton rat is native to the Southeastern United States, Central America and South America. It generally inhabits overgrown areas with shrubs and tall grasses.
- The rice rat (*Oryzomys palustris*) is the reservoir species for the Bayou strain of the hantavirus. The head and body measure 5 to 6 inches long, with a very long 4 to 7 inches of tail. The fur is short and soft and grayish-brown in color. The underbelly is gray or tawny brown. The feet are whitish colored. The rice rat is native to the Southeastern United States and Central America. It generally inhabits marshy areas and is semi-

aquatic.

- The white-footed mouse is the reservoir of the New York strain of the hantavirus. The head and body measure 4 inches long. The tail is shorter than the body length, generally 2 to 4 inches long. The body fur is pale to reddish brown. The underbelly and feet are white, as the name implies. The tail is furred. It resembles the deer mouse, but generally the tail is shorter than the body length. The white-footed mouse is native to southern New England, the mid-Atlantic, Midwest and western states of the United States, and Mexico. It generally inhabits wooded and brushy areas, but will inhabit more open ground.

Another strain, the Prospect Hill strain of the hantavirus, was identified in meadow voles in the northeastern United States, but has not been shown to cause disease in humans.

The oral history of the Navajo Indians suggests that deer mice and people should not be together because deer mice cause sickness. They further say that in 1918, 1933 and 1934, rain provided for large pine nut crops that resulted in high populations of deer mice, causing deaths in young healthy Navajo Indians.

Since the 1993 outbreak, the State and County Health agencies in Nevada have conducted state surveys to gather information about hantavirus in Nevada. In 2010 80 blood samples from rodents were sent in for testing by the Southern Nevada Health District; all 80 samples tested negative for Hantavirus. Testing done by the Southern Nevada Health District from 2001 to 2010 found 19 positive tests out of 824 test submissions, with the last positive test occurring in 2008. The Washoe County Health District also routinely tests rodents for hantavirus. The average rate of infection is 15%, although the rate of infection fluctuates. Test results in Washoe County have been as low as 5% and as high as 50% of the rodents trapped testing positive for hantavirus. Hantavirus can be found to some extent in deer mice populations throughout most of Nevada, regardless of elevation.

Fortunately, HPS is very difficult to contract. Since the disease was discovered in 1993, the Centers for Disease Control have tracked hantavirus cases. From 1993 to January 2017, a total of 697 cases of hantavirus have been reported in the United States. This includes people with laboratory-confirmed hantavirus infection who have either hantavirus pulmonary syndrome (HPS) or non-pulmonary hantavirus infection. More than 96% of reported cases occurred in states west of the Mississippi River. 36% of the cases have resulted in death.

Deer mice have white bellies and feet. Their tails are furred and the underside is also white. House mice have scaly, non-furred tails and do not have white bellies or feet. Deer mice also have larger eyes and ears than house mice.

Hantavirus Hotline 877-232-3322 or 404-639-1510 (non-emergency)

Centers for Disease Control and Prevention, http://www.cdc.gov/hantavirus/

HPS Symptoms: Fever, fatigue and muscle ache of large muscle groups (thighs, hips, back and sometimes shoulders) occur in all cases.

Earaches, rashes, and sore throat are VERY UNCOMMON symptoms in HPS.

The Sin Nombre virus is passed in the feces, urine and saliva of infected deer mice.

The virus is spread to humans when dust particles containing rodent urine, droppings or saliva are stirred into the air and then inhaled.

None of the hantaviruses identified in the United States are transmitted by any animals other than the rodents previously mentioned.

Symptoms of Hantavirus

The symptoms of Hantavirus Pulmonary Syndrome are not specific to HPS. However, there are some characteristic patterns to look for and be aware of:

- Fever, fatigue and muscle ache of large muscle groups (thighs, hips, back and sometimes shoulders) occur in all cases.
- Headaches, dizziness and chills occur in about half the cases.
- Abdominal pain, nausea, vomiting, and/or diarrhea occur in about half of the cases.
- Late symptoms include coughing and shortness of breath.
- Earaches, rashes and sore throat are VERY UNCOMMON in HPS.

Symptoms do not appear for 1 to 3 weeks. Occasionally symptoms may take up to 6 weeks to appear. Shortness of breath is a symptom that appears later as the lungs fill with fluid, leading to frequent misdiagnoses of pneumonia. Abdominal pain and bilateral filling of the lungs in HPS help to differentiate HPS from pneumonia.

Transmission of Hantavirus

The Sin Nombre virus is passed in the feces, urine and saliva of infected deer mice. The major route of transmission to people is through breathing contaminated air. Being bitten by an infected deer mouse can also transmit the virus, but this type of transmission is rare. Biting along with grooming probably help perpetuate the virus within deer mice populations.

The greatest risk of transmission is from rodent infestations in or around the home. Any activity that results in contact with rodent droppings, urine, saliva or nesting materials can put you at risk. The virus is spread when dust particles containing rodent urine, droppings or saliva are stirred into the air and then inhaled. It is very important to avoid stirring up dust when dealing with rodent infestations to avoid risk of hantavirus infection.

Person-to-person transmission has not been observed and health care workers who have cared for HPS patients have not become infected. Pine nuts have been mentioned as a possible source of Sin Nombre virus. This is incorrect. While increases in pine nut harvests contribute to increases in deer mouse populations, they do not carry the HPS virus!

None of the hantaviruses identified in the United States are transmitted by any animals other than the rodents previously mentioned. Guinea pigs, hamsters, gerbils and domestic rats and mice are not known to carry hantavirus. Dogs and cats are not known to carry hantavirus, but they may bring infected rodents into contact with humans if they catch and bring rodents back to their human owners. As with all rodents, use caution when handling injured or dead rodents (see Eliminating an Infestation Safely on the next page.)

Risk Factors

There do not appear to be differences in susceptibility to HPS due to age or sex. An increased likelihood of exposure to deer mice increases your chance of contracting the disease. Entering tightly closed areas that are infested with deer mice increases the risk. Spring and summer are the seasons when most cases occur, due to increased contact with rodents – i.e. deer mice.

Rodent Control Strategies

Prevention

Rodent-proofing and sanitation are the best ways to eliminate deer mice and minimize the chances of contracting hantavirus. To keep deer mice out of a building, seal all openings over ¼-inch in size. Openings can be sealed with steel wool, cement, lath metal, hardware cloth, sheet metal or caulk. Do not seal with materials that can be easily chewed through by rodents. Entrance routes include:

- Holes around doors, windows, closet floors, cupboard floors, fireplaces, etc.
- Gaps around holes cut into walls or floors for gas pipes, vents, electrical lines, plumbing, etc.
- Gaps in rafters, gables, eaves, foundations or basement walls.
- Gaps in attic or crawl space access routes.
- Gaps in seals placed around door, garage doors and windows.
- Disintegrating caulking or rubber seals.

Remove trash, brush and debris from around the outside of structures. Use rodent-proof containers for storing food and trash, both inside and outside the home. Keep pet food in sealed containers when not being used. Do not consume food or use animal feed that you suspect may be contaminated with rodent droppings, urine or saliva.

Eliminating an Infestation Safely

Before cleanup can begin, all rodents should be trapped. Deer mice can be trapped using snap traps (mouse traps.) Peanut butter mixed with uncooked oatmeal is an effective bait. Trapped deer mice can be buried or placed in a bag or container and then into the trash. Continue trapping for a minimum of one week. To prevent re-infestation, seal all potential entry points. To reduce the risk of contracting HPS, wear rubber gloves when handling deer mice.

Rodent-proofing and sanitation are the best ways to eliminate deer mice and minimize the chances of contracting hantavirus.

If at all possible, allow the infested area to remain undisturbed for four to five days after the rodents have been removed. Research indicates that the virus does not remain viable after about three to four days.

Spray any urine, droppings and nesting materials with disinfectant or a solution of one part bleach to nine parts water and leave undisturbed for five to ten minutes before wiping up.

Try to limit disturbance that raises dust, as this will increase the levels of airborne virus.

Avoiding sweeping or vacuuming the materials, especially fresh materials.

If at all possible, allow the infested area to remain undisturbed for four to five days after the rodents have been removed. Research indicates that the virus does not remain viable after about three to four days. Before beginning to clean an infested area, open the windows and doors and allow the room to air out for 30 minutes. Try to establish cross-ventilation, and exit the area while it is airing out. If dusty areas must be entered, wear a respirator or dust mask with a HEPA filter to remove viruses.

Next, spray any urine, droppings and nesting materials with disinfectant or a solution of one part bleach to nine parts water. Soak urine, droppings and nesting materials with the disinfectant or bleach solution and allow them to remain undisturbed for five to ten minutes before wiping up the droppings or nesting materials with paper towels. Try to limit disturbance that raises dust, as this will increase the levels of airborne virus. Avoiding sweeping or vacuuming the materials, especially fresh materials.

Clothing, bedding and other fabric-based materials can be laundered in hot water and detergent and then dried in a machine dryer set on high heat. Detergent breaks down the virus's lipid envelope, rendering it harmless. The virus is also inactivated at a temperature of about 115 degrees F. Unfortunately, not all dryers reach this temperature, even on a high or hot setting. Use both detergent and the dryer heat to inactivate the virus. Fabric materials that can't be washed and dried in conventional machines, such as carpeting, rugs or upholstered furniture, can be disinfected with a commercial-grade steam cleaner or shampoo machine and detergent or disinfectant.

Plastic, glass or metal utensils or items can be disinfected by washing in hot water and soap or detergent. Papers, books and other items that can't be cleaned with liquids can be sanitized by direct sunlight. Research indicates that ultraviolet light can inactivate the virus, so placing contaminated items in direct sunlight for several hours can help render the virus inactive. Use caution when handling contaminated items. Wear rubber, latex or vinyl gloves and respiratory protection when handling these items. Change clothes and wash before eating, drinking, smoking or touching your face. Wash the clothing you wore in hot water and detergent.

Treatment

There is no specific antidote or vaccine for HPS. Treatment consists of ventilation and early aggressive treatment of the symptoms. Medical care in an intensive care unit that provides detailed monitoring is extremely important. The earlier diagnosis and treatment begins, the better the chances of recovery. See your doctor immediately if you experience any of the symptoms mentioned, and be sure to mention that you have been around rodents.

Conclusion

As with all pest control, the best method is prevention. Do not allow rodents to become established in dwellings or outbuildings. Use proper sanitation to reduce the attractiveness of the site for rodents.

Originally published in 1987 as Hantavirus – An Update by J. O'Brien, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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Category 1A: Agricultural Pest Control – Plants

Agricultural Pest Control – Plants Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe some of the most common insect pests of agricultural crops.**
- ✓ **Describe the different types of herbicides used to control weeds and the factors that can affect herbicide uptake in plants.**
- ✓ **Explain the different ways that herbicides move in plants.**
- ✓ **Describe basic types of plant diseases and list symptoms of each.**
- ✓ **Describe the most common diseases found on common Nevada crops.**
- ✓ **Describe the most common vertebrate pests that impact agricultural crops in Nevada and control strategies for each.**

Category 1A, Agricultural Pest Control - Plants

Category 1A, Agricultural Pest Control – Plants, is the category that covers pesticide applications on crops. This includes fruit and vegetable crops, small grain crops, feed crops and forage crops. Agricultural crop production provides the ideal conditions for weeds to grow.

The growth of a single type of plant, also known as a monoculture, can provide an ideal setting for diseases and insect pests to develop and thrive. Pesticides are often needed to reduce pests to tolerable levels, but they can have serious consequences if applied improperly. Pesticides can harm non-target plants, beneficial insects, wildlife, pets, livestock and humans. Thoughtful planning and implementation are required to reduce pest pressure, minimize unintended damage, reduce costs and maximize profit.

Category 1A, Agricultural Pest Control – Plants includes fruit and vegetable crops, small grain crops, feed crops and forage crops.

Integrated Pest Management (IPM)

The principles of Integrated Pest Management (IPM) can be applied to controlling insect pests, weeds, diseases and vertebrate pests on agricultural crops.

- **Pests, their hosts and beneficial organisms must be positively identified.** The pest problem and associated plant species must be correctly identified. If you can't identify the pest, collect samples and submit them to the University of Nevada Cooperative Extension or the Nevada Department of Agriculture for identification. Once the pest has been identified, determine its life cycle, growth cycle and reproductive habits. Pest managers should also be able to identify all life stages of beneficial organisms, such as the lady bird beetle, an insect predator.
- **Establish monitoring guidelines for each pest species.** Routine monitoring of both pests and natural enemies (beneficial species) is an essential part of IPM. Methods of monitoring include visual inspection, pheromone and sticky traps, and sweep nets. Document and track both pest and beneficial organism population numbers. The ratio of natural enemies (usually insects) to pests should be taken into account before a pesticide is applied.
- **Establish an action threshold for the pest**. A fundamental concept of IPM is that a certain number of individual pests can and should be tolerated. Will the pest cause unacceptable damage to the value the crop? **What will happen if no action is taken?** The action threshold in crop production is generally based on economics. The **economic threshold** is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density, or population level, at which a pesticide or other control method should be used.
- **Evaluate and implement control tactics.** Select tactics that will be most effective, most economical and have least impact on non-target species and the environment. Select controls that will harm beneficial organisms as little as possible while suppressing the pest. If a pesticide is one of the selected management tools, beneficial enemies (usually insects) will likely also be killed.
- **Monitor, evaluate and document the results.** This allows you to make adjustments to improve the effectiveness of future pest control strategies.

Principles of IPM:

- **Identify the pest.**
- **Monitor the pest population.**
- **Establish an action threshold.**
- **Evaluate control options.**
- **Implement control options.**
- **Monitor results.**

Worker Protection Standard (WPS)

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use pesticides or (2) employ workers or pesticide handlers who are exposed to pesticides. If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide the following to your employees and, in some cases, to yourself and to others:

Information about exposure to pesticides: To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training for workers and pesticide handlers.
- A pesticide safety poster be displayed for workers and pesticide handlers.
- Access to pesticide labeling information for pesticide handlers and early-entry workers.
- Access to centrally-located information detailing pesticide applications that have occurred on the establishment.

Protection against exposures to pesticides: To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying a pesticide in a way that will expose workers or other persons to pesticides.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI, including providing special instructions related to the correct use of personal protective equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.
- Protect handlers during handling tasks, including monitoring while handling highly toxic pesticides and providing special instructions related to the correct use of PPE.

Mitigation of pesticide exposures: To mitigate pesticide exposures that employees receive, the WPS requires that:

- Decontamination supplies are available to all workers. Employers must provide pesticide handlers and workers with an ample supply of water, soap and towels for routine washing and emergency decontamination.

The Worker Protection Standard (WPS) applies to workers on farms, forests, nurseries and greenhouses.

In 2015 the EPA revised the WPS. A synopsis of the 2015 changes can be found in the Pesticides and the Law chapter of this workbook.

For further information on the WPS, consult the U.S. EPA web publication "How to Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Owners and Employers Need To Know" at http://pesticideresources.com/wps/htc/htcmanual.pdf

- Emergency assistance information is available to all workers. Employers must provide transportation to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and must provide information about the pesticide(s) to which the person may have been exposed.

Insect Pests

Basic insect identification information can be found in the General Knowledge: General Pest Problems section of this manual.

Insects can damage plants in the following ways. They may:

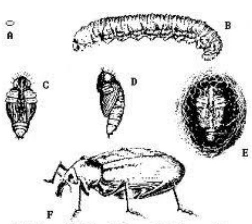
- Feed on leaves.
- Feed on and move into fruit, seeds and nuts.
- Feed on and tunnel into roots.
- Tunnel or bore into stems, stalks, branches and trunks.
- Suck sap or juices from leaves, stems, roots, fruits and flowers.
- Act as vectors, transmitting disease pathogens as they feed.

Insect outbreaks often result from one or more of the following factors:

- Large scale planting of a single crop (the basis of modern agriculture).
- Introduction of an insect pest into an area with no natural enemies.
- Favorable weather conditions that aid in rapid development and reproduction. These same weather conditions may be unfavorable to natural enemies.
- Use of insecticides that kill natural enemies or reduce competing species of pests.
- Cultural practices that encourage the pest infestation.
- Other factors that destroy the natural food chain that normally helps keep the pest insect population in check.

For a listing of insect control strategies, see General Pest Problems in the General Knowledge section of this manual.

Specific Insect Pests in Agricultural Plants



Alfalfa weevil. A, Egg. B, Larva. C-D, Pupae. E, Pupa in cocoon. F, Adult.

Alfalfa weevil

ipm.ncsu.edu

Alfalfa weevil: This is the most serious insect pest of alfalfa in Nevada. Adult alfalfa weevils overwinter in surrounding vegetation and field trash. In early spring, adult females deposit eggs in stems of alfalfa, The eggs hatch and larvae make their way to the growing tips and upper leaves, where they feed. Feeding damage results in a skeletonized appearance on the leaves. Severe damage can give the field a grayish to whitish cast, as if it had been frosted. Mature larvae make their way to the base of the plant and pupate.

On rare occasions, newly emerged adults may cause damage to the second crop. Alfalfa weevil damage is most commonly seen before the first cutting.

Healthy plants are better able to tolerate insect feeding. Resistant cultivars are available. Early cutting can be an alternate to chemical applications, if economically feasible. Cutting will reduce numbers and interrupt the insect's life cycle.

The best time for chemical control is in the larval stage. Compounds previously used for controlling adults have been canceled. Therefore, treat only for larvae. Proper timing is extremely important when applying insecticides to control alfalfa weevils.

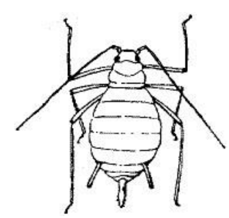
Mites: Mites are not insects, but arachnids. They have eight legs. Mites often appear under dry conditions prior to the first irrigation. Often the first irrigation will reduce their populations by knocking them off the plants and interrupting their life cycle. Mites cause damage by sucking plant juices. Damage first appears as stippling (small yellow areas) on leaves. Severe damage causes leaves to dry and then drop from the plant. The mites are found on the undersides of the leaves and the infestation usually starts on the lower, older leaves and moves upwards. Minimizing plant stress through improved cultural practices, such as proper irrigation and fertilization, can aid plants in withstanding an infestation. They can be controlled with acaracides (pesticides that kill mites).

Aphids: Almost every plant has its own type or types of aphid pests. Aphids are soft-bodied insects with piercing mouthparts that are used to suck out plant fluids. Some species inject toxins into plants, resulting in distortion of the leaves. Heavy infestations can reduce plant vigor, causing stunting in plants and causing leaves to wilt, curl, yellow or become mottled. It is extremely important to identify the specific aphid species that is attacking the crop since thresholds and the effectiveness of chemicals may vary from species to species.

The typical aphid overwinters as either 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. The females mature and begin producing offspring without being mated. This is referred to as asexual reproduction. This may be repeated (adult to adult) in the summertime as often as once a week.

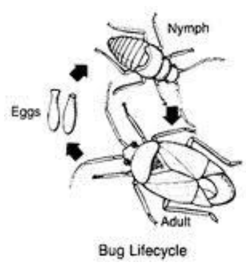
Cultural practices that promote vigorous growth can help plants tolerate aphid feeding. Resistant cultivars are available. Early harvesting may help to reduce numbers. Biological control by lady bird beetles, lacewing larvae,

Proper timing is extremely important when applying insecticides to control alfalfa weevils.



Aphid
extension.missouri.edu

syrphid fly larvae, damsel bugs, big-eyed bugs, minute pirate bugs and parasitoids can keep numbers below action thresholds. Chemical controls should be applied thoughtfully to minimize injury to these beneficial insects.

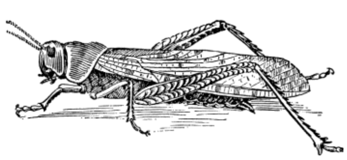


Lygus bug

www3.telus.net

Lygus bugs: This is primarily a pest on alfalfa seed but can cause some damage on hay. Lygus bugs damage plants by puncturing plant tissues with their piercing mouthparts and feed by sucking sap. In addition to the physical injury they cause by feeding, females also damage plants when they lay eggs directly into plant tissues using their piercing ovipositors. This is usually a problem on other crops grown for seed. Lygus bugs preferentially target growing points (buds, flowers, seed pods) and can significantly reduce seed set, plant maturation and seed yield. Control is difficult and the best success is achieved with pesticide applications aimed at the smaller nymphs. Monitor for lygus bugs prior to first bloom, so treatment decisions can be made prior to pollinator release. Apply chemical controls in the late evening or early morning, when pollinators are not active.

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. Tillage and flood irrigation can reduce cutworm populations.



Grasshopper

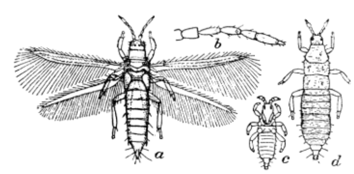
Grasshoppers: Large grasshopper populations generally develop on non-cultivated land or on land that has been left fallow or abandoned. These grasshopper populations or “bands” then move to agricultural lands and feed on crops. Controls must be aimed at the entire band of grasshoppers. Treating only a portion of the band will often result in rapid re-infestation of the treated area. Treatment 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 a number of chemical controls. Remember to make sure the crop or site is specified on the product’s label. *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, the life stage of the grasshopper, and the habitat conditions.

Mormon Crickets: Mormon crickets are not true crickets. They are shield-backed, short-winged katydids. They resemble fat grasshoppers and cannot fly. Similar to grasshoppers, they have cyclic population increases. Mormon crickets form bands that feed on almost any plant material, but they prefer succulent forbs. They damage rangeland forbs, grasses and shrubs. They can also damage small grains, alfalfa and most other crops. Their presence can also cause losses to forage crops they don't eat; hay quality significantly drops if the hay is full of Mormon crickets and their droppings.

Control of Mormon crickets is an ongoing battle in Nevada. Physical or mechanical control by creating a barrier is usually impossible over large land areas. Biological controls include wild birds and poultry. A black wasp (Palmodes laeviventris) has been reported to be a Mormon cricket predator. A parasite (Varimorphan sp.) occurs naturally in populations of Mormon crickets and can be devastating in the early nymph stages. Unfortunately, this parasite is not commercially available. Several different chemical controls are available, with different mechanisms of action. Pesticide baits are available. Since Mormon crickets cannibalize their dead, the bait that kills one Mormon cricket may kill and second or third with subsequent feeding within the band. If you are using chickens as a biological control, you may not want to use these baits or many of the other chemical controls. Other chemical controls include growth regulators. The choice of growth regulator is based on a number of factors, including the age of the cricket population, forage conditions, labeled sites for use with each growth regulator, weather, and environmental impacts. Check with your local pesticide dealer for the most up-to-date chemical control products available for your site and situation.

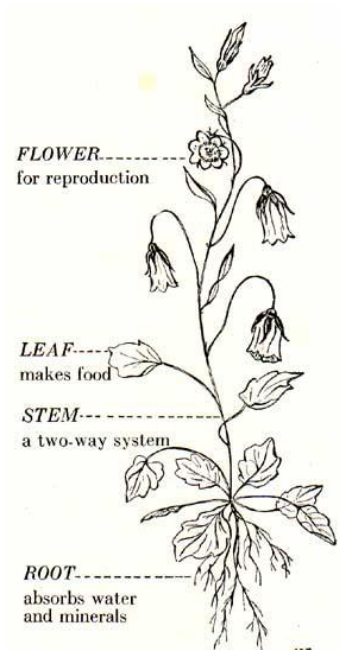
Thrips: These are important pests of onions and garlic. On these crops the economic threshold is considered to be about 10 per leaf. Thrips on other crops can cause cupped or silvered leaves, deformed flowers and problems in pollination resulting from their rasping style of feeding.



Thrips

Thrips are very difficult to control. Consider crop rotation, sanitation near crops, such as removing alternate host plants, planting trap crops, 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. For information on Nevada's Managed Pollinator Protection Plan go to http://agri.nv.gov/uploadedFiles/agrinvgov/Content/Plant/Entomology/nevada_pollinator_protection_plan_final.pdf.



Typical flowering plant

plant-care.com

Successful weed management considers all the potential control methods available:

- **Prevention**
- **Cultural**
- **Physical/ Mechanical**
- **Biological**
- **Chemical**

Weeds Pests in Agricultural Plants

General information on weeds is covered in the General Knowledge: General Pest Problems section of this manual. Please refer to that chapter for discussion on the stages of plant development and the different plant life cycles.

It is impossible to describe and discuss every weed you may encounter in Nevada in this publication. However, it is imperative to identify the weed, its lifecycle and its stage of growth in order to formulate a weed management plan. There are many resources available to help you identify weeds. The Nevada Department of Agriculture and the University of Nevada Cooperative Extension can help in identification. Many books contain pictures and descriptions of weeds. There is a limit to the amount of information they contain, so it is best to consult sources specific to your geographic area.

There is great variability in Nevada's climate. Weeds found in southern Nevada can be much different than those in northern Nevada. Not all weeds that occur in the Las Vegas area occur at Lake Tahoe, and vice-versa. There is a wealth of information available on weed identification on the Internet, but use caution and only trust information from reputable sources.

It is important to understand some of the living dynamics of plant growth to understand how herbicides work and the different ways they may affect plants. Plants consist of roots, stems or trunks, and leaves. Water movement in most plants is from the roots upward through the trunk or stem and into the leaves, where transpiration occurs. Plants produce their own food or carbohydrates through photosynthesis. Movement of the food is from the leaves downward through the trunk or stem to the roots.

Weed control strategies

Most effective weed management plans include two or more control strategies. Weed control can be split into five separate categories.

- **Prevention:** Prevention includes such factors as using certified weed-free seed, hay, transplants, amendments and mulches. Cleaning equipment to prevent the spread of weed seed and weed plant parts from one area to another is another prevention tactic. Prevention also includes removing weeds before they can form seed heads or spread by other methods. It is more difficult to prevent weed seeds from blowing in from an adjoining property.
- **Cultural controls:** Cultural controls are management practices that reduce the incidence of weed infestations. Cultural controls include using proper planting times and planting rates, planting companion

crops, managing fertilization and irrigation to favor desired plants rather than weeds, rotating crops and planting cover crops.

- **Mechanical/Physical controls:** These controls include tillage, hoeing, mowing, flooding, burning, hand-pulling, etc.
- **Biological controls:** This method uses a living organism to control a pest. Success depends upon selectivity, reproduction, adaptation, and ability of the organism to reach a high level of effectiveness.
- **Chemical controls:** Chemical control is the use of pesticides, in this case, herbicides, against a target pest (weeds). Many herbicides are available. In order to be effective, an herbicide:
  - Must come into contact with plant parts (leaves, stems, trunks, roots, etc.).
  - Must remain on the plant surface long enough to penetrate or be absorbed.
  - Must reach a living site to disrupt a vital process or structure.
  - Must be able to kill the target weed.

Herbicide effectiveness is dependent on a number of factors:

- **Herbicide uptake rate and quantity:** Herbicides are applied either to the soil, where they interact with the roots, or applied to the foliage of the plant (the above-ground stems, leaves, etc.).
  - Soil-applied materials, such as preemergence herbicides, generally dissolve in the soil water and enter the plant via the plant's roots. Absorption of the herbicide takes place across the cell walls of the root hairs. The plant must be actively growing, so non-germinating seeds are not affected by these herbicides. To remain effective, the herbicide barrier formed in the soil must not be disturbed.
  - Foliar-applied herbicides are sometimes difficult to get into the plant through the shoots and leaves. The major barrier to herbicide uptake is the cuticle. The cuticle is the waxy covering found on all leaves. The thickness of this waxy coating varies for each plant species and can be thicker within the same species on plants growing in dry, hot climates. Many plants have leaf hairs, which may hold the herbicide spray droplets above the leave surface where they are not readily absorbed. Both the leaf cuticle and leaf hairs can cause herbicides to bead up and run off or evaporate. The addition of wetting agents or oils can help spread out herbicide solution, cover the foliage and penetrate the cuticle, but they are an added expense. Often the wetting agents or oils are included in the product. If they are not included, follow label instructions to add them.
  - Spray volume can affect the effectiveness of an herbicide application. Adjust the spray volume to minimize spray runoff or

To be effective, herbicides must reach a living site to disrupt a vital process or structure.

Contact herbicides have limited movement in plants. They are generally applied to foliage.

Systemic herbicides move through plants, either in the water-conducting tissues or the food-conducting tissues. They may be applied to soil or foliage.

spray drift but maximize coverage and penetrate the crop canopy.

- The amount of <u>foliage or shoot growth</u> can affect the effectiveness of an herbicide application. There must be enough foliage to intercept the spray application. For grasses, this generally means waiting until there are three to five blades. For broadleaf plants, it means waiting until the leaves are one-half inch to one inch in diameter.
- In general, the <u>retention time</u> of water-soluble herbicides on plants must be six to 12 hours to maximize absorption. Oil-soluble herbicides require less time, often as little as one hour. Do not apply herbicides during rain, when rain is expected, or when irrigation will occur before the required retention time has passed.

- **Herbicide movement in the plant:** To be effective, herbicides must reach a living site to disrupt a vital process or structure. Herbicides are subdivided based on how they move in plants.
    - <u>Selective herbicides</u>: Chemicals that kill <u>specific</u> types of plants.
    - <u>Nonselective herbicides</u>: Chemicals that kill <u>all</u> types of plants.
    - <u>Contact herbicides</u>: Herbicides with little to no movement in plants are called contact herbicides. They kill immediately after penetration, usually within hours. They require thorough coverage. They kill only the plant parts they touch, so they will kill the leaves and stems, but not necessarily the roots. For this reason, they are more effective against annual weeds to kill plants and prevent seed production and not very effective against biennial or perennial weeds whose roots remain and produce more above-ground plant parts at a later date.
    - <u>Systemic herbicides</u>: 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. Systemic herbicides are effective against most plants and are recommended for perennials. They take time to be effective and may be soil- or foliage-applied. These types of herbicides can move through the plant tissues in two basic ways: through the water-conducting tissues or through the food conducting tissues.
        - Herbicides that move through the water-conducting tissues, called apoplastic movement: Water movement in most plants is upward only. Water generally is not absorbed by the leaves and transmitted down to the roots, but it moves from the roots up to the leaves. These herbicides are generally soil applied. If they are foliar applied, the herbicide will act as a contact herbicide, only killing the plant parts they touch. The older leaves are affected first.

- Herbicide movement through the food conducting tissues, called symplastic movement: These types of herbicides move through the plant to the points of active growth. They are generally applied to the leaves and move through the plant to the roots. A few are soil applied. They are very effective at killing the roots and can be used on annual, biennial and perennial weeds.

- **Herbicide mechanism of action** is the way the herbicide affects a vital metabolic plant process. There are a number of mechanisms of action and they occur at the tissue or cellular level in the plant. Using the same herbicide over and over can result in resistance to that herbicide. In order to prevent herbicide resistance it is important to alternate herbicides with different mechanisms of action.
  - Synthetic auxins interfere with cell division and cell enlargement. The symptoms of these types of herbicides are downward twisting and curving stems, puckered, twisted or curling leaves, called epinasty. The plant dies as growth stops and mature tissues undergo cell division, choking the vascular tissues. While the symptoms may appear within hours, the plant dies slowly, usually in three to four weeks. Synthetic auxins are translocated through the plant and are usually applied to the foliage. Control occurs at low volumes of spray. Drift is a concern with these herbicides, as very low volumes can cause damage. Synthetic auxins are more effective at controlling broadleaf weeds and trees than grasses. Some are persistent in the soil.
  - Photosynthesis inhibitors cause the plant leaves and stems to stop producing food. The plant turns white and dies. They may be applied to the soil or directly onto foliage. They do not appear to affect the roots. Photosynthesis inhibitors can persist in the soil, depending on the formulation.
  - Cell membrane disruptors cause the cell contacts to leak. Plants wilt, dry, yellow and eventually die. Most of these herbicides are nonselective contact herbicides. Good coverage is required for control. Injury can be visible in few hours to a few days, depending on the formulation.
  - Cell division disruptors inhibit new cell formation. This causes the plant to stop growing and prevents the development of a seed head, which prevents reproduction. These herbicides do not readily translocate from the leaves on which they are applied. They are not persistent in soils.
  - Root and shoot inhibitors prevent the growth of roots and shoots or germinating seeds and small seedlings by disrupting cell division. These herbicides have a very limited ability to translocate in plants,

If more than one application of herbicide is required to control a weed infestation, it is imperative to use herbicides with different mechanisms of action to reduce the possibility of the weed developing herbicide resistance.

Pesticide degradation occurs in three ways:
- Microbial action
- Chemical degradation
- Photodegradation

so they do not control established weeds. They are generally soil applied and have limited mobility in the soil. They require precipitation or irrigation water to activate in the soil.
  - Bud development inhibitors prevent bud development when applied to woody plants late in the growing season, but before leaves start changing colors. The effects are not seen until the following spring, when the woody plants fail to resume growth. These herbicides move only from the leaves to the buds, so they do not translocate in the plants. They have no soil activity and do not injure grasses at normal application rates.
  - General metabolic inhibitors are those herbicides that interfere with enzyme production or activity. The enzymes normally help in amino acid production, which form proteins in the plants. The elimination of protein production eventually eliminates the plant. Symptoms show up slowly in the targeted plants, sometimes taking a week or more to manifest. Some of these types of herbicides have residual soil activity and some are not active in the soil at all.
  - Pigment inhibitors cause the destruction of chlorophyll in the plants. Plants die because the leaves can no longer produce food. These herbicides are sometimes applied as preemergence herbicides and have limited soil mobility. They are considered nonselective herbicides, but may not control deep-rooted, established plants due to limited soil mobility.
- **Herbicide fate in the environment** plays an important role in herbicide effectiveness. Herbicides are applied either to foliage or to the soil. They are absorbed into plant tissues or adsorbed (attached) onto soil particles. They then may combine with plant tissues and disrupt plant functions. As the plants die, the herbicides may break down or they may remain viable in the plant residues or the soil. The breakdown is also referred to as degradation.
  Sometimes degradation is desirable. For example, herbicides that do not remain in the plant residues or soil allow replanting to occur. Other times, degradation is not desirable, as the herbicide may not last long enough to be effective. Degradation is measured as "half-life," which is defined as the time it takes for half the applied herbicide to break down.

  Pesticide degradation occurs in three ways:

  - Microbial action: Chemical breakdown or degradation of pesticides by soil microorganisms, such as fungi, bacteria, etc.
  - Chemical degradation: Breakdown of pesticide chemical components by inorganic methods, often hydrolysis (not by living organisms).

- Photodegradation: Breakdown of pesticide chemical components by reaction with sunlight. This is why many pesticide application instructions require incorporation of the pesticide in the soil, away from direct sunlight.

The major concern is that herbicides that become residues on plants, in animals, or in the soil can contaminate air, surface water or groundwater. Herbicides that do not degrade to harmless chemicals are generally dropped from consideration during the development process or they are only approved for use in non-crop or non-forage applications.

Problems with herbicide applications can be avoided by:

- Reading, understanding and following herbicide label directions.
- Calibrating equipment properly.
- Evaluating site conditions and making appropriate adjustments to reduce the possibility of drift.
- Using the right herbicide for the target site and pest.
- Making the application during the right time in the pest's life cycle.

The major concern is that herbicides that become residues on plants, in animals, or in the soil can contaminate air, surface water or groundwater.

Nevada's Noxious Weeds

A noxious weed is a plant that has been defined as a pest by law or regulation. This designation requires that land owners or occupiers control noxious weeds growing on their property. If a plant is found to be detrimental or destructive and difficult to control or eradicate, the Nevada Department of Agriculture can recommend to the state board of agriculture that the plant be designated as noxious. Nevada's noxious weed list can be found at http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/.

For help identifying noxious or other problematic weeds, contact the Nevada Department of Agriculture, 775-353-3600, or the University of Nevada Cooperative Extension, 775-784-4848. The following publications may help in identifying noxious weeds: Nevada Noxious Weed Field Guide, http://www.unce.unr.edu/publications/files/nr/2010/sp1001.pdf and Nevada Nuisance Weed Field Guide, https://www.unce.unr.edu/publications/files/ho/2018/sp1802.pdf.

For the latest noxious weed listing, go to http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/.

Plant Diseases in Agricultural Plants

There are six major principles of plant disease management:

- Exclusion
- Eradication
- Protection

Most plant disease management plans combine two or more control methods.

A disease is defined as any impairment of plant health or a condition of abnormal functioning.

Canker, rusts and smuts are all diseases caused by fungi.

- Resistance
- Therapy
- Avoidance

These six principles are discussed in detail in the General Knowledge: General Pest Problems section of this manual.

Successful plant disease management considers all of the potential control methods:

- Prevention
- Cultural controls
- Physical or mechanical controls
- Biological controls
- Chemical controls

Most plant disease management plans combine two or more control methods. Chemical control in agricultural plants can be achieved through seed treatments, soil treatments and/or treatment of growing plants.

Plant diseases manifest in a number of ways. A disease is defined as any impairment of plant health or a condition of abnormal functioning.

- **Rot** is decay or disintegration of plant tissue. It can be caused by hundreds of different bacteria or fungi.
- **Blight** is any plant disease that results in withering and killing of leaves, flowers and shoots.
- **Canker** is a disease of woody plants that causes localized damage to the bark of the plant. It can be caused by fungi or bacteria.
- **Gall** is an abnormal outgrowth of plant tissues. This disease can be caused by fungal or bacterial infection or insects.
- **Wilts** are plant diseases characterized by drooping and shriveling, usually caused by vascular pathogens, such as Fusarium.
- **Rusts** are plant diseases that produce reddish-brown pustules on leaves and stems. Rusts are caused by various rust fungi.
- **Smuts** are destructive diseases of plants, especially cereal grains, that produce black, powdery masses of spores. Smuts are caused by fungi.

Nevada cropland exceeds 600,000 acres. Crops include:

- Alfalfa hay and alfalfa seed
- Potatoes
- Small grains
- Onions and garlic
- Fruits and vegetables

Specific diseases related to each of these crops are discussed below.

Alfalfa Hay and Alfalfa Seed: Disease management in alfalfa hay production is largely based on cultural practices to reduce loss, such as variety selection and the use of certified weed-free seed. Many of the diseases mentioned below are favored when soils are heavy and poorly drained. Excessive soil moisture can allow soil-borne fungal or bacterial diseases to develop. Additionally, dodder and nematodes can cause damage to plants and may create entry sites for diseases. Some seed is treated with fungicides to control damping-off disease during seed germination and plant establishment. In many cases, adapted resistant alfalfa varieties are available to combat many of the major alfalfa plant diseases.

Alfalfa seed production is also complicated by dodder. Dodder seeds are similar in size and shape to alfalfa seeds, so producing weed-free seed can be difficult if dodder is present in the field.

Alfalfa root diseases include:

- ***Phytophthora* root rot:** The fungus causing this disease is present in the soil. The disease can build up in the soil. It occurs most often in soils with poor drainage or where water stands for an extended amount of time. It is common at the tail end of flood-irrigated fields, where water collects. Symptoms include stunting and yellowing of the above-ground portions of the alfalfa plants. The plants may wilt due to inadequate water uptake resulting from root damage. The roots may be brownish or dead. Control: Manage irrigation properly, level fields, rotate crops and plant resistant varieties.
- **Fusarium root and crown rot:** The disease occurs in most soils. Infection can become more severe in the presence of nematodes, which cause injury to the plant and provide an open wound for the infection to enter the plant via the roots. Mechanical injury by surface traffic can cause injury to the crowns, allowing the disease to enter. Control: Plant resistant varieties, maintain favorable growing conditions for the plants to reduce stress, reduce surface injury and control nematodes.
- **Bacterial wilt:** This bacterial disease occurs in most soil types, but is more common in cold climates. It can be severe in the presence of nematodes or other root-feeding insects that create entry sites for the disease. Symptom are stunting of the plants and yellowish to brown discoloration inside the root. Control: Plant resistant varieties. Cultural practices that limit damage and maintain favorable growing conditions can limit the infestation. Control nematodes or other root-feeding insects.

Alfalfa

- **Damping-off of seedlings:** Caused by several soil-borne fungi. This disease causes seedlings to rot at the soil surface. Seedlings that survive are stunted and yellowish. The fungi causing this disease can be transported by water, contaminated equipment and movement of infected plant materials. Disease is favored in cool temperatures, excessive moisture, low light or improper fertilization. Control: Plant during conditions that favor rapid germination and seedling growth. Control irrigation and fertilization. Use seed treated with fungicide to protect seedlings from damping off. As these diseases have a wide range of hosts, crop rotation is not an effective cultural control.
- **Nematodes:** These microscopic roundworms live in the soil and feed on alfalfa roots. They cause stunting of plants and/or galls on the roots. Infestation can be localized to a small area of the field or extensive throughout the field. Infestation by nematodes can increase the incidence of other diseases, as their feeding causes root damage, providing an entry point for disease. Control: Planting resistant varieties and rotating crops can aid in control. Pre-plant soil fumigation can be effective but is expensive. There are no non-fumigant nematicides currently registered for use on alfalfa.

Alfalfa foliage diseases include:

- **Common leafspot:** As the name implies, this fungal disease causes numerous small (1-3 mm), brown to black spots on infected leaves. The spots are roughly circular and the margins of the spots can be toothed or smooth. As the disease progresses, the leaves eventually become yellow and die. Infection of established plants is seldom fatal, but the disease can be fatal to seedlings. The disease is favored in cool to moderate temperatures and wet conditions. It can be a problem in the first and second cuttings. The pathogen overwinters in undecayed plant residue and germinates when moisture is present. The windblown spores can infect the lower leaves of the plants directly through the leaf cuticle. Control: Harvest the first cutting early to reduce the severity of the disease in the field over time. Some cultivars may be more resistant than others. Crop rotation and good sanitation can reduce the amount of fungal inoculum.
- **Spring blackstem:** This fungal disease affects both leaves and stems of alfalfa plants. It is a cool-season disease that overwinters in plant debris and is spread by water or infected plant materials. Symptoms are small black to brown spots on leaves and stems. The spots are irregular to triangular in shape. The affected leaves turn yellow and wither before falling off. The affected stems turn black near the base of the plant. Most damage occurs before the first cutting. Control: Plant resistant cultivars,

plant pathogen-free seed, cut early to reduce leaf loss. Good sanitation and crop rotation can reduce the amount of fungal inoculum.

- ***Stemphylium* leafspot**: This fungal disease is a cool-season foliar disease. Moist conditions favor infection and disease spread. Symptoms include irregularly shaped lesions on leaves that have tan centers with a darker border. Defoliation can occur, but generally only under very heavy disease pressure. The disease is spread by spores via water or wind. This disease is usually found in the first and second cuttings. Control: Early harvest is an option with severe infestations. Some cultivars may have more resistance than others, but seed companies do not commonly report resistance to this disease.
- **Downy mildew:** This is another fungal disease that favors cool, wet climate conditions. The upper surface of the leaves become lighter in color. Entire buds and leaves may become infected, becoming distorted and yellowing. Infected leaves can fall off the plant, reducing quality and quantity of the alfalfa. This disease is usually only a problem in the spring. Spring planted fields can be severely affected, as this is when the disease is most common and the field is in the seedling stage. Stand survival is usually not affected. Control: Early harvests can be used to reduce losses. Resistant cultivars are available.
- **Dodder:** Dodder is a parasitic plant that attaches to and eventually kills its host plant. The plant appears as a yellow, stringy mass on infected plants. In alfalfa fields it can be a real nuisance, since the seeds can remain viable in the soil for many years, sprouting and causing new infestations during multiple growing seasons when conditions are right. Control: Dodder reproduces from seed, so it is essential to prevent production of seed. Remove infested plants. For existing stands, preemergence herbicides may help control germinating dodder. Dodder seed can be spread by equipment and livestock. Use certified weed-free seed. Crop rotation using non-host plants, such as grasses, can interrupt the infestation cycle.

Potatoes: Potatoes are another important crop in Nevada. Potato varieties are generally chosen for agronomic characteristics, not disease resistance. All diseases discussed below can be managed by destroying cull piles as the final sanitation practice in the fall. This will reduce the source of spring inoculum of many potato diseases.

Foliage diseases of potatoes

- **Late Blight** is a fungal disease that is most severe during cool, clear weather. It occurs in fields with sprinkler irrigation systems where moisture levels are high. It first appears as small light to dark green water-soaked spots, often with a yellowed halo. Lesions enlarge

Potato

Destroying all cull piles as the final sanitation practice in the fall will help to control all the potato diseases discussed here.

rapidly and turn brown. The lesions are not restricted by leaf veins. Control: Some cultivars are more resistant than others. Crop rotation can reduce the incidence of the disease. Foliar fungicide applications can be used to manage the disease.

- **Early Blight** is a fungal disease that occurs during high humidity conditions. Although it appears early in the season, it spreads later in the growing season and is a problem late in the growing season. Early blight also produces lesions on the leaves. The lesions form on the lower, oldest leaves first and have a bulls-eye or target pattern. As the lesions grow and coalesce, they are restricted by large leaf veins and may appear more angular. The disease appears to increase on plants that are stressed from poor nutrition, so higher rates of nitrogen may help control the disease. Irrigation in cool, cloudy periods or late in the evening when foliage may remain wet for extended periods should be avoided. Control: Some cultivars are more resistant than others. Foliar fungicide applications can be used to manage the disease.
- **Black Leg** is a bacterial disease that occurs on the stem and on the potato tubers. Stems infected with black leg usually have a black decay that begins at the underground seed piece. Leaves of infected plants often roll upwards, yellow and wilt. Plants are stunted and appear stiff before wilting and dying. Mechanical injury of plants by cultivation increases the incidence and severity of the disease. Control: Certified seed will significantly reduce the incidence of Black Leg. Seed treatment may also be required. Remove infected plants to limit the spread of the disease. Avoid injury during harvest and storage. No chemical control measures are available to date.
- **Calico Virus** in potatoes is caused by the same virus that causes alfalfa mosaic disease. Leaves may roll up and appear yellowed. Plants may appear stunted. Control: Aphids are vectors of this virus, so controlling aphids will help control the disease. Use certified seed, remove all infected plants immediately, control volunteer plants and destroy all cull piles. Avoid planting potatoes near alfalfa.

Root and Tuber Diseases of Potatoes

- **Verticillium Wilt** is a fungal disease that plugs the water-conducting tissues, causing premature yellowing and death of the foliage. Tan discoloration of the vascular tissues in cut stems of infected plants is common. This fungus invades through the root system, through root hairs and wounds. The wound can be the result of mechanical injury or may be caused by insect or nematode injury. Control: Crop rotation (4-6 year cycle), planting resistant cultivars, controlling insects and nematodes and good sanitation will help control this disease. Soil fumigants can be used in infected fields.

- **Scab** is a fungal disease that results in corky lesions on the tuber that may be superficial or may cause deep pits. The scab disease can survive on decaying plant debris and can be spread by water or contaminated soil on equipment. The lesions are usually circular, but can coalesce in the later stages to form irregular shapes. A soil pH of 5.5 to 7.5 is most favorable to scab. Scab is most severe when tubers develop under warm, dry soil conditions, so avoid moisture stress during the 2 to 6 weeks following tuber formation. Control: Rotate crops, plant certified seed, treat seed, plant resistant cultivars and practice good sanitation.
- **Root Knot Nematode** causes stunted plants and rough, pebbly-appearing tubers. Additionally, the injuries these worms create provide a pathway for other diseases. Control: Certified seed, crop rotation, seed treatment and good sanitation will help control nematodes. At present, there are no nematode-resistant potato varieties available.

Small Grains (wheat, barley, oats, sorghum, etc.): Smuts are the major disease problem for small grains. Smuts are fungal diseases that are carried in the seed. Smut does not show up until the seed heads form. Diseased plants have darkened, discolored seed heads and are commonly stunted. Control: Certified seed, planting resistant cultivars and seed treatment will help control smuts.

Onions and Garlic: Onions and garlic are important crops produced in Nevada. The major disease problems are fungal diseases. Insects, nematodes and other pests that feed on onions and garlic can cause wounds that provide entry for the fungal diseases.

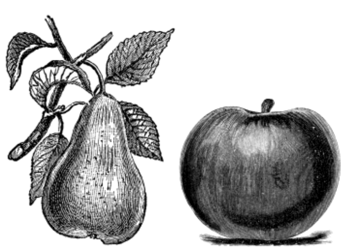
- ***Botrytis* neck rot** is a common fungal disease of onions and, to a lesser extent, garlic. The fungus causes considerable losses during field curing periods and during storage. White globe varieties of onions are very susceptible to the disease. The fungus persists on dead onion and garlic plant tissues for long periods and germinates in moist, cool weather. Control: Cultural practices will help limit the incidence of infection. Do not fertilize with excessive amounts of nitrogen, as this will delay maturity. Limit irrigation late in the season. Always allow time for adequate and proper curing. Store properly, ensuring low temperatures and humidity and good air circulation.

Onions

- **Pink Root** is a fungal disease that affects onions. As the name implies, the most striking symptom of this disease is pink roots. Roots eventually shrivel, turn black and die. The fungus is very common in the soil and can penetrate roots directly. No wound is necessary for an infection to occur. Stressed plants are more susceptible. The fungus can remain viable in the soil for long periods (10 years or more) and can be spread by water and by dirty equipment. Control: Prevention and control include use of resistant varieties, good soil tilth and fertility, control of other diseases and insects that will stress plants, good sanitation and cleaning equipment between fields. Crop rotation will reduce the incidence of infection, but will not eliminate it entirely. Pre-plant soil fumigation is effective for control.
- **White Rot** is a fungal disease that affects both onions and garlic. The leaves of infected plants start to decay at the base, yellowing, wilting and toppling over. The older leaves are affected first. The roots rot and plants are easily pulled from the soil. A fluffy white growth, the fungal mycelium, may be present on the remaining roots and the base of the bulbs. This fungus can remain viable in the soil for 20 years or more. The disease can be spread from field to field by flood water, on equipment or on plant material. Control: Avoidance and good sanitation are effective controls. Once a field is infected, chemical treatments are necessary to produce onion and garlic crops. Soil fumigation provides good control.

Fruits and Vegetables: Nevada grows fruit and vegetable crops, such as grapes, apples, pears, cantaloupe, tomatoes, squash and herbs.

- **Powdery Mildew** is a common problem on grapes. Symptoms are a powdery mycelium and spores on all foliage. Control: This fungal disease is best controlled with various copper and/or sulfur formulations.
- **Fire Blight** is a common problem in apple and pear production. It is a bacterial disease that is spread by pollinators and rain splash. It first appears in the blossom clusters as wilting and collapse of the cluster. Diseased tissue produces brownish, sticky exudates. The tips of the infected, young succulent growth shoots curve into a characteristic shepherd's hook and appear to have been burnt. Warm, wet spring weather is ideal for disease development. Control: Remove diseased plant parts and prune to healthy wood. Dispose of infected plant materials. Use streptomycin or copper spray formulation during bloom to help prevent infestation.
- **Fusarium Wilt** is a fungal disease that can affect cantaloupe. It causes root rot and wilt as the plant develops, generally after fruit set. Plants



Pear, Apple

Melon

may develop a yellow runner on one side of the plant followed by rapid wilting of the infected runner. Other runners begin showing symptoms and the whole plant can collapse. In soils where the inoculum is high, seedlings may wilt. The disease is long-lived in soil and can remain viable for 20 years or more. Control: Good sanitation, planting resistant varieties and cleaning equipment between fields can help reduce the infestation. Seed treatment can also be effective for control.

- **Curly Top Virus** is a disease that affects tomatoes in Nevada. This disease is transmitted by leaf hoppers, which carry the disease for life. Leaf hoppers have a wide range of hosts. Plants with curly top stop growing and become stunted. The plants turn yellow or bronze in color and leaves may have a purple tinge. The plants become stiff and soon die. Leaf hoppers tend to feed on the plants that border bare soil areas, so the edges of the field are most susceptible. Control: Dusting transplants as soon as they are set out and as new foliage appears, until fruit set, will discourage leaf hoppers. Talc, diatomaceous earth or finely ground pumice are equally effective. There are no curly top resistant varieties of tomato to date.

Tomatoes

Vertebrate Pests in Agricultural Plants

Vertebrate pests are those pest animals that have backbones. Specific control measures vary for different species and are discussed in the sections for individual species.

Common vertebrate pest control practices

- **Exclusion:** Keep the pest out or away from crops by using barriers, such as fencing and row covers.
- **Sanitation:** Eliminate food and water sources. Store food and animal feeds, grain and seed in rodent-proof containers. Repair leaky pipes.
- **Trapping:** There are several types of kill traps and live traps available for most vertebrate pest species. Choosing the proper trap and learning the correct way to use it is critically important. **Live trapping and releasing is not acceptable or legal.** Individuals who release live trapped animals are moving the pest problem and sometimes diseases like rabies, distemper or plague along with them. Live trapping followed by an approved method of euthanasia is recommended. The American Veterinary Medical Association has specific guidelines for euthanasia.
- **Repellents:** Repellants may be applied to valuable vegetation or can be used in areas where pests are known to frequent. They often don't work the way people expect them to work. Sunshine can break down the

repellent, and sprinklers and rain can wash away the product. New growth on plants must be retreated and animals may simply get used to the repellent.

- **Rodenticide Baits:** Baits like seeds, grains and vegetation treated with rodenticides are used to control several types of vertebrate pests. Most baits must be applied in bait stations or underground within animal burrows to lessen the risk of killing of non-target species. Pesticide labels describe methods for applying the bait. Pesticides used include strychnine, zinc phosphide and various anticoagulants. Strychnine may only be applied underground.

- **Fumigants:** Smoke bombs and internal combustion engines produce poison gases, including carbon monoxide, that can be used as fumigants. To be effective, all burrow entrances must be blocked. When using smoke bombs, avoid areas near structures, hay stacks, etc.

  Aluminum phosphide fumigants are available either as tablets or pellets. When applied in rodent burrows, they produce phosphine gas, which is deadly. Applied improperly, aluminum phosphide has resulted in numerous human deaths. To purchase, apply or supervise the use of this pesticide, applicators must successfully pass the state rodent burrow fumigation certification category.

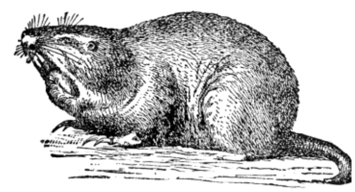
Specific Vertebrate Pests

Ground squirrel

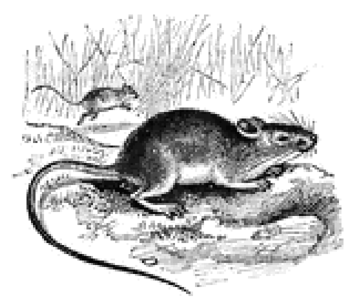
- **Ground Squirrels:** Four species cause problems to crops and ornamental plants in Nevada: Richardson's, Belding's, Townsend's and California ground squirrels. They may also damage irrigation lines by chewing them or damage landscapes and buildings by burrowing. The best time for control is after they emerge from hibernation in early spring. At this time of year, there is little green vegetation, so the ground squirrels are more likely to accept rodenticide baits. Additionally, at this time of year, they have not yet mated and given birth. If control is postponed until later in the spring, there is green vegetation available and the ground squirrels are less likely to accept rodenticide baits. Advanced planning and preparation are essential. Attempting to control squirrels after they have reproduced can be frustrating, expensive and practically impossible. In order to eliminate exposure to non-target species, product labels for some rodenticide baits require application in bait boxes. Live trapping and subsequent euthanasia are also used to control ground squirrels. Check traps often and use caution to prevent unintended injury or death to non-target species. Strychnine cabbage bait, a restricted use pesticide, is well accepted but it must be used underground to protect non-target species. When applying grain baits, pesticide labels advise users to pre-bait. This is the process of applying untreated grain and monitoring to see if the animal takes it. If the animal isn't taking the untreated bait, it won't take the treated bait. As these animals can be carriers of bubonic plague, use care in handling sick or dead animals.

- **Moles:** Moles are insectivorous and are not a serious problem in Nevada. 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. Soil insecticides may be used to reduce the mole's food supply. This may encourage them to move off a property.
- **Pocket Gophers:** Pocket gophers live underground and damage crops and ornamental plants by feeding on roots and sometimes foliage. Their burrows also cause damage to farm equipment and sprinkler systems. Gopher activity is determined by fresh mounds that are typically horseshoe-shaped. Burrows are four to 10 inches underground. Strychnine grain bait, a restricted use pesticide, is most effectively applied in fall or early spring. The bait must be applied below ground. Hand-apply or use in a burrow builder for large areas. Synchronize application with neighbors for best results. Anticoagulant and zinc phosphide baits are also available. Trapping with kill traps is another commonly used control method for pocket gophers.
- **Mice and rats:** These rodents eat and contaminate food and animal feed. They will both defecate and urinate on food and feed. They feed on alfalfa crowns and damage forage, seed and ornamental plants by girdling. They also cause structural damage by chewing both wood and wiring. They carry diseases contagious to humans, such as Rickettsial pox, bubonic plague and leptospirosis. <u>No control method will be successful without excluding subsequent mice and rats from entering the site</u>. Seal any opening over ¼-inch. Use good sanitation practices to remove any food supply that may attract these rodents, including seed for planting. Use rodent-proof containers to store all food and animal feed to prevent attracting and feeding these pests. Anticoagulant baits are most commonly used. Use care in placing these anticoagulant baits. Pesticide baits must be applied in approved bait stations. Snap traps can be effective, provided exclusion measures are also put in place. Baits for trapping include peanut butter plus oatmeal, bacon, gumdrops (for mice), nutmeats and dried fruit. Rat and mouse urine fluoresces under UV light. This can be used to locate their trails and commonly frequented areas. Bait and trap in these areas. Check traps daily and use care handling dead rodents.

Mole



Pocket gopher

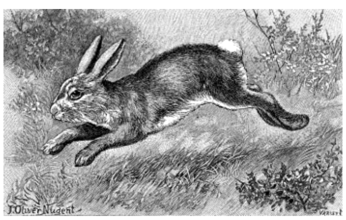


Field mice

- **Voles:** Voles are also referred to as meadow mice or field mice. They eat a wide variety of plants including grasses, forbs and seeds. When populations are high, voles will damage cropland through construction of tunnels and surface runways. They eat bark, primarily in the fall and winter. This can cause severe damage to trees and shrubs by girdling them. Voles breed throughout the year and may have five or more litters of young annually. Populations fluctuate and may reach extremely high densities. Habitat modification and toxicants are the primary means of vole management. Remove ground cover, weeds and litter around croplands to reduce populations. Zinc phosphide is the most common rodenticide used for vole control and is available on grain bait. Pesticide labels require that zinc phosphide baits be applied in the burrows and runways. Some product labels require the use of bait stations.

- **Blacktailed Jackrabbits:** Jackrabbits cause damage by feeding on crops and ornamental plants. A 45-degree angle cut to stems or branches is typical of rabbit damage. Jackrabbits don't hibernate, so they are active all year long. They have cyclic populations. They will travel long distances for food. The best control is exclusion. Jackrabbits are not easily trapped. Since they generally come in from surrounding rangeland, trapping and removing one simply allows another to take its place. Exclusion fences are recommended around haystacks, small areas, ornamentals and gardens. Shooting is an option as blacktailed jackrabbits are not protected, but it must be done only where it is safe and legal to do so. Repellents can be effective, but must be reapplied on a regular basis and especially after rain or irrigation water wash them away. There are no registered poisons or fumigants for use on rabbits in Nevada. Strychnine (a restricted use pesticide) is no longer registered for jackrabbit control.

- **Cottontail rabbits and whitetailed jackrabbits:** Cottontail rabbits and whitetailed jackrabbits are usually considered pests in the landscape. Control is similar to that for blacktailed jackrabbits. Exclusion is the best control option. While they can be trapped, trapping is not the best control method, and there are no toxicants registered in Nevada for control of either of these rabbits. The information provided for jackrabbits applies to both of these rabbits as well, with one exception: cottontail rabbits and whitetailed jackrabbits are game species in Nevada. Since they are designated game species, they can be shot only during cottontail rabbit and/or whitetailed jackrabbit hunting season, and you must have a hunting license.



Rabbit

For all rabbit species, exclusion is the best control method.

- **Birds:** Droppings, disease and consumption of crops and livestock feeds all make pests of certain birds. Caution must be used when dealing with bird pests, as many birds are protected under the Migratory Bird Treaty Act (MBTA). As with all other pests, you must first identify the pest causing your problems. The following common bird pests are <u>not protected</u> by the MBTA:
  - **Pigeons (Rock doves):** Pigeons were introduced to the U.S. as domesticated birds and are now found throughout the country. They depend on human activities to provide them with food and shelter and have become serious pests in agricultural and urban areas. Pigeons feed on grains, seeds and garbage, and food is regularly provided intentionally by humans. Other damage results from pigeon fecal material and filth in areas where they nest, roost and loaf. Pigeons assemble sticks and twigs to form crude nests that are built in or on buildings and other structures such as billboards. Breeding occurs year-round but peak reproduction is in the spring and fall.
  - **House Sparrows:** House sparrows were introduced to New England in 1850 and spread throughout the North American continent. They prefer human habitats, especially urban and farm areas. House sparrows feed mainly on grains and seeds but garbage and other refuse contribute significantly to their diet. Breeding can occur any time but March through August is most common. Problems are caused by feeding activities and fecal contamination in feed storage areas as well as inside and outside of other buildings.
  - **European Starlings:** These birds were introduced to North America in the late 1800's. Starlings cause problems at livestock facilities and in urban areas by consuming fruits and livestock feed. Holes or cavities in trees and structures serve as nesting sites and large roosts in buildings and trees cause health concerns and other problems due to filth, noise, and odor.

Bird Management: Exclude birds from nesting sites by closing openings that are larger than ¾ inch. Eliminate access to nesting and roosting sites by installing barriers, such as metal, netting or needle strips (porcupine wire). Roosting sites, such as ledges, can be eliminated by changing the angle to 45° or more. To discourage birds, use tactile repellents such as sticky bird glue on ledges and roosting areas. Recreational bird feeding attracts pest species. Limit the availability of food by storing livestock and other food in bird-proof facilities and containers. Prevent access to water sources.

Pesticides used for bird control are called avicides. These products are applied on baits and are classified as restricted use pesticides. Bait material

House sparrow

Pesticides used for bird control are called avicides.

The first step in pest control is to correctly identify the pest. It is imperative to determine that the damage you see was actually caused by a pest.

may include small grains and whole kernel corn, depending on the bird species. The process of pre-baiting is recommended on avicide labels.

Conclusion

Category 1A, Agricultural Pest Control – Plants, is the category that covers pesticide applications on crops. This includes fruit and vegetable crops, small grain crops, feed crops and forage crops.

The growth of a single type of plant, also known as a monoculture, can provide an ideal setting for diseases, weeds and animal pests to develop and thrive. Pesticides are often needed to reduce pests to tolerable levels, but they can have serious consequences if applied improperly. Pesticides can harm non-target plants, beneficial insects, wildlife, pets, livestock and humans. Thoughtful planning and implementation are required to reduce pest pressure, minimize unintended damage, reduce costs and maximize profit.

The first step in pest control is to correctly identify the pest. It is imperative to determine that the damage you see was actually caused by a pest. Consider all control options for managing the pest. Keep records of you management efforts and their success.

Unless otherwise noted, all line drawings are from Clipart ETC, Florida's Educational Technology Clearinghouse, University of Southern Florida, http://etc.usf.edu/clipart/index.htm

Originally published in 1987 as Category 1A – Agricultural Pest Control, Plants, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

Category 1B: Agricultural Pest Control – Animals

Agricultural Pest Control – Animals Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe Integrated Pest Management (IPM) as it applies to agricultural pest control on animals.**
- ✓ **Describe pesticide safety around animals.**
- ✓ **Explain the difference between ectoparasites and endoparasites.**
- ✓ **Describe some of the most common insect pests of livestock and the different measures that can be used for control.**

Category 1B, Agricultural Pest Control - Animals

Category 1B, Agricultural Pest Control – Animals, is the category that covers pest control of both internal and external parasites in livestock. Livestock includes cattle, sheep, goats, swine and poultry. Livestock production concentrates groups of animals close together. This can provide ideal conditions for the development and expansion of insect parasites.

Category 1B, Agricultural Pest Control – Animals, covers the pest control of both internal and external parasites in livestock.

Livestock production is a business. Pesticides cost money and time, and their use can reduce profits. Pesticides can have serious consequences if applied improperly. They can harm non-target insects, beneficial insects, wildlife, pets, livestock and humans. Pest management in livestock production is further complicated by the end use of the animals. The products the animals produce, such as milk, eggs and fiber, will be used or consumed by humans, as will the animals themselves. Thoughtful planning and implementation is required to minimize unintended damage, reduce costs and maximize profit.

Integrated Pest Management (IPM)

The principles of Integrated Pest Management can be applied to controlling insect pests in livestock production.

- **Pests, their hosts and beneficial organisms must be positively identified.** The pest must be correctly identified. If you can't identify the pest, collect samples and submit them to the University of Nevada Cooperative Extension or the Nevada Department of Agriculture for identification. Once the pest is identified, determine the pest's life cycle, growth cycle and reproductive habits.
- **Establish monitoring guidelines for each pest species.** Routine monitoring of both pests and natural enemies (beneficial species) is a critical part of IPM. Methods of monitoring include visual inspection and pest counts. Document and track both pest and beneficial organism population numbers. The ratio of natural enemies, usually insects, to pests should be taken into account before a pesticide is applied.
- **Establish an action threshold for the pest**. A fundamental concept of IPM is that a certain number of individual pests can and should be tolerated. Will the pest cause unacceptable damage to the value of the animal? **What will happen if no action is taken?** The action threshold in livestock production is generally based on economics. The **economic threshold** is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density, or population level, at which a control application should be made. The threshold is different for each pest.
- **Evaluate and implement control tactics.** Select tactics that will be most effective, most economical and have least impact on non-target species and the environment. Select controls that are least likely to harm beneficial organisms but are effective at suppressing the pest. If chemical controls are required, rotate pesticides. Use products with different mechanisms of action to reduce the risk of developing pesticide resistance.
- **Monitor, evaluate and document the results.** This allows you to make adjustments to improve the effectiveness of future pest control strategies.

Principles of IPM:

- **Identify the pest.**
- **Monitor the pest population.**
- **Establish an action threshold.**
- **Evaluate control options.**
- **Implement control tactics.**
- **Monitor results.**

If chemical controls are required, rotate pesticides. Use products with different mechanisms of action to reduce the risk of developing pesticide resistance.

Pesticide Safety Around Animals

Pests of domestic animals can be serious threats to an animal's health and the owner's bottom line. Pesticide products are often needed to control the pests. Pesticides are formulated to kill pests and should be used with caution, as livestock are consumed by humans or produce products, such as milk and eggs, that are consumed by humans.

When selecting a pesticide, make sure:

- The label lists the pest you are trying to control.
- The label lists the animal or site on which you want to apply the pesticide.
- The formulation is correct for the application site and conditions.
- The right application equipment is available.
- The right safety equipment is available.

Never use more pesticide than is stated on the label. Young animals are very susceptible to overdoses of pesticides. Overdoses of pesticides may be fatal or may weaken or injure animals. Weakened animals are more susceptible to diseases and predators.

Remember that most pesticides are applied according to the body weight of the animal. Check that there are no minimum weight or age requirements for application of the pesticide. You must also know the withdrawal times for animal harvest or use of animal products. Keep careful records and make sure previous applications of pesticides or medications will not interfere with the pesticide application or cause undesirable effects.

Use caution when applying the pesticides. Mix only the amount of pesticide needed for that day. Cover all animal feed and water. Use the correct Personal Protection Equipment (PPE) specified by the label. Apply the pesticide under the best conditions to reduce drift or contamination of adjacent sites, animals or humans. Clean application equipment properly and dispose of any excess pesticide appropriately.

Insect Pests

Insect pests are the biggest pest problem affecting livestock production. The insects that affect livestock are generally parasitic and feed on livestock at some stage in their lives. These pests can cause loss of gain and undue agitation and stress in infected animals. The damage these pests inflict may also damage the carcass, hide or fleece of the infected animals. The effects of an infestation can be devastating and occasionally life-threatening to very young livestock. Basic insect identification information can be found in General Knowledge: General Pest Problems section of this manual.

Insect pests of livestock can be divided into two basic categories: endoparasites and ectoparasites.

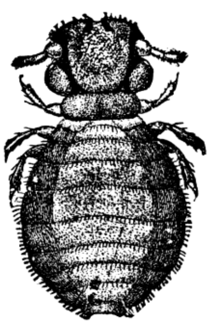
Never use more pesticide than is stated on the label. Overdoses of pesticides may be fatal or may weaken or injure animals.

Remember that most pesticides are applied according to the body weight of the animal. Check that there are no minimum weight or age requirements for application of the pesticide.

Insect pests are the biggest pest problem affecting livestock production.

Endoparasites are those that spend their entire lives inside the animals.

Ectoparasites spend all or a portion of their lives living on the outside of the animal.



Chewing Lice

Lice are about the size of a flea and will be observed moving around.

Endoparasites are those pests that spend their lives inside the animal's organs or organ systems, such as the gut, heart, lungs, etc. Examples are flukes, roundworms, heartworms, etc. Grubs are not endoparasites, but horse bots are. It is imperative to properly identify these pests. This may require collecting feces, blood or other samples and having subsequent microscopic examination. Consult with professionals and select an appropriate method of control for these pests.

Ectoparasites are the most common and damaging pests of livestock. They attach themselves to the outside of the animal and spend all or a portion of their lives there. Examples are flies, ticks, mites and lice. Not all life stages of these pests are harmful to livestock. Control of these pests may be better accomplished at certain life stages of the pest.

Specific Insect Pests of Livestock

Lice: Lice are parasites that must reside on an animal to survive. Lice are species-specific. Each species of lice attacks only one species of livestock. There are many different types of lice. Lice can have either chewing mouthparts (Mallophaga insect order) or sucking mouthparts (Anaplura insect order). Chewing or biting lice bite the animal, feeding on feathers, fur, skin or blood, and then move on to the next meal. Sucking lice attach themselves to the livestock and continuously feed on the animal's blood. Sucking lice can be a vector of disease. Both types of lice are wingless. Both can cause stress and loss of gain in livestock. Lice can cause skin irritation when they feed, which causes the animal to scratch or rub the site. This can cause skin abrasions that can lead to secondary infections. It can also damage hides and fleece. The animal may spend so much time and energy trying to rid itself of the pest infestation that it may eat less and drop its rate of gain. A heavy infestation of lice can be debilitating, causing anemia, dermatitis, hair loss, low weight gain and low milk yield.

Lice are transferred between hosts by direct contact: they crawl from one host to another. Some lice can survive a few days without a host and may transfer to a new host via shared areas, such as bedding, feeding or scratching areas. Lice infestations are generally highest in the winter.

Some animals are more susceptible to lice than others. These carrier animals can infect the whole herd. Checking for a lice infestation can be done during preventative vaccine administration. Look for lice in the hair or fleece around the head, neck, ears and dewlap. Lice are about the size of a flea and will be observed moving around.

The threshold for initiating control measures is the presence of lice. No numeric threshold need be reached. Feeding animals a high-energy diet and maintaining uncrowded conditions will reduce the incidence of a lice infestation. Quarantine of infected animals helps to reduce spread.

There are a number of ways to treat lice. Dipping, spray-applied insecticides, pour-on insecticides, dusting, dust bags, spot-on insecticides and insecticide ear tags are all methods of chemical control for lice. Systemic injectable insecticides work well on sucking lice, but may not control biting lice. Most of the surface treatments only control the adults or nymphs; eggs will not be affected. For this reason, certain treatment methods must be repeated in two weeks to eliminate the hatching eggs.

Horn Fly: Horn flies are small (3-4 mm) gray-black flies. When feeding on livestock, they are usually in a head-down position. Horn flies have piercing sucking-type mouth parts and they feed on livestock blood. They are the number one pest of cattle in the world. The fly spends all of its adult life on livestock, leaving only for short intervals to lay eggs in fresh manure. Each female can lay 500 eggs. The fly progresses from egg to adult in only 10 to 14 days, so a new generation can be produced every 2 weeks. They congregate on body areas of livestock where they cannot be disturbed or easily dislodged. Severe infestation can cause weight loss, reduced milk production and reduced vitality. Animals may become very agitated when trying to dislodge the flies and may injure themselves in the process. The economic threshold is generally 200 flies per animal or 100 flies per side of animal.

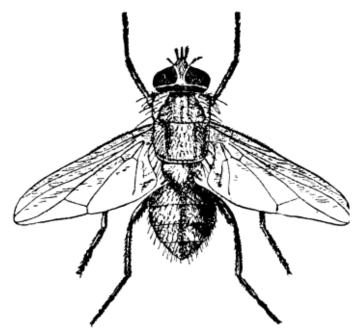
For small operations, breaking up manure by dragging pastures and corrals every 48 hours can reduce fly populations by 50 percent. This cultural control method is not viable for large operations. Because horn flies lay their eggs in fresh manure, manure management is not as viable a cultural control option as it is in house fly and stable fly control.

Biological controls are limited to organisms that naturally occur in the field, such as predaceous mites, predaceous beetles and parasitic wasps. There are no biological controls commercially available to augment these naturally occurring biological controls, like there are for stable flies and house flies. The parasitic wasps developed as a biological control for house flies and stable flies are ineffective against horn flies. Dung beetles can reduce horn fly numbers by removing and burying manure before the fly completes its development, but the dung beetle population has not kept pace with increases in livestock production.

Mechanical control consists of a walk-through fly trap. The trap is based on the inverted cone principle, where insects are funneled in through a large opening and subsequently can't find an escape route through a small opening. The traps are placed in an area in the pen or pasture that all the

Lice are the most common ectoparasite of swine.

Two of the most common ectoparasite pests of beef cattle are the horn fly and lice.

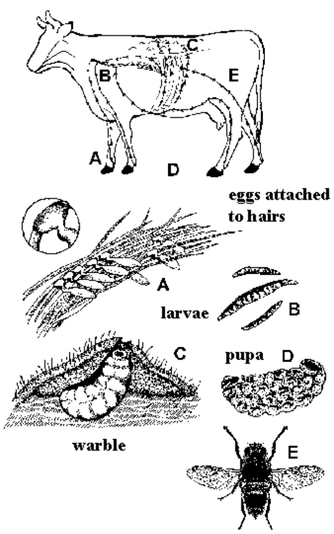


Horn Fly

cattle must walk through on a regular basis, such as water source or salt lick. The trap stirs up the flies and funnels them into an enclosure that has an opening too small for them to exit. Research indicates the use of these types of traps can reduce horn fly populations by 50 percent or more. An explanation and diagrams of this type of trap can be found at the Extension Beef Cattle Resource Committee, Beef Council Handbook, Non-chemical Horn Fly Traps, http://www.iowabeefcenter.org/bch/HornFlyTraps.pdf.

Chemical controls include pesticide sprays, dips or injections. Pesticide-impregnated ear tags will control horn flies and several other pests of livestock. The tags spread pesticide when the animals rub themselves and rub against each other. The tags are removed when the pest season is over to reduce the potential for developing pesticide resistance. There are several different ear tags available that contain pesticides with different modes of action. See http://livestockvetento.tamu.edu/files/2010/10/Insecticide-Impregnated-Ear-Tags-for-Cattle3.pdf. Rotating the use of ear tags with different modes of action will also reduce the potential for pesticide resistance to develop in horn flies and other pests.

Heel or Grub (Bomb) Fly: Heel flies and grub or bomb flies are significant pests of cattle and may also be found on goats, sheep and horses. On rare occasions, they have been found on man. The life cycle of these pests takes an entire year to complete. The adult flies are large and resemble bumblebees. They do not bite or feed on the host animals. The adults lay their eggs on the host animal's hair or hide, generally in the leg areas. The eggs hatch and the larvae or grubs crawl down the hair to the skin and burrow into the host animal. The fly larvae migrate through the animal. Heel fly larvae may cluster together around the esophagus, diaphragm, small intestine or heart. After a few months, the grub or bomb fly larvae migrate to connective tissues on the back, near the spine. The larvae cut small holes through the hide for breathing. In response to the injury, cysts form around the larvae in the host animal. When the larvae are mature, they emerge from the cysts, fall to the ground and pupate.



Life cycle of Heel or Grub Fly
http://edis.ifas.ufl.edu/in146

The adult flies are nuisances and may cause animals to expend a lot of energy running from them or standing in deep shade or water. Once infected with the grubs, the host animal's skin can become irritated and the grubs can cause injury to organs and hides. All of these factors can contribute to a reduction in weight gain and milk production. At slaughter, damaged areas of the carcass cause a reduction in useable meat.

Since the adults do not feed, treatment and control is focused on the larvae. Larval treatment for heel or grub flies must be properly timed. Treating infected animals when the larvae are clustered near the esophagus or spine can cause stress, injury and even death. If the larvae die inside the animal at these sites, it can cause inflammation that may also cause chronic bloat or suffocation when the larvae die near the throat (heel fly) or paralysis of the hind quarters when the larvae die near the spine (grub or bomb fly). Treatment should be done before the grubs migrate to esophagus or spine. In general in Nevada, do not treat for these pests in November and December; wait to treat until January or February. Treatment may be done with sprays, dips or injections.

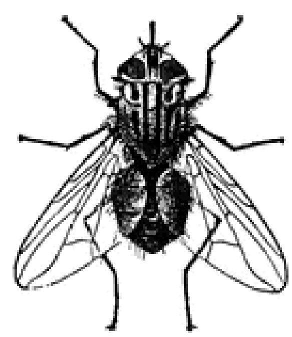
House Fly: House flies are the number one pest of dairy operations. They are difficult to control as they lay eggs in any kind of decaying organic matter. They do not bite livestock but they can be a nuisance, feeding on nasal and ocular (eye) secretions and causing livestock to expend energy in avoiding them rather than feeding. They may also be vectors of certain diseases and parasitic worms.

House Fly

House flies are about 6 mm in length and dull gray in color, with 4 stripes running the length of the thorax. Their eyes are reddish. House flies have sponging mouth parts and do not bite. They breed quite rapidly, going from egg to adult in six to 10 days. The adults can live up to 30 days, with the females laying eggs continuously. This rapid rate of development and large egg population can cause large populations to build rapidly.

Sanitation is the best control method for house flies. Clean up manure, spilled feed and grain, and soiled hay to limit breeding sites. Dust bags placed in dairy operations as the cattle leave the milking parlor can aid in control. Dust bags should contain an insecticide that leaves little or no residue at the next milking. Parasitic wasps as biological controls have shown some success, but require repeated releases of the wasps. Insecticidal baits and traps may help reduce numbers. Residual sprays on buildings, corrals, and other fly resting places may aid in control.

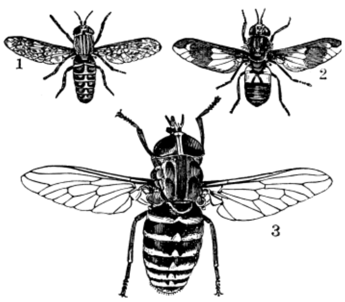
Stable Fly: Stable flies are biting flies, gray in color and approximately 7 to 8 mm long. They have a checkerboard pattern on the abdomen. Stable flies look very similar to house flies, but have a bayonet-like mouth part for sucking blood. Both males and females consume blood. The stable fly bite is quite painful and they will also attack humans. When feeding, they are usually in a head-up position. Unlike horn flies, they do not live on the animal, but only reside on the animals when feeding.



Stable Fly

Stable flies can fly 70 miles or more from their breeding site, so new populations may re-infest operations periodically throughout the season. Breeding sites for these flies are similar to house flies: decaying vegetation and old manure. They will not lay eggs in dried materials. They cause economic losses when their numbers are great enough to cause weight loss due to blood loss and disturbance of feeding.

Similar to house flies, the best control of stable flies is sanitation. Clean up manure, spilled feed and grain, and soiled hay to limit breeding sites. Dust bags placed in dairy operations as the cattle leave the milking parlor can aid in control, but are not as effective as for house flies. Parasitic wasps as biological controls have shown some success, but they are not as effective for stable flies as for house flies. Insecticidal baits and traps may help reduce numbers. Residual sprays on buildings, corrals, and other fly resting places may aid in control.



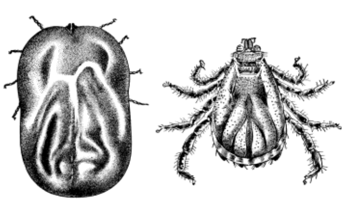
Horse Flies

Horse Fly or Deer Fly: These are large, dark brown to dark gray flies. Horse flies are 25 mm in length and deer flies are 6 to 10 mm long. Females bite livestock using their cutting and sponging mouthparts. The females feed intermittently but frequently, generally feeding on the back, neck and sides of livestock. They lay their eggs on vegetation near water sources. Both horse flies and deer flies can cause agitation and loss of gain in livestock. They may also be vectors of disease.

Control is difficult. Since they lay eggs on vegetation, removing breeding sites is not possible. Larval stage control is impossible, as it requires removing water sources. Control at the adult stage is nearly impossible as the flies only feed intermittently and are able to fly long distances from their breeding sites. Back rubbers and dust bags may provide some control.

Face Flies: Face flies are dark gray flies approximately 6 to 8 mm in length. They resemble house flies, but are slightly larger and darker in color. These pests congregate around the eyes and nostrils of cattle. They feed on nasal and ocular (eye) secretions. Face flies only spend 5 to 10 minutes per day actually feeding on the cattle. They are a nuisance, causing agitation and loss of gain in cattle. They can also be a vector of *Moraxella bovis*, more commonly known as pink eye.

Control is difficult because the flies spend such a limited amount of time on the cattle. Ear tags can aid in control, but ear tags for both ears are required for adequate control. Dust bags and back rubbers can be effective if they are placed low enough to contact the face.



Cattle Tick

Ticks: Ticks are small arthropods with eight legs and no antennae. Ticks can be subdivided into hard ticks and soft ticks. All life stages of ticks are visible with the naked eye. Each life stage of a tick requires a blood meal. Some ticks live on one host their whole lives, but most are three-host ticks, living on three different hosts for larva, nymph and adult stages. Most soft ticks are multi-host animals, feeding from many different animals. Soft ticks generally reside in bedding or nesting areas of animals, feeding on multiple hosts and laying eggs after each meal.

Hard ticks acquire their host animals by a behavior called "questing." The tick climbs onto vegetation, such as a grass blade or the end of a shrub branch, and extends its legs. When an animal brushes against the vegetation, the tick pulls itself onto the animal. The tick attaches to the animal and begins to feed.

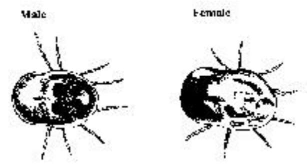
Hard ticks include the American dog tick, Rocky Mountain wood tick, the deer tick, also known as the black tick, the winter tick and the brown dog tick. These ticks feed on wildlife, livestock, pets and humans. Severe infestations can cause anemia from blood loss, worry, agitation and irritation in animals, weight loss or reduced rate of gain, and injury to hides and fleece. The wound made by the tick may provide an entry point for other insect pests or disease. Ticks can be the vectors of several diseases that can affect both animals and humans, including Rocky Mountain spotted fever, Lyme disease and tularemia. It is important to identify the type of tick to determine if further testing for disease is warranted.

Treatment for hard ticks consists of managing vegetation around animal enclosures to limit questing sites. Good sanitation of bedding or crowded animal areas may help limit the infestation. Treatment of the entire range is not practical or affordable. Treatment of individual animals may be done by hand-picking the pests from the host animals.

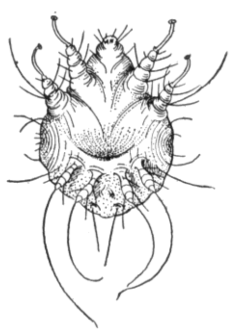
For multiple animal infestations, chemical sprays or dips may be warranted. Ear tags, similar to flea and tick collars for dogs and cats, may aid in controlling tick infestations in livestock. The tags spread pesticide when the animals rub themselves and rub against each other. The tags need to be removed when the pest season is over to reduce the potential for pesticide resistance to develop. There are several different ear tags available that contain pesticides with different mechanisms of action. Rotating ear tags with different mechanisms of action will also reduce the potential for developing pesticide resistance.

Soft ticks of importance to the livestock industry include fowl ticks, also called blue ticks, and Spinose ear ticks (see below). **Fowl ticks** live in bedding or nesting areas, moving onto the animals to feed, mainly at night, and then moving back off the animals. Severe infestation causes anemia, loss of feathers and reduced egg production. Since these ticks do not live full-time on the host animals, control is best achieved by good sanitation in the living and nesting areas. Remove soiled bedding and nesting materials. Severe infestations may require chemical treatment of nesting and living areas.

Spinose Ear Ticks: These pests are soft ticks that infest cattle, horses, dogs



Spinose Ear Ticks
ianrpubs.unl.edu



Sarcoptic Mange Mite

Incidence of sarcoptic mange should be reported to the Nevada State Veterinarian.

and humans. They spend their larval and nymph stages feeding in the ear canal. Affected animals will shake their heads and rub their ears trying to dislodge the pests. Animals with severe infestations will appear dull and listless, and may begin to lose weight. Place new herd animals in quarantine to help avoid infestation. This may not be feasible, since the larva and nymphs can live in the ear for 4 months or more.

Chemical control is the most commonly used control method. Insecticidal ear tags are used, as are insecticides applied into the ear canal during other routine preventive medication applications. Remove the tags when the pest season is over to reduce the potential for developing pesticide resistance. There are several different ear tags available that contain pesticides with different mechanisms of action. Rotating use of ear tags with different mechanisms of action will also reduce development of pesticide resistance.

Psoroptic Mange Mites: Psoroptic mange mites are non-burrowing mites that live on the skin surface of infected animals. These mites puncture the skin and feed on lymph fluids (clear body fluids, not blood) or feed on skin scales. Feeding causes intense itching and scabs. These mites tend to affect the hairiest portions of the animal's body, particularly the back, shoulders and sides. Skin scrapings and microscopic identification is required to diagnose the presence of these pests.

Management of non-burrowing mange mites is difficult. A single infected animal should be quarantined and treated. The whole herd may require quarantine treatment. Control is generally limited to chemical methods, such as dips, sprays, or injectable pesticides.

Sarcoptic Mange Mites: Sarcoptic mange mites are burrowing mites that live under the skin of affected animals. These mites can infest horses, cattle, sheep, goats, swine and dogs. They do not affect cats, rabbits or fowl. These burrowing arachnids cause intense itching and skin irritation. Infested animals may scratch themselves so much they develop weeping sore spots on their skin, which may be a site for secondary infections or insect infestations. Generally, the mites target the least hairy portion of the animal's body, which differs for each species of animal. Females burrow into the skin, feed on lymph fluid and lay eggs. The eggs hatch, leave the burrow and wander on the animals to a new site, finally reaching adult stage. Then, they mate; the females dig a burrow and lay more eggs. Generally, a microscope is required for accurate diagnosis.

Similar to non-burrowing mites, management of burrowing mange mites is difficult. A single infected animal should be quarantined and treated. The whole herd may require quarantine treatment. Incidence of sarcoptic mange should be reported to the Nevada State Veterinarian.

Conclusion

Livestock production concentrates groups of animals close together. This can provide ideal conditions for the development and expansion of insect parasites.

Livestock production is a business. Pesticides cost money and time, and their use can reduce profits. Pesticides can have serious consequences if applied improperly. They can harm non-target insects, beneficial insects, wildlife, pets, livestock and humans. Pest management in livestock production is further complicated by the end use of the animals. The products the animals produce, such as milk, eggs and fiber, will be used or consumed by humans, as will the animals themselves. Thoughtful planning and implementation is required to minimize unintended damage, reduce costs and maximize profit.

The first step to pest control is to correctly identify the pest. Consider all control options for managing the pest. Keep records of your management efforts and their success.

The first step to pest control is to correctly identify the pest. Consider all control options for managing the pest.

Unless otherwise noted, all line drawings are from Clipart ETC, Florida's Educational Technology Clearinghouse, University of Southern Florida, http://etc.usf.edu/clipart/index.htm

Originally published in 1987 as Category 1B – Agricultural Pest Control, Animals, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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Category 2: Pest Control on Forest and Rangelands

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Pest Control on Forest and Rangelands Learning Objectives

After studying this section, you should be able to:

- ✓ **Define the major forest and rangeland use objectives.**
- ✓ **Describe the different types of forest insect pests based on the type of feeding damage they inflict.**
- ✓ **List the most common forest diseases.**
- ✓ **Apply Integrated Weed Management (IWM) on rangelands.**
- ✓ **Identify the different control methods available for rangeland IWM.**
- ✓ **Describe the most common vertebrate pests that impact forests and rangelands in Nevada and control strategies for each.**

Category 2, Pest Control on Forest and Rangelands

Category 2, Pest Control on Forest and Rangelands, is the category that covers pests of forest trees, both evergreen and deciduous, and rangelands plants, which include grasses, forbs and shrubs.

Recent changes in Nevada's legislation limit forest and rangeland certified applicators to the following: residential landscapers, homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the

If you wish to apply pesticides to public properties you must now be a licensed government applicator.

Forest and Rangeland Uses:

- **Watershed protection**
- **Wildlife habitat**
- **Timber management**
- **Recreation**
- **Forage for livestock**
- **Tree nurseries**
- **Suburban and urban forest**

Defoliators are chewing insects that attack foliage.

Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

Category 2, Pest Control on Forest and Rangelands, covers insects, plant pathogens, weeds and vertebrate pests that cause damage on or interfere with land use on forest and rangeland sites. Nevada covers more than 100,000 square miles and a significant portion is made up of forests and rangelands. Nevada's forests and rangelands provide valuable forage and habitat for livestock and wildlife. Recreational activities are also important land uses. Applicators must consider various land use practices and resources associated with these lands when developing pest management strategies.

The primary pests on these sites are weeds and insects. Plant pathogens and burrowing rodents are less frequent but can become pest problems. Pesticides are useful tools but must not interfere with other land management strategies. In order to accomplish effective pest control, applicators should take into account all land uses, consider all control methods available and apply pesticides according to label instructions.

Forest Insect Pests

Native and exotic species present unique threats to forests and wildlands. 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 occurred. 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.

Forest insect pests are usually grouped by how they feed and the location on the tree where they feed. Pest control is targeted accordingly.

- **Defoliators:** These are chewing insects that attack and remove foliage from trees. Defoliation of evergreens is much more serious than defoliation of hardwoods. Evergreens often die from a single year of attack, whereas some hardwood trees can withstand one or two defoliations in a single year or repeated 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, 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 can be difficult. Outbreaks may cover wide expanses of up to one million acres or more, and may be recurrent and progressive. It is against this group of insects that most chemicals are applied in forest areas. 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 pests that attack stressed and dying trees, although a few, especially 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 pitch moths and round headed woodborers.

Cambium and phloem feeders are insects that feed on the water- and food-conducting tissues in trees.

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 type of beetle. Pheromones can also be used to enhance the effect of trap trees.

- **Shoot and Root Feeders:** These insects are the most important insect pests 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.

Shoot- and root-feeding insects are serious pests in the nursery and Christmas tree industries.

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 root-feeding insects. Timing of chemical application to coincide with the

Sap-sucking pests include mites, aphids, scales, mealy bugs, spittle bugs and plant bugs.

Dwarf mistletoes are host-specific parasitic plants.

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 smaller trees and can cause severe tip damage if not controlled.

- **Sap Suckers:** This group includes mites (not insects), aphids, scales, mealy bugs, spittlebugs and plant bugs. These pests extract food from the plants through sucking mouthparts. This often results in the infested tree having a dry appearance. Trees often drip honeydew from the insects. If infestations continue, defoliation can occur. With evergreens, this is usually seen as loss of the two- to four-year old needles. 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. Only a limited number of recommended disease management practices involving chemicals apply to the urban environment.

- **Dwarf Mistletoe:** 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, minerals and organic compounds 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 tree’s normal physiological processes. Damage by dwarf mistletoe is recognized in four general categories:

- Reduced incremental growth. This may be 75 percent in some species.
- Increased mortality. This is often very high in young trees.
- Lower timber quality. Increased cull of logs or degradation of lumber.
- Indirect losses. Affected trees are predisposed to attack by opportunistic insects and fungi.

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 infested 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 infestations is an effective control practice. Replanting no-host species is a viable alternative where mistletoe infestations are severe.

- ***Cytospora* canker:** This fungal disease of poplars, cottonwoods, willows and some other shade trees is a common disease in Nevada. Pruning out infected branches and destroying them will help control this disease. It is important that trees not be stressed for water by drought or stressed by other factors in the establishment phase, as this increases their susceptibility to infection.
- **Forest nursery diseases:** 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 certain chemicals has given some control. Soil fumigation with various formulations has been relatively effective. Disease incidence is dramatically increased by overwatering or improper drainage.
  - **Foliage, stem and branch diseases:** *Phomopsis* canker, white pine blister rust, *Lophodermium* needle cast, *Cercospora* blight of juniper, and *Cytospora* canker of poplar are examples of this group. Various

Chemical formulations change all the time. Consult your local dealer for recommendations for your particular pest and site.

protective fungicides have provided 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.

Forest and Range Weed Pests

Properly managing for current and potential weed infestations on Nevada's vast rangeland is vital to protect and preserve rangeland health. There is a smaller amount of forest land, but weed management is equally important on these sites.

For the latest noxious weed list, see http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/

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, http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/.

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

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

The objectives of weed management on forest or range lands are to:

- Improve carrying capacity and productivity of range and forest lands.
- Reduce competition from weeds, thus improving growth of desirable vegetation and overall health of the range or forest.
- Improve 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)

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

Prevention: Prevention of weed infestations is a major component in effective long-term range and forest weed management programs. When planting in forests or on rangelands, use certified weed-free seed. Many weed species including noxious weeds are transported to uninfested areas in contaminated hay and straw. 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 other purpose.

Equipment, recreational vehicles, livestock and wildlife are capable of moving weeds. Clean equipment after working or traveling in an infested area 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, as 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 seven days and feeding them clean feed. Do not move soil, sand or gravel that is 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, are competitive and require the least number of inputs per acre. Most have fewer pests associated with them and, as a result, have 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 brush blades or chains dragged between two dozers are used to remove brush and prepare a site

Successful weed management considers all the potential control methods available:

- **Prevention**
- **Cultural**
- **Physical/ Mechanical**
- **Biological**
- **Chemical**

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 seven days with weed-free forage before moving them to anew area.**

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

for planting. Unfortunately, wheeled and tracked vehicles are limited to gentle terrain.

Prescribed burning can sometimes be used for pre-plant brush control, but is usually not effective on long-lived perennial noxious weeds and some native shrubs that re-sprout from the roots.

Hand removal of weeds by pulling, digging or hoeing, can be effective for selected weed species. Small infestations of annual and biennial weeds, such as musk thistle, Scotch thistle and dyer's woad, may be controlled in this manner. Remove weeds prior to flowering and seed set. The practice is usually not effective on perennial noxious weeds. Hand removal is labor-intensive and requires repeated treatment for several years to be successful.

Biological: Biological control uses living organisms or natural enemies, 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 rangelands. 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, but 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. Consult Nevada Dept. of Agriculture for information and permits for insect biocontrols.

Chemical: There are many herbicides registered for use on non-crop range, and forest sites and weed infestations in these areas often require herbicide treatment. For herbicides to be effective they must be applied according to label instructions. Herbicide selection should be based on the site and the weed species. Proper weed identification, environmental conditions and plant growth stage must be considered to get the maximum benefit from herbicides. Products that are effective at controlling one species may have no effect on others.

Serious infestations of Canada thistle, leafy spurge, purple loosestrife and perennial pepperweed will often be found in riparian areas and very near or 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 on weeds in forests and on rangelands is affected by:

- Site specific conditions, including soil class, type of terrain and aspect.
- Applicator skill.
- The chemical applied.
- The species and growth stage of the weeds.
- The type of equipment used.
- Climatic conditions at the site.

Environmental Fate of Herbicides

After an herbicide is applied, one or more things may happen. The herbicide may be taken up by the target plant or be washed off the plant and onto the soil by precipitation or irrigation. The herbicide may volatilize or be broken down by sunlight, a process called photodegradation. When herbicides contact the soil they may be broken down by microbes or sunlight. Herbicides can be transported through the soil into groundwater. This process is called leaching. Herbicides may also be carried by runoff from the target site into surface waters.

Application Methods

The size of the weed infestation, terrain and accessibility of the site are all factors when selecting application methods. Aerial applications are appropriate and necessary for some locations, while backpack spray applications are fine for others. Proximity to sensitive sites, such as water or urban and landscaped areas, may require that buffer zones be implemented, especially if using aircraft.

<u>Foliar Applications</u>: 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 3 to 10 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 adequate drift control, damage can occur to non-target plants in nearby watersheds, the herbicide may contaminate water, and private property may be damaged. Always read and follow the instructions on the label. Doing so reduces risks to the applicator, other people, non-target plants, animals and nearby properties. It is also the law.

1. Spot treatments are especially useful in controlling noxious weeds while avoiding drift. When making spot treatments, mix and load at the application site. To avoid water contamination, never mix and load herbicides near waterways, lakes, or wells. Use a nurse tank to supply the water, rather than

Chemical formulations change all the time. Consult your local dealer for recommendations for your particular pest and site.

Many chemicals effective on 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.

Follow grazing restrictions on the label when grazing animals are present.

If more than one application of herbicide is required to control a weed infestation, it is imperative to use herbicides with different modes of action to reduce the risk of developing herbicide resistance.

Without adequate drift control, damage can occur to non-target plants in nearby watersheds, the herbicide may contaminate water, and private property may be damaged. Always read and follow the instructions on the label.

filling spray tanks directly from a water source.

Wick 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.

Many herbicides used on forest and range sites are foliar applied compounds. Be aware that herbicides used for controlling weed species may also damage or kill desirable vegetation, and many native plants are extremely vulnerable. Some foliar applied products also have soil activity and may prevent germination of desirable species after the weeds have been controlled.

Basal Application: Trunks of trees and brush can be treated to selectively control woody species. 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 herbicide products in increasingly greater concentrations to control small woody plants less than 6 inches in diameter.

Cut-surface or Cut-stump and Other Applications: Trunks that are frilled or hacked at intervals around the trunk and stumps can be treated with herbicides to kill woody species and prevent resprouting. Cut-stump treatments are commonly used to control brushy or woody species, such as saltcedar (tamarisk). Seasonality affects how well a chemical works with this treatment method. Many products work best during the spring when the movement of sap is upward. Others are effective when the sap is moving down into the roots during the fall. Some work best during the growing season, from 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 break down more quickly during warm, moist conditions because of increased microbial activity. They may be leached from the soil with excessive precipitation. Some formulations have both a pre- and post-emergence effect and are used in conifers to control annuals and some perennial weeds. Because these chemicals are commonly water-soluble and can easily contaminate water, including groundwater, they must be applied at the proper rate and according to label directions.

Soil active or pre-emergence herbicides are the most common pesticide contaminants found in Nevada's groundwater. Some pesticide labels advise the applicator not to apply or to reduce applications of these products in sites that are vulnerable to groundwater contamination. Risky sites include those with sandy or gravelly soils and areas where groundwater levels are near the surface (areas with shallow ground water).

Applicators must take into account the proximity of desirable non-target vegetation. Some soil active herbicides will damage or kill existing vegetation and some have no effect on it at all. Product labeling describes precautions related to protecting non-target trees and other vegetation. Serious violations, resulting in enforcement actions, have occurred after applicators have damaged or killed adjacent non-target vegetation with pre-emergence herbicides.

A major barrier to uptake of foliar applied herbicides is a waxy layer of the leaf surface known as the cuticle. Herbicide labels tell you if a surfactant or adjuvant should be added to the mix to improve plant absorption of the herbicide.

Herbicide formulations change all the time. To find out if a product is registered for forest or range weed control, go to http://npirspublic.ceris.purdue.edu/state/

Using toxic baits to control deer or rabbits is strictly prohibited.

Forest and Range Vertebrate Pests

Animals play an important role in range and forest ecosystems. Several species of rodents including pocket gophers and ground squirrels occur naturally in range and forest sites. Other native species, such as deer and rabbits, also inhabit these areas. Harm to rangelands and forests is rare but adjacent agricultural lands or urban landscapes may sustain significant damage due to burrowing and feeding activities.

While uncommon, animal damage may occur during reseeding, land rehabilitation or reforestation activities. Forest nurseries may also sustain damage by gophers, squirrels, deer or rabbits. Baits or traps are most commonly used on burrowing rodents such as gophers. Using wire cylinders to protect individual plants from deer and rabbits is labor intensive but effective. Chemical repellents can be useful in some situations but must be reapplied when washed off by precipitation.

Using toxic baits to control deer and rabbits is strictly prohibited. Deer and some rabbit species are game animals and are protected under state fish and game laws.

Conclusion

Nevada's forests and rangelands provide valuable forage and habitat for livestock and wildlife. Recreational activities are also important land uses. Applicators must consider various land use practices and resources associated with these lands when developing pest management strategies.

The primary pests on these sites are weeds and insects. Plant pathogens and burrowing rodents are less frequent but can become pest problems.

Pesticides are useful tools but must not interfere with other land management strategies. In order to accomplish effective pest control, applicators should take into account all land uses, consider all control methods available and apply pesticides according to label instructions.

Originally published in 1987 as Category 1A – Agricultural Pest Control, Plants, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

Category 3: Ornamental and Turf Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Ornamental and Turf Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the principles of Integrated Pest Management for Ornamentals and Turf.**
- ✓ **Describe the factors affecting pesticide application effectiveness.**
- ✓ **Describe the most common ornamental and turf insect pests and methods to control them.**
- ✓ **Describe the most common ornamental and turf diseases and methods to control them.**
- ✓ **Describe the different control methods available for weed management in ornamentals plantings and turf areas.**
- ✓ **Describe the most common vertebrate pests that impact ornamentals and turf, and control strategies for each.**

Category 3, Ornamental and Turf Pest Control

Recent changes in Nevada's legislation limit ornamental and turf certified applicators to the following: residential landscapers, homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

If you wish to apply pesticides to public properties you must now be a licensed government applicator.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality

Principles of IPM:

- **Identify the pest.**
- **Monitor the pest population.**
- **Establish an action threshold.**
- **Evaluate control options.**
- **Implement control options.**
- **Monitor results.**

properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

Landscapers must become licensed if they are doing any off the following:

- Using anything other than "CAUTION" pesticides.
- Advertising pest control or soliciting for pesticide applications, including bidding for maintenance contracts that involve pesticide applications.
- Using powered equipment to apply pesticides.
- Operating as a commercial (for hire) pest control company.
- Conducting any pesticide applications on non-residential properties (includes commercial and public properties).
- Applying pesticides to sites other than homeowner's lawns and gardens.

For further information or clarification go to Nevada Department of Agriculture Pest Control Website, http://agri.nv.gov/Pest-Control/.

Ornamental and turf pests occur in landscaping found around commercial establishments (hotels, casinos, resorts, restaurants), industrial parks, private golf courses and residential properties (private homes, apartments, condos).

Plants in these locations are often chosen for their aesthetic qualities, not for their pest resistance. Some of these areas are also used by and under scrutiny from the general public. Thoughtful planning and implementation of pest control measures is required to maintain public health and a visually pleasing landscape.

The single most important factor in ornamental and turf pest control, as for all pest control, is to identify the pest. Before considering control measures, pest managers must also understand the pest's life cycle.

Ornamental and Turf Integrated Pest Management (IPM)

The principles of Integrated Pest Management can be applied to controlling insect pests, weeds, diseases and vertebrate pests of ornamentals and turf.

- **Pests, their hosts and beneficial organisms must be positively identified.** The pest problem and associated plant species must be correctly identified. If you can't identify the pest, collect samples and submit them to the University of Nevada Cooperative Extension or the Nevada Department of Agriculture for identification. Once the pest is identified, determine the pest's life cycle, growth cycle and reproductive habits. Pest managers should also be able to identify all life stages of beneficial organisms, such as the lady bird beetle, a beneficial insect predator.

- **Establish monitoring guidelines for each pest species.** Routine monitoring of both pests and natural enemies (beneficial species) is a critical part of IPM. Methods of monitoring include visual inspection, pheromone and sticky traps, and sweep nets. Document and track both pest and beneficial organism population numbers. The ratio of natural enemies (usually insects) to pests should be taken into account before a pesticide is applied.

- **Establish an action threshold for the pest**. A fundamental concept of IPM is that a certain number of individual pests can and should be tolerated. **Consider: What will happen if no action is taken?** Will the pest cause unacceptable damage to the value of the lawn or landscape?

  Sometimes the action threshold is based on economics. The **economic threshold** is defined as the pest population level that produces damage equal to the cost of preventing damage by controlling the pest. The threshold is the pest density, or population level, at which a control application should be made.

  Urban landscapes are judged on their appearance and whether or not the presence of a pest presents a health or safety issue. The aesthetics and healthful condition of an individual plant or a whole landscape may be affected by pests. The presence of pests and their damage, though not serious, may be intolerable or annoying to some, yet readily accepted by others. Ornamental and turf IPM strategies are developed with emphasis on aesthetic thresholds. It is often the appearance of a pest or the damage it causes that triggers control actions. This is called the **aesthetic threshold**. The aesthetic threshold varies from person to person, making it difficult to establish control criteria for most landscape pests.

  Sometimes, the action threshold is based solely on the emotions of the property owner. This is referred to as an **emotional threshold**. For many people, a single mouse, cockroach or spider is unacceptable. Many people fear pests and this triggers their need to implement control actions.

- **Evaluate and implement control tactics.** Select tactics that will be most effective, most economical and have least impact on non-target species and the environment. Select controls that will impact beneficial organisms as little as possible while suppressing the pest. If a pesticide is

Pest Thresholds:

- **Economic:** Point at which the pest infestation causes enough economic damage to justify the cost of treatment.
- **Aesthetic:** Point at which the infestation causes enough visual damage to justify treatment.
- **Emotional:** Point at which the pest infestation causes enough emotional trauma to justify treatment.

one of the selected management tools, beneficial enemies (usually insects) will likely also be killed.

- **Monitor, evaluate and document the results.** This allows you to make adjustments to improve the effectiveness of future pest control strategies.

Factors Affecting Pesticide Application Effectiveness

Use the correct pesticide, one that is labeled for use on the plant and/or site, and one that will be effective on the identified pest

If the decision has been reached to apply a pesticide, there are many factors that affect the success of the application. Early detection can increase success. For example, applying herbicides to annual weed seedlings is far more effective than applying herbicides to mature plants. Mature plants are much larger, require more herbicide and are harder to control. It is important to regularly inspect the areas in your care and look for signs and symptoms of pests.

Correct timing and a thorough application of pesticide are necessary for good control. Pesticide applications should be timed to coincide with the times the pest is most susceptible. This could be the time of day, the time of year or the life cycle stage of the pest, or a combination of these factors. Applying pesticides in the wrong place or at the wrong time is a waste of time and money and has the additional potential to harm the environment.

Use the correct pesticide, one that is labeled for use on the plant and/or site. Make sure the pesticide will be effective on the identified pest. Use the correct amount applied by the correct method using the correct equipment. Take into account the weather, including temperature, wind speed and the potential for precipitation. Most pesticides are not effective below 50 degrees F and many tend to volatilize above 85-90 degrees F. Applying pesticides in windy conditions increases the risk of pesticide drift and reduces the amount of pesticide reaching target plants. Many pesticides require a drying period, so applying them when rain is forecast can be a waste of time and money. All these factors can diminish pesticide effectiveness and increase the potential for drift or other environmental damage.

Insect Pests

Not all insects are injurious. Most are benign and many are beneficial. Identifying the insect first will reduce the chances of destroying a beneficial insect.

The insect pest and the degree of infestation should be determined before control measures are implemented. What insect is present, and how many are there? What plant species is affected? It may be more expensive to apply a pesticide than to simply replace the plant(s) with a different type that is less likely to be damaged by insects. In some cases, the easiest and most effective control may be simply spraying water on the plant to remove insect pests. For example, aphids may be removed from plants by spraying them with a strong jet of water. This interrupts their life cycle and can reduce pest numbers significantly. While this method is often used on small or medium sized plants, it would not be as effective on large trees.

Knowing the life cycle of the insect pest helps you to identify when it is most susceptible to a pesticide. Some insects produce one generation per year and others may produce multiple generations each year. If multiple generations are likely, you may have to apply pesticides more than once in a given year. Review the insect section in General Knowledge: General Pest Problems in this manual for more information on insect life cycles.

It is important to consider what would happen if you did nothing at all. During the field inspection, did you identify predators or parasites that will provide biological control for the insect pest? If the infestation is small, it may be managed (but not eradicated) by letting nature take its course.

What are some indications that there may be an insect infestation? For ornamental plants, there are many. The following signs and symptoms may indicate an insect pest problem:

- Webbing, silk shelters or silk enclosures on foliage, indicating mites or caterpillars.
- Insect or mite remains, such as egg shells, shed skins, cocoons, trails of silk or excrement.
- Scale or aphid protective coverings, generally waxy substances.
- Honeydew, a sticky liquid excreted by some insect pests. Black, sooty mold may grow on the honeydew.
- Sawdust, wood chips or pitch balls found either on tree trunks or at the base of the tree trunk, indicating bark beetles or wood borers.
- Decline of the plant.
- Feeding damage.
- Holes in any part of the plant.

For above-ground turf insect pest infestations, damage to grass blades or stems can indicate an infestation. This damage may be due to sod webworms, army worms or cutworms.

Below-ground turf insect pest infestations are more difficult to identify. If you can grab a handful of grass and easily pull it up, it indicates the roots are damaged. Identification of what is damaging the roots is more difficult and

Indications you may have an insect pest:

- **Webbing or silk**
- **Insect remains**
- **Waxy protective coverings**
- **Honeydew**
- **Sawdust, wood chips or pitch balls**

generally requires cutting and pulling up a portion of the sod. If no insects are present, the damage may be caused by one or more poor cultural practices: excess thatch, poor nutrition, inappropriate soil, lack of water, mowing too short or over-fertilizing, causing fertilizer burn. Disease may be the cause, as may dog urine spots and/or pesticide damage.

Common Invertebrate Pests

Mites: Mites are not insects. They are actually arachnids, related to spiders. They have eight legs, no wings, no antennae and two body parts. They are very small and are usually identified by the presence of fine, delicate webbing on the plant leaves, stems and trunk. Mites often appear under dry conditions. Mite damage often appears as bronzing of the foliage, which can give the foliage a dusty appearance. Severe infestations may lead to leaf drop. Mites can be controlled with insecticidal soaps, horticultural or "dormant" oils, and acaricides. It may be wise to alternate chemical control methods to reduce the chance of developing pesticide resistance in the mites.

Aphid

Aphids: These small, soft-bodied insects are common problems. There are many species of aphids and most are plant or plant-family specific. They have piercing-sucking mouth parts and can be disease vectors. They can be green, black or red in color, and some excrete a white, waxy coating that obscures them from sight. A good portion of the sap they ingest may pass through them undigested and is then excreted on the plants. This liquid, known as honeydew, makes leaves sticky and can also host a black, sooty mold. Some aphids will also cause leaves to pucker, curl or twist. Small infestations may be reduced or controlled by a strong spray of water that knocks the adults off plants and interrupts their life cycle. Large infestations can be controlled with insecticidal soaps, horticultural or "dormant" oils, and many other insecticides. Read and follow label instructions.

Scale

Scales: These are also small, soft-bodied insects. Scale insects protect themselves by producing a waxy shell. The life cycle of these insects starts after hatching with an immature, crawler stage. The insects then find a likely plant host, lose their legs, excrete a waxy covering and live out their lives in that spot. Plants infested with scales appear sickly and lack vigor. Some scale insects produce honeydew. Control is best achieved during the crawler stage, before they produce the protective shell. A second treatment two to three weeks after the first is often recommended. Scales can be controlled with insecticidal soaps and many insecticides during the crawler stage. Control during the adult stage is more difficult. Horticultural or dormant oils will smother adult scale insects. Read and follow label instructions.

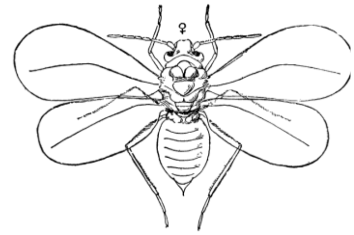
Whiteflies: These small white insects look like tiny moths. The larval stages of whiteflies are similar in appearance to scale insects. When an infested plant is disturbed, the adult insects will fly up, but then settle back down. Both larval and adult whiteflies suck sap from leaves. Infested plants turn yellow, wilt and may die. These insects can also produce honeydew, which can make the leaves sticky and can also host a black, sooty mold. They can be controlled with insecticidal soaps and many insecticides. Read and follow label instructions.

Thrips: Thrips are tiny, slender insects with rasping-sucking mouth parts. Adults can be yellow, brown or black and have two sets of feathery wings that are held flat on their backs. Immature thrips resemble adults, but are lighter in color and have no wings. They feed on foliage and flowers. Thrips-infested plants may have streaked or silvered foliage. Flowers may be deformed and flower petals may show brown edges. The flower buds may drop off the plant or fail to open. Control is difficult because thrips continually migrate and re-infest plants. Thrips are known vectors of some plant diseases. They are difficult to control, but some control can be achieved with insecticidal soaps and many insecticides. Read and follow label instructions.

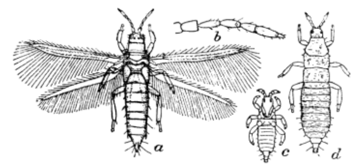
Beetles: Beetles belong to the order Coleoptera, which is the largest order of insects. Beetles have two pairs of wings. The front pair is generally hard or leathery and the wings meet in a straight line down the center of the back. Beetles may attack any part of a plant and they may do damage at any stage in their life cycle. Some beetles do damage as adults, some as larva (grubs), and some do damage at all life stages, but on different parts of a plant. Some feed only at night and some feed during the day. Because there is such a wide variety of beetles, it is very important to identify the beetle and its life stage. Read and follow label instructions when using insecticides.

Japanese beetle: These beetles are less than ½-inch long, with shiny brown wing covers over a metallic green body. Tufts of white hair rim each side of its body, sticking out from under its wings. The larvae are small. White grubs have brown heads and dark tail ends. The adults chew the flowers, leaves and fruit of hundreds of ornamental and fruit-producing plants. The larvae feed on the roots of most plants, seriously damaging lawns, landscapes and gardens. They have not been reported in Nevada to date, but are designated as an "Alert" organism. If they are found, a sample must be taken and the discovery must be reported to the Nevada Department of Agriculture State Entomologist.

Bronze birch borer: As the name implies, these insect pests target all species of birch. The adult beetles are ½-inch long, hard-shelled and slender. They are brown with a greenish tint. The larvae are creamy white, slender and flattened. The larvae are responsible for damage to trees. They bore through



Whitefly



Thrips

Japanese beetle
ag.purdue.edu

Bronze birch borer
oardc.osu.edu

Box elder bug
extension.umn.edu

the bark to the cambium layer, creating long, winding galleries. Feeding results in raised bumps or welts on the surface of the bark. The feeding larvae damage tissues, interrupting the flow of water and nutrients in the tree. This causes yellowing and thinning of the leaves in the upper crown or marginal burning or browning of the leaves on affected branches. Eventually, the affected tree dies. The larvae pupate within the trunk and large limbs of the birch tree. They emerge as adults through a 1/8-inch D-shaped hole they cut in the bark. The best control strategy is prevention. Maintain healthy trees, as the borers target stressed trees. Mulch to moderate soil temperatures and conserve soil moisture. Woodpeckers and a Chalcid wasp (*Phasgonophora sulcata*) are biological controls. Pesticides may be applied to kill egg-laying adults and larvae before they enter the bark. Once the larvae enter the bark, systemic pesticides are the only effective chemical control. Affected limbs can be removed from the tree. Remove and destroy dead trees or pruned limbs.

True bugs: True bugs belong to the order Hemiptera. Their wings form an "X" when folded on their backs. This group is very diverse and includes many beneficial predatory insects. They have piercing-sucking mouth parts and go through simple metamorphosis, which means they have a nymph stage that looks very similar to the adult stage, but without wings. This group includes box elder bugs and stink bugs.

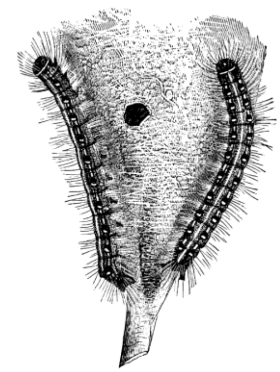
Box elder bugs are nuisances that cause little actual damage. They can make outdoor living and entertaining difficult and they may also try to move into homes as the weather cools in the fall. They prefer box elder or maple trees. They feed on tree litter, especially seed pods, and will overwinter in yard litter. Good sanitation can help reduce the population of box elder bugs during the following year.

There are several varieties of **stink bugs**. They feed on a variety of plants, resulting in to seedling death and stunting of plants. As they feed on plants, they leave a brown liquid called frass, a mixture of excrement and honeydew, which dries to brown spots. They overwinter on plants and in plant debris, so sanitation can help reduce populations.

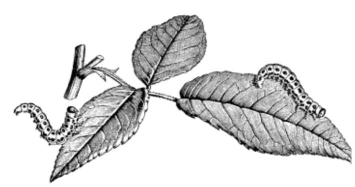
Caterpillars: Caterpillars are the worm-like larval stage of moths or butterflies. They have distinct heads and several pairs of fleshy legs on their bodies. They may be fuzzy, smooth or spiny. They are primarily foliage feeders, so damage consists of irregular holes, ragged edges or entirely stripped leaves. They tend to damage tender new growth. They may also form protective shelters or coverings out of silk or fine webbing. The shelters may harbor the caterpillars continuously or they may feed outside the shelters and return to the shelters for protection from weather, predators, etc. Caterpillars are also referred to as webworms, tent caterpillars, leaf rollers, leaf folders, bagworms or leaf miners. When only a few caterpillars are present, hand picking is an effective method of control. Larger infestations may call for chemical controls. A single treatment applied when the caterpillars are young usually gives very effective control.

Sawflies: Sawflies are wasp-like insects that lack the very constricted abdomen. They are related to bees, wasps and ants. The larvae of sawflies resemble naked caterpillars. Some even appear slug-like, such as the pear slug and rose slug. Depending on the species, the larvae are foliage feeders, consuming the whole leaf, or skeletonizers, consuming the portion of the leaf between the major veins. Other species are wood borers or leaf miners. When only a few sawfly larvae are present, hand picking is an effective method of control. Larger infestations may call for chemical controls. A single treatment applied when the larvae are young usually gives very effective control.

Bees and wasps: These are mostly beneficial insects that can become nuisances if they set up housekeeping too close to human habitation.



Caterpillars



Sawfly larva

Plant Diseases

Good management is the best way to prevent plant disease. This is extremely important to remember when dealing with ornamentals and turf. Unlike production agricultural crops, plant breeding and selection for ornamental plants has been based more on specific horticultural characteristics than on disease resistance. Most management techniques are designed to achieve some selected norm for each ornamental and turf species. Review the general sections of the manual for a full description of plant pathology principles and concepts.

There are six major principles of plant disease management:

- Exclusion
- Eradication
- Protection
- Resistance
- Therapy
- Avoidance

These six principles are discussed in detail in the General Knowledge: General Pest Problems section of this manual.

Successful plant disease management considers all of the potential control methods:

- Prevention
- Cultural controls
- Physical or mechanical controls
- Biological controls
- Chemical controls

Most plant disease management plans include a combination of two or more control methods. Chemical controls are often used to manage diseases in ornamental plants and turf and include both soil treatments and/or treatment of growing plants.

A disease is defined as any impairment of plant health or condition of abnormal functioning. Plant diseases manifest as a number of symptoms:

- **Rot** is decay or disintegration of plant tissue. It can be caused by hundreds of different bacteria or fungi.
- **Blight** is any plant disease that results in withering and killing of leaves, flowers and shoots.
- **Canker** is a disease of woody plants that causes localized damage to the bark of the plant. It can be caused by fungi or bacteria.
- **Gall** is an abnormal outgrowth of plant tissues. This disease can be caused by fungal or bacterial infections or insects.
- **Wilts** are plant diseases characterized by drooping and shriveling, usually caused by vascular pathogens, such as Fusarium.
- **Rusts** are plant diseases that produce reddish-brown pustules on leaves and stems. Rusts are caused by various rust fungi.
- **Smuts** are destructive diseases of plants, especially cereal grains, that produce black, powdery masses of spores. Smuts are caused by fungi.

A disease is defined as any impairment of plant health or condition of abnormal functioning.

Ornamental plant diseases

- **Root Rot:** This is a common problem in ornamental plants. Root rot is caused by a number of different fungi species in the *Phytophthora* or *Pythium* genera. Although root rot is caused by fungi, the condition is almost always associated with poor cultural practices that result in waterlogged plant roots. These practices include inadequate drainage, improper planting depth and/or incorrect water management. Correcting cultural practices must be part of the management plan, along with other controls, including chemical controls.
- **Crown Gall:** This disease is caused by bacteria and affects many ornamentals. The bacteria are present in the soil and can remain viable for years. It causes abnormal growth on the roots and trunks or stems of infected plants. Mechanical injuries, such as lawn mower or string weed trimmer damage, create an entry site for this disease. Prevention strategies include minimizing injury to limit entry sites for the disease

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 due to mismanagement.

and managing plants to reduce stress. Chemical controls are also available.

- **Fire Blight** occurs in a number of plant species, but is very common in roses, apples and pears. It is a bacterial disease that is spread by pollinators and rain splash. It first appears in the blossom clusters as wilting and collapse of the cluster. Diseased tissue produces brownish, sticky exudates. The tips of the infected, young succulent growth shoots curve into a characteristic shepherd's hook and appear to have been burnt. Warm, wet spring weather is ideal for disease development. Remove diseased plant parts and prune back to healthy wood. Dispose of infected plant materials. Use streptomycin or copper spray formulations during bloom to help prevent infestation.
- **Verticillium Wilt** is a fungal disease that plugs the water-conducting tissues, causing premature yellowing and death of the foliage. Look for a tan discoloration of the vascular tissues in cut stems of infected plants. This fungus infects the root system through root hairs and wounds. Wounds can be mechanical or caused by insect or nematode injury. Planting resistant cultivars, controlling insects and nematodes and good sanitation will help control this disease. Fungicide treatment offers effective control.
- **Leaf Spots:** Fungal leaf spots, also known as anthracnose, scab, leaf blotch or shot hole, affect many ornamental plants. The disease manifests differently in each plant species, but some generalizations can be made. Many spots are brown or black in color. Many have a distinct margin and are surrounded by a yellow halo. The spots may be circular or irregular in shape. The disease may progress to affect the entire leaf. Leaf drop can occur. Infected leaves that fall and remain in place provide a habitat for fungal spores to overwinter. Leaf spots first occur on the lower leaves, generally in the spring or fall when moisture is high. The disease is spread through wind and rain splash. Cultural controls include cleaning up leaf debris to remove infected leaves, removing diseased plant parts and planting resistant varieties. Foliar applications of fungicides can aid in controlling established infections.
- **Powdery Mildew:** This fungal disease affects almost all ornamental plants, with some species being more susceptible than others. Infected plants commonly show a white or gray layer of fungus growth on the surface of the leaves, stems and flower bracts. Powdery mildew is a common disease of roses, oaks, lilacs and many other ornamental plants. The disease flourishes under moist, cool conditions. Spores can be spread by wind and rain splash to new plants. The fungus can overwinter in plant debris. Cultural controls include planting resistant varieties, good

Fire blight
extension.usu.edu

Powdery mildew
www.ipm.iastate.edu

sanitation (cleaning up and removing plant debris) and avoiding overhead watering. Chemical controls include foliar applications of fungicides.

Turf Diseases

Turf areas present their own problems in landscapes, golf courses or recreational areas. Vigorously growing turf is usually less severely damaged by diseases and recovers more quickly from them. Good cultural practices help to limit most turf diseases. Whenever possible, plant disease-resistant varieties of turf. Thatch and aerate to reduce stress and favor vigorous turf growth. Water deeply and infrequently to promote deep root growth. Try to water early in the morning rather than in the afternoon or evening. Inspect turf often to identify problems early, when they are more easily managed. Rotate the use of fungicides to reduce the possibility of developing fungicide-resistant strains of pathogens.

- **Brown Patch (*Rhizoctonia solani*):** Brown patch is a common fungal disease of grasses, especially fescues and perennial ryegrasses. The disease generally starts from the top of the leaf blade and moves downward. It occurs in light brown patches in lawns, from a few inches to several feet in diameter. The edges of the dead area may have a gray "smoke ring" appearance. Brown patch is favored when daytime highs exceed 80 degrees F and nighttime lows are in the mid-60 degrees F. High humidity and large amounts of nitrogen also favor the disease. Plant resistant turf varieties, control fertilizer applications and maintain a health lawn to prevent infestation. For chemical control, use fungicides. Read, understand and follow label instructions.
- **Sclerotinia Dollar Spot (*Sclerotinia homeocarpa*):** Dollar spot affects a wide range of grasses. It is active throughout the growing season, especially when there is low soil moisture and an excess of dew or fog. It most commonly occurs in the spring. The disease commonly forms small white patches, 1-inch to 3-inches in diameter. Individual grass blades show spots that are tan with reddish edges that start at the leaf margins. The lesions may grow across the grass blade, forming girdling lesions that kill the blade tip. To prevent infestation, control soil moisture and maintain a healthy. Chemical controls include fungicides. Read, understand and follow label instructions.
- **Melting-Out (*Dreschlera ssp.* and *Bipolaris ssp*.):** Another common fungal turf disease in Nevada is called melting-out disease. From a distance, the affected patches of turf appear yellowed, as if they are drought-stressed. The disease starts as eye spot lesions on individual grass blades in the spring when temperatures are cool. As the weather becomes warmer and drier, the roots and crowns of grass plants can be

Chemical formulations change all the time. Consult your local dealer for recommendations for the specific pest and site.

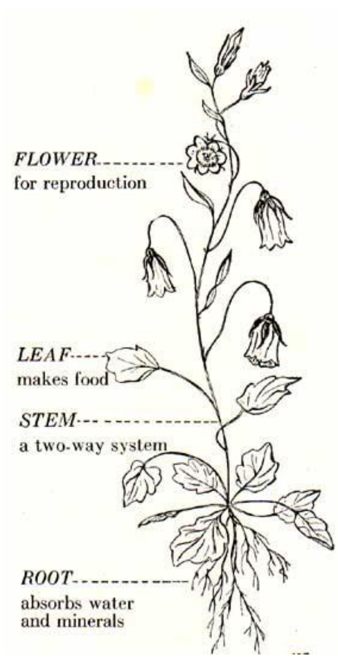
affected, with patches of turf dying off or "melting out." Cool, wet weather during the spring followed by drought in the summer favors development of this disease. Prevent this disease by controlling soil moisture and maintaining a healthy lawn. Fungicides provide chemical control. Read, understand and follow label instructions.

- **Pink Snow Mold (*Monographella nivale)*:** Pink snow mold is a fungus that grows under cool, wet conditions. It can begin growing under snow cover in turf areas, hence the name "snow mold." It is active across a wide range of cool temperatures (32 to 65 degrees F), but temperatures above 70 degrees F inhibit the growth of the fungus. The disease first appears as a small circular area that rapidly expands. The crown or basal area of the dead stems appears pink or purple and grass blades may take on a pinkish cast in early morning light. The mycelia of the disease are pink to white. The fungus survives in plants and plant debris as dormant mycelia. Prevention consists of good sanitation, controlling soil moisture and maintaining a healthy lawn to prevent infestation. Fungicides provide chemical control. Read, understand and follow label instructions.
- **Fairy Ring *(Marasmius oreades* and *Lepiota* spp.):** Fairy ring appears as a discolored circular patch of grass with a dark-green outer band. The dark-green band is darker than the grass in the center of the ring and the unaffected grass outside of the ring. The grass inside the dark green ring commonly dies. The mycelium of the fungus responsible for this disease is water-repellant. The mycelia grow through the pores in the soil, preventing water from reaching the turf roots. As a result, the turf roots dry out and eventually the affected turf dies. The dark green color of the grass in front of the brown, dead or dying turf results from nitrogen the fungus releases as it decomposes organic matter in the soil. A second type of fairy ring may show only a ring of mushrooms (the fruiting structures of the fungus) and no discoloration of the lawn inside the ring. Prevention consists of providing adequate soil moisture, as the fungus prefers to grow in dry soil. Maintain a healthy lawn to prevent infestation. Do not bury lumber, stumps or other wood products in lawn areas, as these materials promote fungal growth. Mechanical control consists of drilling or aerating the affected patch and adding water and, if possible, a wetting agent to keep the soil moist. Fungicides provide only partial control of fairy ring.

Pink snow mold
William M. Brown, Jr., Bugwood.org

Fairy ring
Wendy Hanson Mazet, UNCE

Proper identification is essential when managing weeds. Contact the University of Nevada Cooperative Extension or the Nevada Department of Agriculture for help in identifying weeds.



www.plant-care.com

Weeds

General information on weeds is covered in the General Knowledge: General Pest Problems section of this manual. Please refer to that chapter for a discussion of the stages of plant development and plant life cycles.

It is impossible to describe and discuss every weed you may encounter in Nevada in this publication. However, it is essential to identify the weed, its lifecycle and its stage of growth in order to formulate an effective weed management plan. There are many resources available to help you identify weeds. The Nevada Department of Agriculture and the University of Nevada Cooperative Extension can help identify weeds. Many books contain pictures and descriptions of weeds. There is great variability in Nevada's climate. Weeds found in southern Nevada can be very different than those in northern Nevada. Not all weeds that occur in the Las Vegas area occur at Lake Tahoe, and vice-versa. It is best to consult sources specific to your geographic area. There is a wealth of information available on weed identification on the Internet, but use caution and only trust information from reputable sources. Most University resources have been reviewed for accuracy.

It is important to understand some of the living dynamics of plant growth to understand how herbicides work and the different ways they may affect plants. Plants consist of roots, stems or trunks, and leaves. Water movement in most plants is from the roots upward through the trunk or stem and into the leaves, where transpiration occurs. Plants produce their own food or carbohydrates through photosynthesis. Movement of this "food" is from the leaves downward through the trunk or stem to the roots.

Weed control strategies

Most effective weed management plans include two or more control strategies. Weed control can be split into five separate categories.

- **Prevention:** Prevention includes such practices as using certified weed-free seed, hay, transplants, amendments and mulches. To prevent the spread of weed seed and weed plant parts from one area to another, clean equipment between uses. Prevention also includes removing weeds before they can form seedheads or spread by other methods. It is more difficult to prevent weed seeds from blowing in from adjoining properties.
- **Cultural controls:** Cultural controls are management practices that reduce the incidence of weed infestations. Cultural controls include using proper planting times and planting rates, planting materials that are well-adapted to Nevada's climate, and managing fertilization and

irrigation to favor desired plants rather than weeds. Another cultural practice that will help control weeds in turf areas is to mow the grass high. Mowing high shades grass plant roots and helps to conserve soil moisture. It also prevents weed seeds from sprouting and growing and encourages deeper root growth. All these factors contribute to healthier lawns.

- **Mechanical/physical controls:** These controls include tillage, hoeing, mowing, hand-pulling, mulching, etc.
- **Biological controls:** Biological control is the use of a living organism to control a pest. Success depends upon selectivity, reproduction, adaptation, and ability of the organism to reach a high level of effectiveness.
- **Chemical controls:** Chemical control is the use of pesticides, in this case, herbicides, against a target pest (weeds). Many herbicides are available. In order to be effective a herbicide:
    - Must contact the plant (leaves, stems, trunks, roots, etc.).
    - Must remain on the plant surface long enough to penetrate or be absorbed.
    - Must reach a living site to disrupt a vital process or structure.
    - Must be able to kill the target weed.

Noxious Weeds

A noxious weed is a plant that has been defined as a pest by law or regulation. This designation requires that land owners control noxious weeds growing on their property. If a plant is found to be detrimental or destructive and difficult to control or eradicate, the Nevada Department of Agriculture (NDOA) can recommend to the state board of agriculture that the plant be designated as noxious. Nevada's noxious weed list can be found at http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/.

For help identifying noxious or other problematic weeds, contact NDOA, 775-353-3600, or the University of Nevada Cooperative Extension, 775-784-4848. The following publication provides information on the identification and management of noxious weeds: Nevada Noxious Weed Field Guide, http://www.unce.unr.edu/publications/files/nr/2010/sp1001.pdf.

Vertebrate Pests

Vertebrate pests are those pest animals that have backbones. Specific control measures vary for different species and are discussed in the sections for individual species.

Successful weed management considers all the control methods available:

- **Prevention**
- **Cultural**
- **Physical/ Mechanical**
- **Biological**
- **Chemical**

For the latest noxious weed listing, go to http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/

Common vertebrate pest control practices:

- **Exclusion**
- **Sanitation**
- **Trapping**
- **Repellent**
- **Rodenticide baits**
- **Fumigants**

Common vertebrate pest control practices

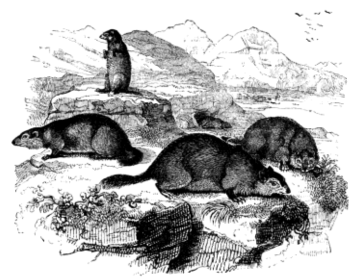
- **Exclusion:** Exclusion is the practice of keeping the pest out or away from trees, ornamental plants, gardens and lawns by using barriers such as exclusion fencing, tree guards and netting.
- **Sanitation:** Eliminate food and water sources. Store food and animal feeds, grain and seed in rodent-proof containers. Repair leaky pipes.
- **Trapping:** There are several types of kill traps and live traps available for most vertebrate pest species. Choosing the proper trap and learning the correct way to use it is essential. It is illegal to live trap and release vertebrate pests. Individuals who release live trapped animals are relocating the pest problem and any diseases they host, such as rabies, distemper or plague. Live trapping followed by an approved method of euthanasia is recommended. The American Veterinary Medical Association has specific guidelines for euthanasia.
- **Repellents:** Repellents may be applied to valuable vegetation or can be used in areas that pests are known to frequent. They often don't work as effectively as expected. Sunshine can break down the repellent, and sprinklers and rain can wash away the product. New growth on plants must be retreated and animals may simply get used to the repellent.
- **Rodenticide baits:** Baits, such as seeds, grains and vegetation treated with rodenticides, are used to control several types of vertebrate pests. Most baits must be applied in bait stations or underground within animal burrows to lessen the risk of killing of non-target species. Pesticide labels describe methods for applying the bait. Pesticides used include strychnine, zinc phosphide and various anticoagulants. Strychnine may only be applied underground.
- **Fumigants:** Aluminum phosphide fumigants are available either as tablets or pellets. Their use is limited to insects which infest stored commodities and control of burrowing pests. Use of these products is **strictly prohibited** on single family and multi-family residential properties, nursing homes, schools (except athletic fields), daycare facilities and hospitals. When applied in rodent burrows, they produce phosphine gas, which is deadly. Applied improperly, aluminum phosphide has resulted in numerous human deaths. To purchase, apply or supervise the use of this pesticide, applicators must successfully pass the state rodent burrow fumigation certification category.

Specific Vertebrate Pests

- **Ground squirrels:** Four species cause damage to crops and ornamental plants in Nevada: Richardson's, Belding's, Townsend's and California ground squirrels. They may also damage irrigation lines by chewing or damage landscape and buildings by burrowing. The best time for control is after emergence from hibernation in early spring. At this time of year, there is little green vegetation, so ground squirrels are more likely to accept rodenticide baits. Also, at this time of year, they have not yet mated and given birth. If control is postponed until later in the spring, there is green vegetation available and the ground squirrels are less likely to accept rodenticide baits. Advanced planning and preparation are essential. Attempting to control squirrels after they have reproduced can be frustrating, expensive and practically impossible. In order to eliminate exposure to non-target species, product labels for some rodenticide baits require application in bait boxes. Live trapping followed by euthanasia is also used to control ground squirrels. Check traps often and use caution to prevent unintended injury or death to non-target species. Strychnine bait, a restricted use pesticide, is well accepted but it may be used underground only to protect non-target species. When applying grain baits, pesticide labels advise users to pre-bait. This is the process of applying untreated grain and monitoring to see if the animal takes it. If the animal isn't taking the untreated bait, it won't take the treated bait. As these animals can be carriers of bubonic plague and other diseases, use care in handling sick or dead animals.

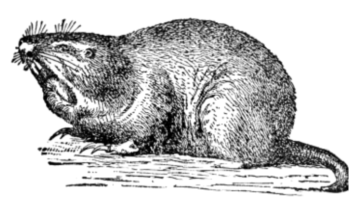
- **Marmots or rock chucks:** Marmots cause damage by consuming ornamental plants and burrowing. Common along the Eastern Sierra, these animals tend to like areas with large boulders, which provide cover. Many landscaped areas, such as golf courses, provide the perfect mix of vegetation for food and boulders for cover. Control is similar to that for ground squirrels. Use live trapping and subsequent euthanasia, zinc phosphide baits or strychnine bait. Use caution when using strychnine, especially in urban areas. It must be applied underground to reduce the potential for harm to other wildlife and dogs. Strychnine is especially poisonous to dogs.
- **Moles:** Moles are insectivorous and are not a serious problem in Nevada. 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. Soil insecticides may be used to reduce the mole's food supply. This may encourage them to move off a property.
- **Pocket gophers:** Pocket gophers live underground and damage crops and ornamental plants by feeding on roots and sometimes foliage. Their burrows also cause damage to farm equipment and sprinkler systems. Gopher activity produces fresh mounds that are typically horseshoe-shaped. Burrows are found 4 to 10 inches below the soil surface. Strychnine grain bait, a restricted use pesticide, is most effectively

Ground squirrel

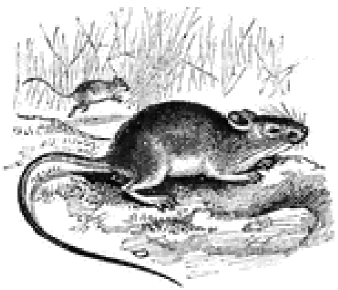


Marmots

Mole



Pocket gopher



Field mice

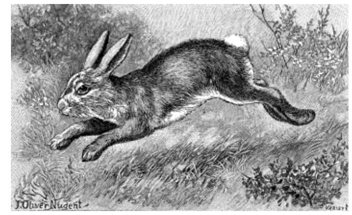
Vole

applied in fall or early spring. The bait must be applied below ground. Hand-apply or use in a burrow builder for large areas. Synchronize application with neighbors for best results. Anticoagulant and zinc phosphide baits are also available. Trapping with kill traps is another commonly used control method for pocket gophers.

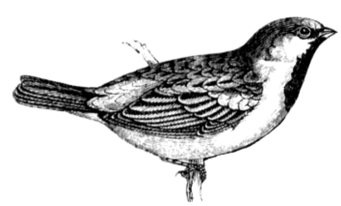
- **Mice and rats:** These rodents eat and contaminate food and animal feed. They will both defecate and urinate on food and feed. They feed on alfalfa crowns and damage forage, seed and ornamental plants by girdling. They also cause structural damage by chewing both wood and wiring. They carry diseases contagious to humans, such as Rickettsial pox, bubonic plague and leptospirosis. No control method will be successful unless mice and rats are excluded from entering the site. Seal any opening over one-quarter-inch in size. Use good sanitation practices to remove any food supply that may attract these rodents, including seed for planting. Use rodent-proof containers to store all food and animal feed to prevent attracting and feeding these pests. Anticoagulant baits are most commonly used. Use care in placing baits. Pesticide baits must be applied in approved bait stations. Snap traps can be effective, provided exclusion measures are also put in place. Baits for trapping include peanut butter plus oatmeal, bacon, gumdrops (for mice), nutmeats and dried fruit. Both rat and mouse urine fluoresces under UV light. This characteristic can be used to locate their trails and commonly frequented areas. Bait and trap in these areas. Check traps daily and use care when handling dead rodents.
- **Voles:** Voles are also referred to as meadow mice or field mice. They eat a wide variety of plants including grasses, forbs and seeds. When populations are high, voles cause damage to cropland and turf by constructing tunnels and surface runways. They eat bark, primarily in the fall and winter. This can cause severe damage to trees and shrubs by girdling the trees. Voles breed throughout the year and may have five or more litters of young annually. Populations fluctuate and may reach extremely high densities. Habitat modification and toxicants are the primary means of vole management. Remove ground cover, weeds and litter around croplands to reduce populations. Zinc phosphide is the most common rodenticide used for vole control and is available on grain bait. Pesticide labels require that zinc phosphide baits be applied in burrows and runways. Some product labels require the use of bait stations.
- **Blacktailed jackrabbits:** Jackrabbits cause damage by feeding on crops and ornamental plants. A cut to stems or branches at a 45-degree angle is typical of rabbit damage. Jackrabbits don't hibernate, so they are

active all year long. They have cyclic populations and will travel long distances for food. The best control is exclusion. Jackrabbits are not easily trapped. Since they generally come in from surrounding lands, trapping and removing one simply allows another to take its place. Exclusion fences are recommended around lawn areas, ornamentals and gardens. Shooting is an option as blacktailed jackrabbits are not protected, but it must be done only where it is safe and legal to do so. Repellents only provide temporary protection and must be reapplied on a regular basis, especially after rain or irrigation water washes it away. There are no registered poisons or fumigants for use on rabbits in Nevada. Strychnine, a restricted use pesticide, is no longer registered for jackrabbit control.

- **Cottontail rabbits and whitetailed jackrabbits:** Cottontail rabbits and whitetailed jackrabbits are usually considered pests in the landscape. Control is similar to that for blacktailed jackrabbits. Exclusion is the best control option. While they can be trapped, trapping is not the best control method, and there are no toxicants registered in Nevada for control of either of these rabbits. The information provided for jackrabbits applies to both of these rabbits as well, with one exception: cottontail rabbits and whitetailed jackrabbits are game species in Nevada. Since they are designated game species, they can only be hunted during cottontail rabbit and/or whitetailed jackrabbit hunting season, and you must have a hunting license.
- **Birds:** Droppings, disease potential and consumption of crops and livestock feeds all make pests of certain birds. Caution must be used when dealing with bird pests, as many birds are protected under the Migratory Bird Treaty Act (MBTA). As with all other pests, you must first identify the pest causing your problems. The following common bird pests are <u>not protected</u> by the MBTA:
  - **Pigeons (Rock doves):** Pigeons were introduced to the U.S. as domesticated birds and are now found throughout the country. They rely on human activities to provide them with food and shelter and have become serious pests in agricultural and urban areas. Pigeons feed on grains, seeds, and garbage. Humans also feed them intentionally. Damage also results from the accumulation of pigeon fecal material and filth deposited in areas where they nest, roost and loaf. Pigeons assemble sticks and twigs to form crude nests that are built in or on buildings and other structures, such as billboards. Breeding occurs year-round but peak reproduction is in the spring and fall.
  - **House sparrows:** House sparrows were introduced to New England in 1850 and have spread throughout the North American continent.



Rabbit



House sparrow

Pest mangers should identify the pest, understand its life cycle and identify other host plants before they try to control a pest.

Unless otherwise noted, all line drawings are from Clipart ETC, Florida's Educational Technology Clearinghouse, University of South Florida, http://etc.usf.edu/clipart/index.htm.

They prefer human habitats, especially urban and farm areas. House sparrows feed mainly on grains and seeds but garbage and other refuse contribute significantly to their diet. Breeding can occur any time, but commonly from March through August. Problems are result from feeding activities and fecal contamination in feed storage areas as well as inside and outside of other buildings.

- **European starlings:** These birds were introduced to North America in the late 1800s. Starlings cause problems at livestock facilities and in urban areas by consuming fruits and livestock feed. Holes or cavities in trees and structures serve as nesting sites. Large roosts in buildings and trees cause health concerns and other problems due to filth, noise and odors.

Bird Management: Exclude birds from nesting sites by closing openings that are larger than ¾-inch. Eliminate access to nesting and roosting sites by installing barriers, such as metal, netting or needle strips (porcupine wire). Roosting sites, such as ledges, can be eliminated by changing the angle to 45° or more. To discourage birds use tactile repellents, such as sticky bird glue on ledges and roosting areas. Recreational bird feeding attracts pest species. Limit the availability of food by storing livestock and other food in bird-proof facilities and containers. Prevent access to water sources.

Pesticides used for bird control are called avicides. These products are applied on baits and are classified as restricted use pesticides. Bait material may include small grains and whole kernel corn, depending on the bird species. The process of pre-baiting is recommended on avicide labels.

Conclusion

The most important factor in ornamental and turf pest control is to identify the pest. This is true for all pest control activities, regardless of the pest, category or site. Pest mangers should identify the pest, understand its life cycle and identify other host plants before they try to control it. Another important consideration is the goals for the landscape. A low-maintenance landscape will have different management strategies than an arboretum or park.

Originally published in 1987 as Integrated Pest Management, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

Category 4: Seed Treatment for Pest Control

Seed Treatment for Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the pest control management principles that are used in seed treatment.**
- ✓ **Describe the labeling requirements for treated seed.**
- ✓ **Describe the most common methods of applying pesticides to seed.**
- ✓ **Describe the most common seed insect pests in Nevada.**
- ✓ **Describe the most common seed diseases in Nevada.**

Category 4, Seed Treatment for Pest Control

Seed treatment for pest control includes the application of pesticide to the seed surface to reduce, control or repel a pest. The pests that most commonly affect seeds are disease-causing pathogens and insects. These pests may attack both seeds and seedlings.

Pest management in seed treatment relies on two of the six pest control management principles: protection and eradication.

Protection consists of applying a chemical barrier to the seed that protects the seed or young seedling from disease or insects.

Eradication includes methods used to eliminate, inactivate, repel or destroy insects and pathogens from the seed or seedling. The methods can be divided into three categories:

- **Disinfestation** is the application of a chemical that kills or inactivates organisms present on the surface of the seed.

Category 4, Seed Treatment for Pest Control, includes the application of a pesticide to a seed surface to reduce, control or repel a pest.

Pesticide-treated seed should be handled in the same manner as a pesticide.

Dispose of any unused treated seed as you would a chemical pesticide.

Chemical formulations change all the time. Consult your local dealer for recommendations for your particular pest and seed.

- **Disinfection** is the application of a chemical that kills or inactivates a pathogen that has infected a seed (it frees the seed from infection).
- **Systemic pesticides** are those that penetrate the seed and extend into the plant as it grows. These chemicals repel or inactivate diseases and insects, eliminating or reducing damage from these pests to the seeds and plants.

Seed treatment generally controls insect pests and fungal diseases. Most seed treatments do not control bacterial pathogens and none control seed-borne viruses.

Pesticide treated seed should be handled in the same manner as a pesticide. Read, understand and follow label directions. Wear the proper protective equipment and use caution around children, pets, livestock, wildlife and water bodies. Dispose of any unused treated seed as you would a chemical pesticide.

Combinations of some fungicidal and insecticidal seed treatments can be toxic to the seed, rendering the seed inactive and unable to germinate. Read the label carefully before mixing insecticides and fungicides.

Treated seed must have a statement on the seed container that indicates the following:

- That the seed has been treated.
- The name of the pesticide used for the seed treatment.
- A precautionary statement indicating that the treated seed cannot be used for food, feed or oil under any circumstances.
- Seed treated with highly toxic substances requires a skull and crossbones label and the word POISON within the precautionary statement. Most of these types of pesticides are no longer available to treat seed.

There are a number of methods for applying pesticides to seed. Good coverage is essential for adequate results.

- **Dust** is a dry powder formulation of pesticide that is applied to the seed in the planter box.
- **Dip slurry** is a suspension of pesticide in water that the seed is dipped into or mixed with.
- **Mist** is a pesticide that is sprayed or misted onto the seed, usually resulting in good coverage.
- **Pelleted** pesticide is a two-step process. The seed is misted with a pesticide and then the treated seed is coated with a fine layer of clay or calcium material. This is the most effective method of pesticide seed treatment because the pesticide is contained and protected by the pellet coating.

Seed should only be treated with a pesticide once, either commercially or by the grower. If the application rate is too high or if the pesticide is applied more than once, it may result in reduced or complete lack of germination due to chemical toxicity. It is important to use high-quality certified seed for seed treatment. Damaged seed or seed of poor quality would be a poor investment.

Seed Insect Pests

There are two major soil insects that require seed pesticide treatment: wireworms and the seed corn maggot.

Wireworm is a name applied to several species of click beetle larvae. These pests are found in both irrigated and dryland soils. No crop is immune to attack by wireworms, but they are most severe on beans, corn, potatoes and small grains.

Seed corn maggot adults look like small houseflies. They lay eggs on organic matter. The larvae (maggots) feed on young seedlings or sprouting seeds and may bore into plant stems below ground. They are serious pests on corn, beans, cucumbers, onions and garlic.

Common seed insect pests are wireworms and the seed corn maggot

Seed Diseases

Seed treatment is only useful in the control of fungal diseases. It has limited usefulness in the control of bacterial diseases and does not provide any control of seed-borne viral diseases. Below is a list of common crops and the diseases that can be controlled through seed treatment. A description of many of the diseases can be found in the Category 1A, Agricultural Pest Control - Plants chapter of this manual.

- **Potatoes:** Seed treatment is primarily for protection against "black leg" and potato seed piece decay. Black leg is caused by a bacterial pathogen.
- **Small grains (wheat, barley):** Seed treatment is for control of smuts, rots and damping off.
- **Alfalfa:** Seed treatment reduces loss due to damping off and reduces the spread of verticillium wilt.
- **Onions and garlic:** Seed treatment is for control of onion smut, white rot, seed decay or seedling blights.
- **Vegetables:** Seed treatment is for control of seed decay, seedling blight and damping off.

Seed treatment generally controls insect pests and fungal diseases. Most seed treatments do not control bacterial pathogens and none control seed-borne viruses.

Read, understand and follow label directions. Dispose of any unused treated seed as you would a chemical pesticide.

Conclusion

Seed treatment for pest control includes application of a pesticide to the seed surface to reduce, control or repel a pest. Once seeds have received an application of pesticide, they should be handled with the same safety concerns as any pesticide. Read, understand and follow label directions. Wear the proper protective equipment and use caution around children, pets, livestock, wildlife and water bodies. Dispose of any unused treated seed as you would a chemical pesticide.

Originally published in 1987 as Category 4, Seed Treatment, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2013 by M. Hefner and S. Donaldson, University of Nevada Cooperative Extension, and J. Carpenter, Nevada Department of Agriculture.

Category 5: Aquatic Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Aquatic Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Identify the National Pollution Discharge Elimination System (NPDES) permit requirements for pesticide applications on or near water and the pesticide annual thresholds.**
- ✓ **Describe the classification of aquatic weeds.**
- ✓ **Explain the impacts of aquatic weed infestations.**
- ✓ **Identify aquatic weed management options.**
- ✓ **Describe management of aquatic invertebrate pests.**
- ✓ **Outline management of nuisance or pest fish.**

Category 5, Aquatic Pest Control

Recent changes in Nevada's legislation limit aquatic certified applicators to the following: residential landscapers, homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

Category 5, Aquatic Pest Control, is the category that concerns itself with aquatic weed pests and, to a lesser extent, aquatic animal pests, such as nuisance or pest fish, mollusks and other aquatic life.

If you wish to apply pesticides to public properties you must now be a licensed government applicator.

For more information on the NPDES permit required for pesticide applications to or near water, contact the Nevada Division of Environmental Protection, https://ndep.nv.gov/water/water-pollution-control/permitting/nevada-pesticide-application-program

Category 5, aquatic pest control, includes applications of pesticides to or near running or standing surface water bodies. It does not include applications to water for mosquito control. This is included in Category 8, Public Health Pest Control and Category 10, Mosquito Control. Aquatic pests are found in irrigation ditches, lakes, ornamental ponds, reservoirs, creeks and livestock water troughs. The major pest problem in the waters of Nevada is aquatic weeds. Introduced species of mollusks and nuisance or pest fish are also discussed in this chapter.

NPDES Permit

The Clean Water Act (CWA) provides that the discharge of pollutants to waters of the United States from any point source is prohibited unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Pesticide applications made to or near water are now considered point source discharges and require a permit. The Nevada Division of Environmental Protection (NDEP) has issued NPDES General Permit NVG870001 for pesticide discharges in the State of Nevada. This permit authorizes qualified operators to discharge pesticides, including fungicides, herbicides, rodenticides, molluscicides and insecticides, to Waters of the United States, provided that they comply with the permit conditions. Permit conditions include annual thresholds:

- **In water:** 80 acres of treatment area per year. Applying a pesticide twice a year to a 10-acre site equals 20 acres of treatment for a year.
- **At water's edge:** 50 linear miles of treatment area per year. Treating both sides of a 10-mile-long ditch equals 20 miles of treatment.

For more information, contact the Nevada Division of Environmental Protection, https://ndep.nv.gov/water/water-pollution-control/permitting/nevada-pesticide-application-program.

Aquatic Weeds

There are two types of aquatic vegetation that commonly become weed problems in Nevada. These are algae and vascular plants, also known as flowering plants. They have different characteristics.

Algae: Algae are nonvascular 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:

- **Microscopic algae**: Blooms of this type of algae discolor the water, giving it a pea soup appearance. They may also cause red streaking at the water's surface.

- **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.
- **Chara:** This algae is often confused with flowering plants because it attaches to the sediments by structures that resemble roots. Chara has a brittle texture and 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.

- **Submersed:** These flowering 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.
- **Rooted floating:** These flowering plants are rooted in the sediment. Some species have both submersed and floating leaves, while 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 water lilies.
- **Free-floating:** As the name implies, these flowering 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 the soil, these plants require waters that have a high nutrient content. Examples include duckweed and watermeal.
- **Emergent:** These flowering plants grow in shallow waters, typically less than 3 feet deep. These are the most serious of the aquatic weeds in Nevada. This group also includes shoreline vegetation. Examples include cattails, bulrush, arrowhead, perennial pepperweed (also known as tall whitetop) and purple loosestrife.

Impacts of Aquatic Weeds

Many aquatic weed species were introduced from other continents 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 reduce property values 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 trap silt, resulting in reduced capacities in reservoirs and ponds.

Aquatic weeds:

- **Cause flooding by clogging ditches and canals**
- **Reduce water flows**
- **Impair water quality**
- **Displace native plants**
- **Interfere with recreation and access**
- **Affect aesthetics**
- **Provide habitat for mosquitoes**

Factors that affect aquatic weed growth:

- **Nutrients**
- **Sunlight**
- **Substrate**
- **Temperature**

Weed prevention methods:

- **Reduce nutrient inflows**
- **Place rip-rap around pond edges**
- **Eliminate shallow areas**
- **Clean watercraft**
- **Line ponds or ditches**
- **Construct nutrient settling 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 propagate by breaking apart as fragments, re-rooting and growing from the broken portions. 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

- All plants require sunlight to survive. Waters that have limited light penetration because of depth or turbidity are inhospitable to aquatic weeds, particularly algae.
- Nutrients, such as nitrogen and phosphorus, are essential for plant growth. Nutrients enter water in many ways, including erosion from unstable soils and runoff from feedlots and urban areas. Nutrients may also enter water by other means, such as improper fertilizer applications.
- 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 invites the establishment of aquatic weeds.

Aquatic Weed Management

Prevention:

It is nearly impossible to prevent weed spread by wild animals or water. However, we can reduce the spread of aquatic weeds by carefully inspecting and cleaning watercraft and boat trailers when removing them from waters that are infested with aquatic weeds.

Aquatic weeds can also 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 plants, inhibiting the growth of submersed plants and algae. The dye must be applied before plants begin growing in the spring. Light penetration is also limited by the depth of water. Waters that are 3 feet deep or more will have fewer aquatic weed infestations. Deepening ponds can help reduce weed infestations.

Prevent nutrient inputs into waterways and ponds by reducing runoff and stabilizing erodible slopes with vegetation. Maintain a buffer zone of at least ten feet around the edge of ponds and waterways to help prevent aquatic weed growth. Do not apply fertilizers or pasture animals within the buffer zone. If nutrients are entering a pond from an incoming stream, settling ponds may be constructed upstream from the main pond. Nutrients trapped by the settling pond before they reach the main pond can be removed from the settling pond by periodic dredging.

Proper planning and construction of ponds or waterways can help prevent aquatic weed growth. Many aquatic weeds require stable soil to germinate and take root. Aquatic weed infestations can be prevented by using sand in ponds and watercourses. Sand shifts with water currents and does not allow seeds to germinate. Likewise, large gravel or boulders can be used in ponds or waterways. Emergent weed growth on the edge of ponds and waterways can be prevented by piling large boulders, also known as rip-rap, in the shallow areas on the water's edge out to a depth of about 3 feet. Weed infestations may also be prevented by installing plastic liners. However, inflow of nutrient-rich sediments 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. This is done to reduce ditch maintenance, to improve flow and to reduce loss of water by seepage.

Good light penetration and somewhat warmer temperatures allow aquatic weeds to grow best in shallow areas at the water's edge. Constructing ponds with steep banks that have slopes of 1:1 or 1:1.5 out to a depth of 3 feet will prevent weed establishment. However, steep banks may result in 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 using boats or tractors. Mechanical weed harvesters remove weeds that are growing in deep waters. Mechanical control of weeds shows quick results but there are some disadvantages. Most aquatic weeds are perennial plants and will quickly grow back if root systems are not removed. This results in the need for repeated management. Plants are often broken apart and fragmented during mechanical removal, which may result in plant

Most aquatic weeds are perennial plants. They will grow back quickly if their roots are not removed.

Mechanical removal can increase perennial weed infestations. Broken portions of the original plants can regenerate, resulting in more weeds. Always identify the weed and its life cycle before developing a control plan.

regeneration and a bigger infestation. Mechanical control is often very costly and is most effective in small areas.

Burning can be 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. Burn permits may be necessary in some areas, and the risk of wildfire is an issue.

If possible, partial pond draw-down or draining can be effective at controlling or reducing aquatic weeds. Roots that are dried out or exposed to freezing temperatures may die. For this method to be effective, the pond should remain empty for an extended period of time, usually in the winter months. Draw-down 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 may be released in Nevada. Permits are required and can be obtained from the Nevada Department of Wildlife, http://www.ndow.org/ and click on the Forms and Resources button

Biological control of aquatic weeds includes the use of insects, waterfowl, and fish that feed on vegetation. The most common biological control agent used to control aquatic weeds in Nevada is the white amur, also known as the grass carp. Grass carp are vegetarian fish used to control submersed weeds and algae. The number of fish needed depends on the degree of the weed infestation, the species of weed, the size of the pond and the size of the fish stocked.

A proper balance of plants must be maintained because grass carp show preference for some plants over others and will graze the more palatable species before moving to less preferred ones. In some cases, grass carp may eliminate all submersed plants. Without adequate vegetation, fish will stir up silt, resulting in cloudy, unsightly water.

The Nevada Department of Wildlife issues permits for the stocking of grass carp. Requirements for the permit include that only triploid (sterile) fish may be planted into a closed aquatic system. A closed aquatic system is a water body where fish are prevented from ingress (entering) or egress (leaving) by a natural or manmade barrier. Contact the Nevada Department of Wildlife for information on the process for permitting grass carp.

Chemical Control

There are several factors to consider before making the decision to manage aquatic vegetation with herbicides.

- Use of the water to be treated (is it used for drinking water, etc.?)
- Species of the weed
- Stage of plant growth
- Effect on non-target species
- Characteristics of the water
    - Temperature
    - Turbidity
    - Depth
    - Velocity

Aquatic weed control with herbicides is often less expensive than other management measures. However, aquatic herbicide applications include restrictions on applications to recreational waters and drinking water sources. Remember that pesticide discharge permits (NPDES) are required. Also, there is much public opposition to pesticide applications in or near water. Finally, herbicides may affect non-target species, including desirable plants, invertebrates and fish.

After an herbicide application, natural decomposition of the dead plant material may deplete oxygen levels in the water, especially if there is a large amount of dead material. This may result in a fish kill. To reduce the risk, no more than one-quarter to one-third of the surface area should be treated at a time. Wait two weeks before the next application to allow time for plants to adequately decompose and the oxygen level in the water to stabilize. These steps are also listed on pesticide labels. Read the label!

Vascular Plants: Herbicides labeled for aquatic use are formulated as granules and liquids. Liquid formulations are applied as sprays and are used for rooted-floating, free-floating, and emergent weeds. Granular formulations are preferred when controlling submersed plants because they sink to the bottom and perform similarly to soil treatments. Granular applications work best when applied uniformly. They may be broadcast from spreaders mounted on boats. Foliar sprays are best for rooted-floating plants. Products may be applied by aircraft, ground rigs or boats.

Weeds growing on the bank and emergent weeds present the most serious aquatic weed problems in Nevada. Weed species vary depending on

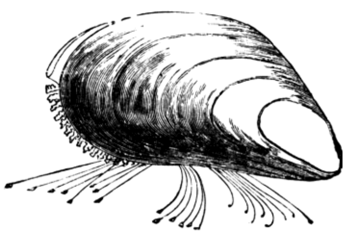
Liquid formulations are applied as sprays and are used to control rooted-floating, free-floating and emergent weeds.

Granular formulations are preferred for controlling submersed plants because they sink to the bottom and perform similarly to soil treatments.

Herbicide formulations change frequently. Check with your local dealer for the newest products available.

presence of moisture. Cattails and bulrushes grow in the water and at the water's edge. Weeds that do not require as much water, such as leafy spurge, perennial pepperweed (tall whitetop) and Canada thistle grow adjacent to water but are also found in much drier sites.

Algae: There are herbicides 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 effectiveness. Herbicides are also available to control algae in static, ponded water. Herbicide formulations change all the time. Check with your local dealer for the newest products available.



Management of Nuisance Aquatic Invertebrates

Mollusks are a large group of invertebrates that include snails, slugs, clams, mussels and many other animals. While slugs and snails are often pest species in wet and humid areas, they pose a little to no risk in Nevada due to the dry climate.

Quagga and zebra mussels are freshwater aquatic mollusks native to the Black and Caspian Seas. Both species were first detected in the Great Lakes in the late 1980s. It is believed that the mussels were introduced to North America in ballast discharge water from transoceanic ships. Quagga mussels were detected in Lake Mead in 2007. Efforts are underway to prevent their spread to other water bodies in Nevada. As of 2017, neither species has been detected in Lake Tahoe. Efforts are underway to prevent their spread to Tahoe and other waterways in Nevada. In 2011 the Nevada Legislature passed Assembly Bill 167, requiring an Aquatic Invasive Species (AIS) decal for all motorized and non-motorized vessels capable of retaining water, such as canoes and kayaks. Paddleboards and float tubes are exempt. Go to http://www.ndow.org/uploadedFiles/ndoworg/Content/Wildlife_Education/Publications/AIS-Decal-Brochure.pdf for more information

Both species are prolific filter feeders that reduce the microscopic plants and animals that form the base of the food web, ultimately disrupting the ecological balance of entire water bodies. In addition, both species are capable of displacing native mollusk species.

Quagga and zebra mussels attach to surfaces, such as piers, pilings, water intakes and fish screens. Intake structures become clogged, reducing water flows to municipalities and power plants. The mussels colonize hulls, engines and other parts of watercraft, which then transport mussels to other water bodies. Boats and other watercraft are the primary routes by which quagga and zebra mussels are moved from infested areas to uninfested areas.

Watercraft must be immediately drained after leaving a water body to keep runoff that could contain quagga and zebra mussels from reaching storm drains and uninfested water bodies. Many water bodies now have either voluntary or mandatory “clean, drain and dry” orders for watercraft to prevent the spread of these invasive pests.

Management of Nuisance and Pest Fish

Pest fish are often non-indigenous (exotic) species that were intentionally transported and introduced to a body of water. Introductions of pest fish often result in adverse economic or environmental impacts. Pest fish competing with native fish for food and other resources, and they often prey on desirable species. In addition, pest fish may introduce parasites and diseases into the native population.

Occasionally, desirable species may overpopulate a body of water, exhausting the food supply and resulting in stunted fish. An unusually high fish population, whether of desirable or undesirable species, requires some type of control. Fortunately, various techniques to control fish are available.

Mechanical Control

Barriers can 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 species of fish can be eliminated from ponds, reservoirs and lakes by draining the body of water. Partial drawdown of a pond during the winter months that results in a body of water freezing solid kills all fish in the pond.

Chemical Control

Often, mechanical control and habitat modifications are neither effective nor practical in reducing or eradicating a fish population. In this case, a pesticide application may be necessary. Pesticides used for fish control are called piscicides. The product most commonly used for control of pest fish contains the active ingredient rotenone. Various formulations, such as liquids or dusts, are available. You must contact the Nevada Department of Wildlife before initiating any chemical control of fish.

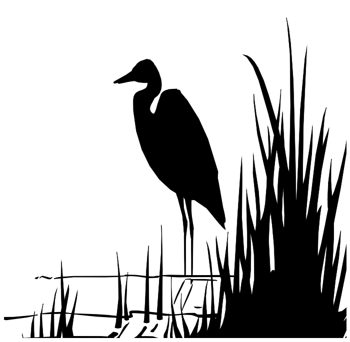
You must contact the Nevada Department of Wildlife before initiating any chemical control of fish.

Read, understand and follow pesticide label directions.

Proper identification of the pest is essential.

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.



If possible, it is best to lower water levels in lakes and ponds prior to applying pesticides. 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.

Conclusion

Aquatic environments provide habitats for many species of fish, birds, mammals and plants. Occasionally aquatic areas such as waterways, ponds, or lakes become infested with pest species, such as weeds or fish. These pests can have undesirable effects on the environment, including reduced water quality, flooding and competition with desirable species. Water from aquatic areas may eventually be used for domestic drinking water or agricultural irrigation. When considering control methods, it is essential to take into account downstream effects and impacts on beneficial uses.

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 has been identified, take the integrated pest management approach for its control. Use mechanical, preventive, and chemical means. When 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. You must read pesticide labels thoroughly before purchasing and applying pesticides. Apply products according to the rates and only to sites that are listed on the label.

Originally published in 1987 as Category 5, Aquatic Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and
B. Allen and C. Moses, Nevada Department of Agriculture.

Category 6: Right-Of-Way Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC RIGHTS-OF-WAYS YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Right-Of-Way Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Identify distinct right-of-way sites.**
- ✓ **List the goals of pest control in right-of-way sites.**
- ✓ **List and explain methods of pest control in rights-of-way.**
- ✓ **Describe factors to consider when selecting pesticides.**
- ✓ **Describe different types of herbicides.**

Category 6: Right-of-Way Pest Control

Rights-of-way are distinct areas involved in the transport of people, goods and services.

Recent changes in Nevada's legislation limit right-of-way certified applicators to the following: private applicators, homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County, State or Federal Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .The material provided in this chapter is still valid and useful for those wishing to become a Licensed Government Applicator.

Landscapers must become licensed if they are doing any off the following:

As of July 1, 2017, pesticide applications at all Federal, State, County, City or other municipality properties, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/

A "noxious weed" is a plant designated by law as requiring control.

- Using anything other than "CAUTION" pesticides.
- Advertising pest control or soliciting for pesticide applications, including bidding for maintenance contracts that involve pesticide applications.
- Using powered equipment to apply pesticides.
- Operating as a commercial (for hire) pest control company.
- Conducting any pesticide applications on non-residential properties (includes commercial and public properties).
- Applying pesticides to sites other than homeowner's lawns and gardens.

For further information or clarification go to Nevada Department of Agriculture Pest Control Website, http://agri.nv.gov/Pest-Control/.

Rights-of-way are distinct areas involved in the transport of people, goods and services. These areas include:

- Federal, state and county highways and roads*
- Roadside rest areas*
- Railroad lines, stations, substations and equipment yards
- Electric utility lines, including transformer stations and substations
- Telephone lines and other communication network infrastructure
- Pipelines, including pumping stations
- Equipment yards
- Bicycle, horse, snowmobile or other public paths or trails that are outside of established public recreational areas*

**pesticide applications in these areas now must be made by Licensed Government Applicator or a licensed pest control company.* (preceded by *)

There are many goals when managing rights-of-way. Safe access is important, as are fire prevention, visibility, erosion control and safety for workers and the general public. Weeds, especially noxious weeds, must be controlled to prevent weed spread to adjacent lands. Aesthetics become an important factor in and around urban areas.

Rights-of-ways are generally long and narrow and pass through areas with different soil types, vegetative communities, topographies and sensitive sites. Many rights-of-way are limited in size or purpose. For example, some road widths are mandated not to exceed a certain size. The differences in use and in physical attributes make a "one-size-fits-all" solution to right-of-way pest control impossible. Pest management will vary from site to site.

Right-of-Way Sites

Roadsides: Roadsides are common rights-of-way in Nevada, and include federal, state and county roads and roadsides, intersections, barrow pits (or bar ditches) and medians. Pest control goals along roadsides include maintaining or improving visibility, reducing fire hazards, providing clear and safe emergency areas for vehicles, and maintaining or improving aesthetics.

The amount of vegetation to be maintained varies depending on the specific use and needs of each right-of-way site. Some areas must be vegetation-free, including the roadbed, road shoulders, guardrails, signs, posts and fences. It is difficult and expensive to maintain bare rights-of-way by mowing, so vegetation in these areas is generally eliminated by chemical means.

Other areas may be vegetated with low-growing shrubs or grasses to reduce erosion. These zones generally encompass the portion of the right-of-way not contained within the road shoulder or other areas previously mentioned, and include barrow pits (or bar ditches), road intersections (other than shoulders) and medians. Care must be used in these areas to maintain sufficient vegetation to reduce erosion and provide competition with weeds, while keeping the height of the vegetation low enough that it does not interfere with visibility or safety. Maintaining or controlling vegetation in these areas can also help reduce fire hazard potential.

Some areas, such as medians, may be landscaped. Maintaining these areas may require mechanical, cultural and chemical controls to provide safety, visibility and aesthetics.

Railroads: Railroads are another common type of right-of-way requiring pest control, with the primary focus on vegetation management. Railroads are long paths that traverse public and private lands that are used for multiple purposes, such as rangeland, cropland, pasture, recreation, residential and commercial industry. Weeds, especially noxious weeds, must be controlled to prevent spread to adjacent lands. The goals for railroad right-of-way pest control also include fire prevention, visibility and safety of work crews.

Railroads and rail yards are generally owned by the railroad, so planning for vegetation or other pest management is possible and can be done well in advance. Since railroads own the land, access is generally not a problem and ground application equipment can be used. Because railroad tracks are long, narrow paths, care must be taken to prevent drift. Always consider adjacent land uses when planning railroad weed control programs.

Weed management along railroads commonly relies on chemical methods. Tracks, signals, switches and informational signs generally are kept bare of all vegetation. At crossings, brush control and especially vegetation height reduction is important. Complete removal of vegetation may not be permissible in these areas due to local regulations set by the crossing roadway's jurisdiction. Visibility must be maintained for both rail and

Roadside right-of-way goals include:

- **Maintaining or improving visibility**
- **Reducing potential fire hazards**
- **Providing clear and safe emergency areas for vehicles**
- **Maintaining or improving aesthetics**

Some portions of the roadside right-of-way should be free of vegetation. This is generally accomplished using chemical controls.

Railroad right-of-way goals include:

- **Preventing weed spread to adjacent lands**
- **Reducing potential fire hazards**
- **Maintaining or improving visibility**
- **Maintaining safety for work crews**

Chemical controls are generally used to keep railroad tracks, signals, switches and signage bare of all vegetation.

Public utility right-of-way goals include:

- **Prevent weed spread to adjacent lands**
- **Reduce potential fire hazards**
- **Maintain or improve access for maintenance and emergencies**
- **Maintain wildlife food, shelter and travel corridors**

If the adjacent areas are used for livestock grazing, applicators must check pesticide labeling to ensure compliance with grazing restrictions.

Vegetation management on utility and pipeline rights-of-way should focus on maintaining low-growing plants that are best adapted to the local soil, water and climate.

vehicular traffic crossing the railroad lines. Railroad yard treatment includes vegetation removal or reduction to maintain visibility and safety, and to prevent fires.

Public Utilities: Public utilities are another right-of-way location requiring vegetation control. Public utilities fall into two broad categories: pipelines and electrical transmission lines. The goals of both categories are the same: weed spread prevention, fire protection, maintenance of sites, maintenance of services, and public safety.

Generally, in Nevada, the rights-of-way for both power lines and pipelines are not paved. Access is necessary for maintenance and emergencies, but the areas are often in locations where land use is more rural, such as cropland, pasture or rangeland. The areas may also be used as natural wildlife corridors, providing food and shelter for many wild animals. These uses must be considered when planning pest control programs on transmission lines or pipelines.

Removal of vegetation may be accomplished by mechanical means, such as mowing. Chemical methods may also be used, taking into account adjacent land uses and the multiple uses of the right-of-way itself. Weeds, especially noxious weeds, must be controlled to prevent spread to adjacent lands. In sensitive areas, ground equipment can be used to provide more controlled applications of herbicides. Special care should be taken in areas near homes, crops, feed lots, reservoirs and locations where the right-of-way crosses highways, railroads or streams. If adjacent areas are used for livestock grazing, applicators must check pesticide labeling to ensure compliance with grazing restrictions.

Tall vegetation may interfere with visibility and routine maintenance, and can contribute to fire potential. Selective applications of herbicides should be used to reduce or eliminate taller vegetation while maintaining lower-growing plants that do not interfere with site goals. Vegetation management on utility and pipeline rights-of-way should focus on maintaining low-growing plants that are best adapted to the local soil, water and climate. Establishment of stable, low-growing ground cover will minimize required maintenance. Of course, the low-growing plants must not add to the fire hazard potential at the site.

Facilities related to power lines or pipelines may require more stringent vegetation removal programs. Pole yards, electrical transformer stations, electrical substations, pumping stations, etc. may require complete vegetation removal to reduce fire potential and for security reasons.

Construction Sites: New construction sites are another type of right-of-way that requires pest management plans, primarily for weeds. The main goals at these sites include reducing fire hazards and preventing the spread of weeds. As with all the other types of rights-of-way discussed previously, weeds, especially noxious weeds, must be controlled to prevent spread to adjacent lands.

Construction sites related to road building and maintenance often disturb adjacent vegetation. To prevent erosion and weed invasion, these areas are often re-seeded, or materials such as gravel or mulch are used to prevent erosion. Seed and other material applied to construction sites should be certified weed-free. See http://agri.nv.gov/Plant/Noxious_Weeds/Programs_Weed_Free_Certification_Certified_Weed_Free_Forage/ for listings of weed-free materials suppliers.

In most cases, temporary weed management will be followed by permanent landscaping after construction is completed. Keep the eventual site goals in mind when selecting control methods. Mechanical control methods, such as mowing, tilling and grading, should not interfere with landscaping plans. Short-residual chemical controls may also be used.

Other Types of Rights-of-Way: Other sites that may require right-of-way weed control include hiking trails or paths, bike paths, bridle trails or paths, snowmobile trails, etc. The portions of these paths or trails that are within parks or private lands are covered by the regulations and restrictions set by those authorities. Trails and paths that exit the originating jurisdiction then become rights-of-way. As with all previous rights-of-way discussed, weed control plans must take into account adjacent land uses. Weeds, especially noxious weeds, must be controlled to prevent spread to adjacent lands. These types of rights-of-way generally occur in urban to suburban areas, increasing the potential for publicity and protest by adjoining land users and owners. Many of these areas may also be near water bodies. Thoughtful planning and implementation is required. Use materials according to their label directions, use common sense and know the goals of the application.

Protecting Adjacent Sites from Pesticides

Many rights-of-way sites are long and narrow and pass through many different types of land uses. It is vitally important to be aware of adjacent land uses and modify the pesticide application accordingly. Caution should be used when applying pesticides, especially herbicides, in areas susceptible to wind and water erosion, because herbicides can be transported into waterways and onto susceptible vegetation and crop land. Pesticide residues that persist in soil for long periods can prevent the establishment and growth

Construction site right-of-way goals include:

- **Preventing weed movement and controlling weeds onsite**
- **Preventing weed spread to adjacent lands**
- **Reducing potential fire hazards**

Other types of rights-of-way include:

- **Hiking trails or paths**
- **Bike trails or paths**
- **Bridle trails or paths**
- **Snowmobile trails**

Goals of other types of rights-of-way include:

- **Preventing weed spread to adjacent lands**
- **Reducing potential fire hazards**
- **Protecting adjacent water bodies**

Many rights-of-way sites are long and narrow and pass through many different types of land uses. Be aware of the adjacent land uses when formulating a pest control plan for your right-of-way.

Many plant roots extend far beyond the drip line of the plant. Using preemergence herbicides can damage them. Use caution when using preemergence herbicides and soil sterilants.

Some herbicide labels prohibit application to water, either directly or through drift. Check product labeling if applying pesticides adjacent to aquatic sites.

of plants and may leach into groundwater and surface water. The rate at which herbicides and other pesticides break down in soil varies greatly and depends on several factors, including soil type, pH, moisture and microbes, and exposure to sunlight. To work properly, some herbicides must be incorporated into the soil mechanically. This exposes germinating seed to the herbicide and protects the herbicide from sunlight.

The presence of adjacent sensitive vegetation is a common concern when applying herbicides along rights-of-way. These areas may include landscaping, forests, wildlife habitat, cropland, orchards, pasture or other forage, and rangeland. Use care when applying pesticides in these areas and consider the adjacent land uses when formulating a pest management plan.

Bare ground is often the desired result in some right-of-way sites, as well as driveways, fence lines and property lines. Preemergence herbicides or soil sterilants are often used to achieve bare ground. However, misusing these products can result in injury or death to nontarget, nearby vegetation. The root zone of trees and shrubs can extend well beyond their branch spread or canopy. Trees growing in or adjacent to fence lines, driveways or property boundaries often have roots extending well into those zones. Herbicide applications in those sites may result in death or injury to desirable vegetation. Read labels carefully. Some products have specific label language prohibiting the application of the product in the root zone in order to protect trees and other sensitive vegetation.

The topography of the right-of-way and the adjacent sites must also be considered in the pest management plan. If the right-of way or adjacent site is sloped, use care when removing all vegetation, as this can lead to soil erosion. Using selective herbicides that leave desirable vegetation in place is a better choice in this situation than complete vegetation removal.

Many pesticides can be corrosive to metals, so use care around automobiles, metal guard rails, buildings or other metal surfaces.

Protecting Surface Water from Pesticides

Right-of-way sites often extend over, or are located adjacent to, lakes, rivers, streams, ditches or other waterways. Many herbicides are not approved for use in water, and product labeling will instruct the user not to apply the product directly to water, and not to allow the product to drift into water. It may be necessary to obtain a pesticide discharge permit under the Clean Water Act if a pesticide application is made near a surface water body. Aquatic organisms and downstream users of the water may be negatively impacted. Illegal herbicide application can result in serious environmental contamination and enforcement actions. See the chapter on Aquatic Pest Control, Category 5, for more information on the safe and lawful application of pesticides in or near surface water. See https://ndep.nv.gov/water/water-pollution-control/permitting/nevada-pesticide-application-program for more information on permits.

Protecting Groundwater from Pesticides

Sampling and monitoring for pesticide residues in groundwater is a major component of the Nevada Department of Agriculture's pesticide program. As a result of normal use, registered pesticides used on right-of-way sites are frequently detected in water samples collected from a network of monitoring wells throughout the state. Detections include the preemergence herbicides bromacil, diuron, simazine, atrazine, and prometon. All of these products have a high potential for leaching and contaminating groundwater. Pesticide labeling advises applicators not to use these products in areas where soils are permeable and subject to leaching.

Applicators can protect groundwater and help to reduce contamination by using other control options, such as mechanical and cultural methods. When herbicides are used, newer alternative pesticide products less likely to leach into water supplies should be considered.

Methods of Control

Weed control is the major focus of most right-of-way pest management efforts. It is imperative that you correctly identify the weed or weeds you are trying to control as well as understanding the life cycle of the weed(s). Several control methods are generally needed to achieve good results.

Control methods fall into five distinct categories: prevention, physical or mechanical, cultural, biological and chemical. In general, physical or mechanical control methods are considered short-term controls, while chemical and biological methods generally provide longer-term control.

Many factors should be considered when deciding on control methods for rights-of-way:

- Accessibility and safety of pesticide applicators and others
- Adjacent desirable vegetation (crop, pasture, ornamental, etc.)
- Proximity to urban areas, sensitive vegetation, surface water or groundwater
- Livestock, wildlife, and human use of the right-of-way and adjacent land
- Cost

Preemergence herbicides detected in groundwater:

- **bromacil**
- **diuron**
- **simazine**
- **atrazine**
- **prometon**

To protect groundwater, do not apply leachable herbicides in areas where soils are permeable. Consider other control methods or alternate products.

Methods of control:

- **Prevention**
- **Physical or mechanical**
- **Cultural**
- **Biological**
- **Chemical**

Preventing weed introduction and spread is the most cost-effective method of managing weeds.

Using mechanical controls on perennial weeds that spread by the roots can make infestations worse.

Cultural controls make conditions favorable for desirable vegetation that can compete with weeds.

Prevention: Prevention is the most effective weed control method. This involves keeping weeds out of a new or an existing site.

- Use only certified weed-free seed when replanting or overseeding.
- Inspect all mulches to make sure they are weed-free, or use certified weed-free mulches.
- Use weed-free sand, gravel and fill materials.
- Make sure weed seed and perennial plant parts, especially roots and other underground plant parts, are not carried into new areas by contaminated machinery. Remove mud, dirt and plant parts from project equipment before moving into a new project area. Collect seeds and plant parts and incinerate them, or bag them and send them to a landfill.
- Inspect, remove and properly dispose of weed seeds and plant parts found on clothing and equipment before leaving an infested project site.
- Control weeds prior to seed set. Hand-pulling a few weeds before seeds set or roots spread will prevent an infestation and reduce work in the future. Catching an infestation in the early stages, when plants are few, will stop new weeds from becoming established.

Physical or Mechanical Control: *These methods include hand-pulling,* hoeing, blading, mowing, disking, tilling, burning and flooding. They are considered short-term control methods. While they work well for annual and biennial weeds, they are not very effective for perennial weeds that have extensive root systems. In fact, for some perennial weeds, blading, disking and tilling may ***increase*** the weed population. Many noxious perennial weeds spread by both root and seed. For these types of weeds, cutting or tearing a plant root into many small pieces can generate new plants. Burning must be done carefully and thoughtfully to prevent accidental fires. Burn permits may be required. Flooding is not always possible and the risk of spreading weeds with floodwater may outweigh any benefits.

Cultural Control: These are practices that prevent or reduce weed infestations by making the conditions favorable for desirable competitive vegetation and unfavorable for weeds. Cultural controls include planting competitive native species, overseeding, proper sanitation and mulching. Planting competitive native species helps to reduce weeds by providing competition for space, nutrients, water and light. Overseeding fills in bare spots with new plants. Use caution when overseeding. Select species that will not outcompete existing desirable species at the site. Proper sanitation includes removing dead vegetation to reduce both weed seeds and fire hazards. Proper sanitation also includes removing disease- or insect-infested plants to reduce the spread of the disease or insect. Mulching helps by excluding light, reducing seed germination and inhibiting the growth of weeds. Mulches are effective in smaller areas, but may not be a realistic method of cultural control for the long expanses in some rights-of-way.

Biological Control: Biological control uses living organisms, such as insects, animals or pathogens, to control undesirable vegetation. It is another tool that can be incorporated into a comprehensive pest management program. Biological control is considered a long-term approach, and is rarely effective at eradicating an entire infestation. Biological controls generally are used to reduce infestations to an acceptable and manageable level.

Although most biological controls are inexpensive to maintain, they do take time to become established, usually lagging behind the rate of infestation. Repeated annual or regular releases of the biological control organism into an infested site may be required for effective control. This method is called augmentation. Most biological controls are species-specific, controlling only one species of plant or insect. Biological controls are a tool used in conjunction with other pest management methods.

Routine monitoring is needed to track success or failure of biological control organisms. Sometimes a single release is all that is required. Record the locations of biological control organism releases. Do not apply pesticides at these sites while the biological control agent is becoming established.

Chemical Control: Chemical control of weeds involves the use of herbicides, which are useful tools that should be used in conjunction with other methods. Successful weed management programs use several control strategies and do not rely on herbicides alone to do the job. Many herbicides used in the right-of-way also have specific uses in cropland and other sites. Extreme care must be used when applying herbicides to rights-of-way that are adjacent to croplands, ornamental and turf areas, water and sensitive sites in order to avoid unintended damage.

The active ingredients in pesticides are the chemicals that control the pest. Pesticides are sold in a variety of formulations, which can be divided into finished, ready-to-use products or products that require dilution. Pesticide product formulations may include one or more active ingredients plus other inert ingredients. Some common formulations include dry flowables, emulsifiable concentrates and wettable powders. There are also granular products that can be applied directly to the site without mixing in water. If you find that more than one formulation of a pesticide is available for your pest control situation, you must choose the best one for the job. **READ, UNDERSTAND AND FOLLOW THE LABEL DIRECTIONS.**

When selecting herbicides, several factors should be considered:

- Weeds present. As with all pest control, you must first identify the pest.
- Objectives for the area. What level of control is desired: bare soil, some

Biological controls rely on living organisms to manage unwanted vegetation, and the results may not be quick enough to meet goals.

Herbicides can be effective tools when used in conjunction with other weed management strategies.

When selecting chemical controls, consider the goals for the site, including bare ground, specific vegetation, etc., and be aware of adjacent land uses and sensitive sites.

Phytotoxic: poisonous to plants

Systemic herbicides are used on perennial weeds because they are translocated (moved) through the entire plant.

Preemergence herbicides must be applied prior to seed germination.

vegetation, no grass, only grass?

- The leachability, or potential for lateral or downward movement of the herbicide away from the treatment site.
- Adjacent land uses and sensitive sites (crop, pasture, ornamental, water, etc.).
- Human, livestock or wildlife use of the right-of-way and adjacent lands.

Types of Herbicides

Herbicides can be subdivided in several different ways:

- Contact versus systemic
- Selective versus nonselective
- Preemergence versus post-emergence

Contact herbicides are those that kill only the green tissues of plants on which the herbicide has been applied. Many contact herbicides are also nonselective (see below). They are mainly used to control annual weeds and to manage, but not permanently remove, perennial vegetation like willows that are invading a roadside.

Systemic herbicides are those that are absorbed and translocated, or moved, within a plant. Systemic herbicides may move upward to the growing points, or downward into the roots. These herbicides can be used to control weeds of any plant life cycle (annual, biennial and perennial), but they are especially useful in controlling perennial weeds.

Selective herbicides are those that are phytotoxic to some weeds, but have little or no effect on others. Broadleaf herbicides, which kill broadleaf plants but do not harm grasses, are an example of this type of pesticide.

Nonselective herbicides are those that that are phytotoxic to a wide range of plants. A nonselective herbicide will kill all the susceptible plants that it contacts. For example, if applied to a lawn, it will kill both the grass and the broadleaf plants in the lawn.

Preemergence herbicides are those that are applied before plants have emerged from the soil. These products interfere with germination of seeds, disrupting and preventing root growth. Some may also have post-emergence effects. Preemergence herbicides require moisture from either irrigation or precipitation to activate them in the soil.

Post-emergence herbicides are applied to the foliage after the plants have emerged from the soil. Most often, they are applied to green, actively growing plant tissues.

Other Pests in Rights-of-Way

Most other pests are not common problems along rights-of-way. Occasionally, burrowing rodents can cause damage to right-of-way sites, such as roads, roadsides, canals or ditch banks. Prevent rodent damage by using traps and/or rodenticides. Rodent management options are outlined in the general pest problems section of this manual.

Another pest that occasionally presents a problem on rights-of-way is the Mormon cricket. These insects have cyclic populations. During peak population booms, they can present hazards along roads and other rights-of-way, both by consuming vegetation in the right-of-way and adjacent sites and by creating a slippery road surface as they attempt to cross and are squashed by vehicles. Control Mormon crickets using baits or other insecticides. Choose the control method carefully to ensure safety of nearby people, their pets, domestic livestock and wildlife.

Conclusion

Rights-of-way are distinct areas involved in the transport of people, goods and services. There are many goals when managing rights-of-way. Safe access is important, as are fire prevention, visibility, erosion control and safety for workers and the general public. Weeds, especially noxious weeds, must be controlled to prevent weed spread to adjacent lands. Aesthetics become an important factor in and around urban areas.

Rights-of-ways are generally long and narrow and pass through areas with different soil types, vegetative communities, topographies and sensitive sites. Many rights-of-way are limited in size or purpose. For example, some road widths are mandated not to exceed a certain size. The differences in use and in physical attributes make a "one-size-fits-all" solution to right-of-way pest control impossible. Pest management will vary from site to site.

Be sure to read, understand and follow the pesticide label directions.

Originally published in 1987 as Category #6 Right-of-Way Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Revised in 2018, by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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Category 7A and 7B: Industrial and Institutional Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Industrial and Institutional Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Identify the different types of stored product pests and strategies to control or prevent an infestation of these pests.**
- ✓ **Describe general industrial and institutional pest control strategies.**
- ✓ **Describe microorganism pests in industrial and institutional pest control.**
- ✓ **List the most common invertebrate pests encountered in industrial and institutional pest control and methods to control them.**
- ✓ **Identify the most common vertebrate pests encountered in industrial and institutional pest control and methods to control them.**

Category 7a and 7b, Industrial and Institutional Pest Control

If you wish to apply pesticides to public properties, including public schools, you must now be a licensed government applicator.

Recent changes in Nevada's legislation limit industrial and institutional certified applicators to the following: homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality

Category 7a and 7b, Industrial and Institutional Pest Control, covers pests in grain elevators, warehouses, hotels, casinos, food establishments, stores, offices, operational sites, schools, rest homes, homes and hospitals.

Remember that all pesticides are considered toxic and should be used with caution around food, food storage and food preparation areas.

properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

Category 7a and 7b, Industrial and Institutional Pest Control, describes management practices for pests found in both industrial and institutional sites. The primary pests found in industrial and institutional sites are insects and rodents. Birds can also be pests. This category does not cover pests in ornamental and turf sites or wood-destroying pests.

Both industrial and institutional settings have similar sites. For example, most hospitals, rest homes and schools have kitchens and offices. So, many industrial and institutional pest control practices overlap.

Industrial sites include:

- Stored product facilities and farm structures
- Food processing facilities
- Retail sites, such as stores, hotels, casinos and restaurants
- Related sites, such as offices, kitchens and operational sites

Institutional sites include:

- Schools
- Hospitals and rest homes

Good sanitation and cleanliness are the keys to control and management of pests in industrial and institutional sites.

General Pest Control Strategies

Most effective pest control plans include more than one control strategy or method. Using Integrated Pest Management (IPM) categories, the following are control strategies that have applications in Industrial and Institutional Pest Control.

- **Prevention:** Prevention is an essential management practice that includes sanitation and exclusion. Insects and rodents must have food water and shelter to survive. Remove one or preferably all of these and pest problems will be significantly reduced.
    - **Food:** Clean food preparation areas, classrooms, and other problem sites frequently to greatly reduce pest problems. Thorough cleaning under and behind furniture, equipment, shelving and appliances may be necessary to remove all food sources. Remove trash regularly and

use trash can liners. Keep areas around dumpsters clean. Store food in rodent-proof and insect-proof containers.

  - **Water:** Pests find water in numerous places. Wring out and hang wet mops to dry. Repair leaky pipes. Clogged rain gutters and leaking faucets are also important water sources for rodents, insects and birds. Clean floor drains routinely as they are sources of both food and water.
  - **Shelter:** Restrict the pest's access to shelter and food by sealing entry points. Install door sweeps and window screens. Seal cracks and crevices with screens, silicone or other sealant material. Eliminate clutter and keep stored products on shelving off the floor. Bird netting and metal bird spikes will restrict birds from accessing sites where they might roost and nest.

- **Inspection and Monitoring:** Routine monitoring is an important part of managing pests in industrial and institutional sites. Monitoring not only includes surveying for pests but also observing conditions that are favorable for pests, including unsanitary conditions, entry sites and shelter locations. When conditions favoring pests are found, they should be corrected as soon as possible.

  Sticky traps and pheromone traps are used for insect monitoring. Sticky traps are simple devices made of cardboard with one surface covered in a glue-like material. When insects contact the trap, they become stuck. Some sticky traps include the use of pheromone lures. Pheromones are natural scents produced by insects that are used to communicate with each other. Some pheromones are sex attractants that attract only males and others attract both males and females.

  When monitoring, look for pests and evidence of pests, such as fecal material, shed insect skins, tracks and grease marks left by rodents. Routine monitoring will indicate if pests are present and help you to evaluate whether your pest management strategies are successful.

- **Mechanical/Physical Control:** While stepping on and smashing an occasional ant or cockroach is considered physical control, it is not a sustainable, effective long-term management method. Trapping is the most common means of mechanical control for both insects and rodents in industrial and institutional sites. Trapping is also a monitoring technique used to determine where pests are present and what species are present.

  Sticky traps can be used for insects and small rodents, but they are not considered to be the most effective means of control. Mechanical kill traps, such as snap traps, are used for mice and rats. Live traps may be

Traps can be used both as inspection and monitoring tools and as mechanical controls.

The site where the pesticide is applied must be listed on the product label. Applying a pesticide to a site not listed on the label is a violation of federal law.

used, but releasing live rodents is illegal. Most often, live trapping is followed by humane euthanasia. Rodents can transmit diseases, so use proper precautions when working around live or dead rodents.

Other mechanical or physical management options include vacuuming and sweeping up pests such as ants. Mechanical control should be done in conjunction with prevention. If you trap mice or vacuum ants but don't remove food sources and eliminate access, you will never solve the pest problem.

- **Pesticides:** Pesticides including rodenticides and insecticides are applied as sprays, dusts, fumigants, baits and granules. The site where the pesticide is applied must be listed on the product label. Applying a pesticide to a site not listed on the label is a violation of federal law.
  - **Rodenticides:** Rodenticides are usually applied in bait form. Pesticide labels describe how and where to apply baits. Tamper-resistant bait boxes or bait stations are often required. Some rodenticides are applied as tracking powders that are sprinkled in areas where rodents are present. They are picked up by rodents on their feet and fur and are ingested during grooming.

    Many rodenticides are classified as restricted use pesticides and may be used only by certified applicators or persons under their direct supervision.

    Rodenticides should be used in combination with preventative methods, including exclusion and sanitation.
  - **Fumigants:** Fumigants are used in industrial sites to control commodity pests. **This category does not cover commodity fumigation.** Refer to the Category 9: Fumigation, commodity fumigation (L1) subcategory in this manual.
  - **Insecticide baits:** Baits used for insect control are typically applied as gels or granules. Some are applied in bait stations, while others are applied in cracks and crevices where insects occur. Baits used for cockroach or ant control are picked up by insects and taken to the colony where they are shared with the rest of the colony.
  - **Insecticide sprays:** Insecticide sprays may be applied to cracks and crevices, by broadcast treatment, or as perimeter applications. Applicators must identify the insect, select the proper insecticide treatment, and apply the product according to label instructions.

Stored Product Insects

There are four classes of stored product insects:

- Internal feeders: The larvae feed inside the grain. Examples are the rice weevil and the granary weevil.
- External feeders: Larvae enter through holes in the outside shell and the larvae then eats inside the kernel. Examples are the lesser grain borer and the drugstore beetle.
- Scavengers: These organisms are eaters of damaged grain. The sawtooth grain beetle (most common) and the confused flour beetle are examples.
- Secondary: These are mold and fungi eaters. An example is the yellow meal worm. It eats products that are out of condition.

These pests require very definite temperature ranges (40°F to 70°F) and humidity ranges (40% to 70%) to survive. Moisture and temperature are important factors for reproduction of stored product pests. The importance of good housekeeping cannot be overemphasized. Do not store packaged goods for long periods. In some situations, storing foods in two sealed containers may be required.

Good sanitation and cleanliness aid in prevention and control. In warehouses, grain elevators or retail establishments, any infestation discovered should be immediately removed and destroyed. Seal all cracks and crevices to eliminate additional infestations. If a pesticide application is warranted, apply according to label directions. Cover and avoid contamination of unpackaged goods or exposed foods. Always cover foods with plastic or a nonporous cover. All pesticides are considered toxic, and most have residual effects. Never apply pesticides to uncovered food or utensils. Pesticide formulations change all the time. Consult your local pesticide dealer for the correct product to use in the situation.

Microorganism Pests

The only microorganisms of importance are fungi and water molds. They both require moisture. Fungi may cause additional damage to structures by the growth of their hair-like mycelia. For control, dry up and aerate the area or materials. If chemical controls are 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.

Good sanitation and cleanliness aid in prevention and control.

Pesticide formulations change all the time. Consult your local dealer for the correct product for the situation.

Selected Invertebrate Pests

Invertebrate pests include insects and arachnids, such as spiders and mites. The following are those insects or arachnids most commonly encountered in industrial or institutional settings.

Cockroaches: There are four species of importance.

- The German cockroach is the most common. Usually found outdoors, these cockroaches enter the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. The German cockroach has developed resistance to chlorinated hydrocarbons, so use one of the newer insecticides developed for cockroach control. Contact your local dealer for specific insecticides to control German cockroaches.
- The American cockroach is large and red. Like the German cockroach, the American cockroach is usually found outdoors and enters the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific recommendations.
- The Oriental cockroach is black and shiny. Usually outside, these cockroaches also enter premises in search of moisture, like the German and American cockroaches. Limit food and water sources and eliminate access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific insecticides.
- The brown banded cockroach is very common in certain areas. Unlike the other three species mentioned, brown banded cockroaches prefer warm and dry locations. They are found in structures generally away from water sources. Good sanitation is important. Eliminate food sources. Block entry points by filling in cracks, crevices and other entry sites at ducts, moldings or other openings. Baits and traps are used to control these pests, along with quick knockdown residual insecticides. Contact your local dealer for specific recommendations.

Clothes Moths: These pests eat holes in clothing and furniture. While termites are able to digest cellulose, the clothes moth is capable of digesting keratin for its protein requirements. Keratin is a protein component found in all animal hair, such as wool and the hair of hide-producing animals. These pests feed on wool clothing, fur garments, animal hides, upholstered furniture, carpets and rugs. They may also feed on wool blend fabrics. They are small, ¼ inch in length. They generally do not fly far from the site of

Clockwise from top left: German, brown banded, American and oriental cockroaches.
Art Cushman, USDA, Smithsonian Institution, Department of Entomology, Bugwood.org

Clothes moths
Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

infestation. The larval stage is the damage-producing stage. Storing susceptible items in air-tight containers can limit infestations. They prefer humid conditions, so lowering the humidity inside structures can aid in limiting infestations. Practice good sanitation by removing pet hair accumulations or wool debris and removing infested items before they spread. Insecticidal sprays may be used, but make sure the sprays themselves will not damage the infested fabric, fur or hide.

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 and some on dew or similar substances. All ants may bite, and some bites are rather severe. Identification of the specific species is important in control. Adequate control is only possible when the species and habits are considered. Satisfactory results rely on insecticides that provide prolonged exposure. Formulations used are wettable powders (WP), emulsions (EC), dusts (D), granules (G) and poison baits. Contact your local dealer for specific insecticide recommendations once you have identified the species of ant. For aid in identification, contact the University of Nevada Cooperative Extension or the Nevada Department of Agriculture.

Wasps: Wasps include those insects called yellow jackets, hornets, umbrella (paper) wasps and mud daubers. Wasp control varies with the location of the nest. It is recommended that control applications be made at dusk or during the coolest period of the day. When treating aerial nests, spray the insecticide directly into the nest opening as well as the entire nest. Liquid insecticides may be poured into openings of subterranean nests. Contact your local dealer for specific recommendations.

Spiders: Most spiders are beneficial, preying on insect pests. In an industrial or institutional setting, tolerance for spiders is not as high as it is in a garden or outdoor setting. 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 spiders. 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. Contact your local dealer for recommendations on pesticides for spider control.

Wasp
Whitney Cranshaw, CSU, Bugwood.org

Black widow spider
James Solomon, USFS, Bugwood.org;

Rat

Clipart ETC, Florida's Educational Technology Clearinghouse, University of South Florida, http://etc.usf.edu/clipart/ index .htm

No control method will be successful unless mice and rats are kept from entering the site.

Selected Vertebrate Pests

Rats and Mice: Rats and mice are the rodents most likely to be found in industrial and institutional sites. These rodents eat and contaminate food and animal feed. They also cause structural damage by chewing both wood and wiring. They carry diseases contagious to humans, such as Rickettsial pox, bubonic plague and leptospirosis.

No control method will be successful unless mice and rats are kept from entering the site. Seal any opening over ¼-inch wide. Use good sanitation practices and remove any food supply that may attract these rodents. Use rodent-proof containers to store all food and animal feed to prevent attracting and feeding these pests.

Anticoagulant baits are the most commonly used chemical controls. Use care when placing them. Pesticide baits must be applied in approved bait stations.

Snap traps can be effective, provided exclusion measures are also put in place. Baits for trapping include peanut butter plus oatmeal, bacon, gumdrops (for mice), sardines (for mice), nutmeats and dried fruit.

Rat and mouse urine fluoresces under UV light. This characteristic can be used to locate their trails and commonly frequented areas. Bait and trap in these areas. Check traps daily and use care when handling dead rodents.

Norway rats are good climbers, jumpers and diggers. They contaminate 25 times as much as they eat by urination and defecation. They eat a wide variety of foods, but are wary of new food items. Pre-baiting may be required. They are active mainly at night.

Roof rats are not widespread in Nevada, and are primarily found in Las Vegas and the vicinity. Excellent climbers, they live in trees and often nest in palms, etc. They can transmit diseases, especially plague. Controls are similar to those for the Norway rat.

House mice are very prolific and can have six to eight litters per year. Mice harbor mites that spread rickettsial pox. They are random feeders, so set baits or traps 10 to 15 feet apart. Use sardines, peanut butter, candy or anything that is oily. The life span of a mouse in the wild is usually less than one year.

To prevent infestations, remove food sources, line garbage cans with plastic bags, make entranceways rodent-proof, and put garbage cans up on racks. All of these practices will discourage both rats and mice.

Deer Mice: Deer mice can carry hantavirus. Although the chance of infection is low, the mortality rate is high. As with other mice and rats, anticoagulant baits, snap traps and excluding the mice from structures are recommended management measures. Clean up droppings and urine with disinfectants or a five percent to ten percent bleach solution. Do not sweep, vacuum or atomize these wastes. Use a micron-filtered dust mask and gloves during the cleanup. Close openings over one-quarter inch in size to exclude further infestation. See the General Knowledge: Hantavirus – An Update chapter in this manual for further information.

Bats: Big brown and little brown bats are the most common species found in buildings in Nevada. Nursery colonies are produced in summer. Occasionally, these nursery sites are in the attics or basements of buildings or in other structures. These sites may also be used for hibernation during the winter. The best control is exclusion. Young bats must be able to fly before an exclusion strategy will work. If you seal entry/exit points while young are present, they will die inside the building. This results in additional problems. Make sure the bats have departed for the evening and then seal up all openings greater than ¼-inch wide. This includes vents, chimneys and other opening in the roof, eves or soffits, gaps around windows or doors, gaps around conduits or pipes, and holes or gaps in window screens. For migratory species, the best time to implement exclusion measures is during fall or winter.

Bats can carry rabies, but the infection rate is low. Most bat bites occur when people handle or provoke a bat. As with all animals, use caution and common sense when handling dead bats. Some species of bats in Nevada are protected. No chemicals are registered for bat control.

Deer Mouse
Clipart ETC, Florida's Educational Technology Clearinghouse, University of South Florida, http://etc.usf.edu/clipart/ index .htm

Little brown bat
Ohio Department of Natural Resources, http://www.dnr.state.oh.us

Summary

Exclusion is the best method of control for all industrial and institutional pests. Good sanitation and cleanliness will aid in prevention and control. Any infestation discovered should be immediately removed and destroyed. Seal all cracks and crevices to eliminate additional infestations. If a pesticide application is warranted, use extreme caution when applying the pesticide. Avoid contaminating unpackaged goods or exposed foods. Always cover foods with plastic or nonporous covers. Never apply pesticides on or near to uncovered food or utensils. All pesticides are considered toxic. Most have residual effects. Pesticide formulations change all the time. Consult your local pesticide dealer for the correct product to use in your situation.

Exclusion is the best method of control for all industrial and institutional pests.

Originally published in 1987 as Category 7a and 7b, Industrial and institutional Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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Category 7C: Structural Pest Control (Wood-Destroying Pests)

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Structural Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the most common wood-destroying pest microorganisms and strategies to control or prevent infestations of these pests.**
- ✓ **Explain how to tell the difference between termites and ants.**
- ✓ **Describe the three different types of termites and pest control strategies for each.**
- ✓ **Identify the most common invertebrate wood-destroying pests (excluding termites) and methods to control them.**

Category 7C: Structural Pest Control

Category 7C, Structural Pest Control, covers wood-destroying pests in structures.

Recent changes in Nevada's legislation limit structural pest control certified applicators to the following: homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the

The most common wood-destroying pests in Nevada are:

- Termites
- Wood-destroying beetles
- Carpenter ants

Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

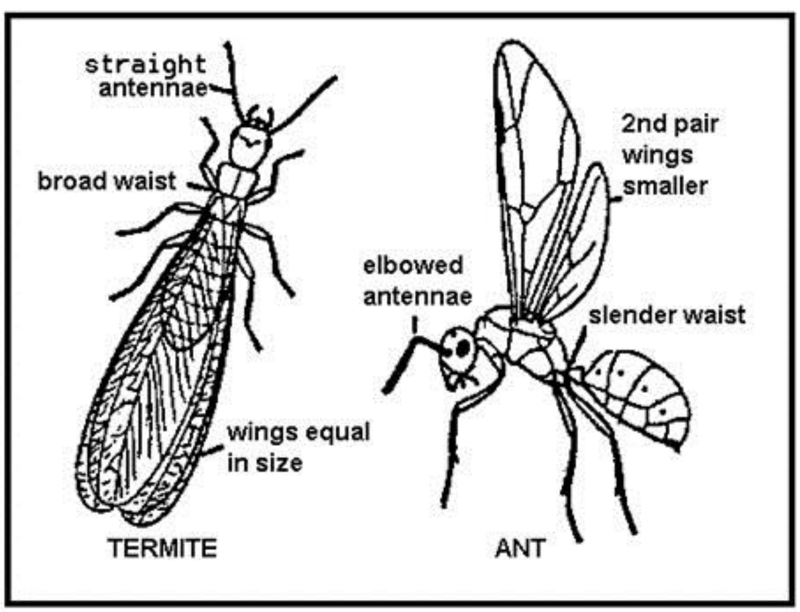
Category 7c, Structural Pest Control, is the category concerned with control of wood-destroying pests. The most common wood-destroying pests are termites. Wood-destroying powder post beetles, carpenter ants and wood damaging fungi are also pests of concern in this category.

Wood Damaging Microorganisms

Microorganisms that damage wood are generally fungi. Fungi are plants that lack chlorophyll. They cannot make their own food like other plants. Fungi feed off other organic matter, in this case wood. Fungi damage wood when their mycelia, a mass of thread-like filaments, enter wood cells in search of food. The food sources in wood are damp wood that has started to break down or rot. The best control is prevention, by monitoring and correcting excess moisture problems in the structure. If a fungal infestation has started, drying the area and applying borates with oil will aid in control. Other chemical controls may be available. Consult your local pesticide dealer for products that will work for your particular site.

Wood-destroying Insect Pests

The most common wood-destroying insect pests in Nevada are termites, wood-destroying beetles and carpenter ants.



How to tell winged ants from termites. U Ark Extension

It is easy to confuse ants with termites. Both are insects, with three body parts, six legs and antennae. Both may have two pairs of wings. The following will help you distinguish termites from ants:

- **Thorax-abdomen junction:** Ants have a thread-like waist with spikes. Termites have a thick waist.
- **Antennae:** Ants have "elbowed" antennae or antennae with an almost 90-degree bend. Termites have straight antennae that may also look like strings of beads (called moniliform).
- **Wings:** Both ants and termites may have two pairs of wings. The second pair of ant wings is smaller than the first pair. Ant wings do not have a lot of veining. Both pairs of termite wings will be the same size and show a lot of veining.

Termites

All termites are social insects, meaning they live in groups. The nest or colony can have a number of different looking individuals, called castes. The largest termite is the queen, who lays eggs. A king is always by her side. There can be a soldier caste, with large heads and powerful jaws. The most numerous is the worker caste. Termites are unique in the insect world, as the workers can be both female and male. Termites can be long lived, queens and kings can live for decades and workers can survive for several years. Termites utilize fungi for their protein requirements and digest cellulose with the aid of a microorganism they have in their gut. Termites provide a vital function in the wild by helping in the decomposition of wood and plant materials. They become a problem when the wood they choose to consume is part of a man-made structure.

There are three types of termites: subterranean, dry wood and damp wood.

Subterranean termites: This group of termites basically has three castes: worker, soldier and reproductives (queen and king). They feed on sound or decaying wood. They make mud tunnels that regulate their moisture requirements and harbor the fungi they must have for their protein requirement. The tunnels they form in the wood are usually full of debris. All subterranean termites are soft bodied and all require contact with the soil.

Control of subterranean termites requires prevention (proper construction and good sanitation) and chemical controls. Proper construction requires that all wood portions of structures be at least 12 inches above the soil beneath the building. Good sanitation reduces food sources for termites. Do not stack wood on the bare ground next to a wood structure. Pick up wood debris in the yard, especially if it is adjacent to a structure (house, shed, barn, etc.). Remove dead wood, tree stumps, lumber scraps or other attractants to termites. Contact your local pesticide distributor for the latest

There are three types of termites:

- **Subterranean**
- **Dry wood**
- **Damp wood**

Good sanitation and cleanliness will aid in prevention and control.

Pesticide formulations change all the time. Consult with your local pesticide dealer for the proper product for your situation.

Dry wood termites do not require contact with the soil.

Damp wood termites are most commonly associated with rotting wood.

information on pesticide products available for your site and situation. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators. Oils or other adjuvants may be required to achieve penetration of the chemical into the soil.

Dry wood termites: Dry wood termites have soldier, nymphs and reproductive castes. They do not have a worker caste. The immature termites or nymphs perform the "worker" tasks in the colony. Dry wood termites are most prevalent in hardwoods. The tunnels they make are very clean. They produce very small holes that lead into large galleries. The galleries are also very clean. Dry wood termites do not require as much moisture to establish a colony, hence the name. Because they tolerate less moisture, they do not require contact with the soil, as subterranean and damp wood termites do. These termites form new colonies when mature, winged reproductives (queen and king termites) fly in search of a new site. Any openings in a structure may provide access for a new colony to form.

Control of dry wood termites requires prevention (sanitation), physical control (exclusion) and chemical controls. Locating the colony is a difficult task and may require the services of a licensed professional. Openings, cracks, gaps or improperly covered vents in attics, substructure, garages, window frames, outbuildings or any other susceptible cellulose building materials may provide colonization sites for these termites. A thorough inspection is required. Prevention includes using resistant wood or pressure-treated wood. Mechanical control includes blocking all access points where dry wood termites could enter and colonize a structure or a site. Use fillers, wire mesh or putty. Putty can be destroyed by normal wear and tear and may not be one hundred percent effective as an exclusion measure. Exposed wood can be protected by a heavy coat of paint.

Chemical control for these termites is complicated. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators. For attic and wall protection, a preventive dusting with silica aerosol that is impregnated with a termiticidal compound can be blown into attic and wall voids. The best form of chemical control for dry wood termites is fumigation, but this is a very complex control method to set up and should be left to a licensed professional. Fumigation is discussed in a separate chapter in this manual.

Damp wood termites: This is the largest sized termite in Nevada. They occur mostly in western Nevada. Damp wood termites have soldier, nymph and reproductive castes; they have no worker caste. These termites may cause structural damage, but they need wood with an excessive amount of moisture to be successful. They are most often associated with rotting wood, often near the soil. They, like the subterranean termites, require contact with the soil.

Control of damp wood termites requires prevention (good sanitation), mechanical control (exclusion) and chemical controls. Prevention, first and foremost, requires routine monitoring and correcting any excess moisture. Fix leaks, dry out the wood and prevent rot from starting. Good sanitation reduces the food sources for termites. Remove any rotting wood from sites near or adjacent to structures. Store all firewood and other wood products off the ground to eliminate the wood-soil interface that damp wood termites like. Do not stack firewood adjacent to wood structures. Eliminate all openings and make sure all wood portions of structures are at least 12 inches above the soil beneath the building. Use lumber from resistant wood or pressure-treated wood products. Contact your local pesticide distributor for the latest information on pesticide products available for your site and situation. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators. Oils or other adjuvants may be required to achieve penetration of the chemical into the soil.

Wood-destroying beetles: There are two species of importance: the powder post beetle and the long horned wood boring beetle.

The powder post beetle is the most common wood-destroying beetle in Nevada. The larva of this insect produces a fine, dust-like powdered frass, a mixture of feces and fine wood fragments. Much of the frass remains in the boring tunnels the larva cut into the wood, but some can spill out of the holes and form small piles on or adjacent to infested materials (furniture, moldings, paneling, door frames, plywood, flooring, etc.). These pests most commonly attack hardwoods, but they also attack bamboo. They prefer low-moisture wood materials.

The long horned wood boring beetle can digest cellulose.

As with all pests, prevention is the best method of control. Remove all dead wood, scrap lumber and other waste wood products before infestation can occur or spread. Only bring in enough firewood for daily use to limit the chances of infestation. Inspect all furniture and wood products before bringing them inside structures. Small items can be heated (if they are not upholstered, painted or fur-covered) for 6 hours at 120 to 140 degrees F. Small items can also be frozen at 0 degrees F for 72 hours. Remove and replace all infested structural wood whenever possible once an infestation is discovered. The wood should be burned or disposed of in a landfill. If removal of infested materials is not possible, chemical controls maybe required. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators. Contact your local pesticide

The powder post beetle is the most common wood-destroying beetle in Nevada.

The long horned wood boring beetle can digest cellulose.

Carpenter ants do not feed on wood, but they cause damage when they construct their nests in wood.

Remember that if you are planning to apply pesticides to the parent nest that is probably outside the structure in the landscape, you will need to have ornamental and turf certification also.

distributor for the latest information on products available for your site and situation. Oils or other adjuvants may be required to achieve penetration of the chemical control into the wood. Fumigation may be required for severe infestations. This is a very complex control method to set up and is best left to a licensed professional.

Carpenter ants: Carpenter ants only damage wood while constructing a nesting site. They do not actually feed on the wood. They generally attack only soft or decaying wood, but once they have established a nest, they may attack adjoining wood that is not decaying. They also commonly nest in wall voids, hollow doors and insulation. The nests carpenter ants form in structures are commonly satellites of a larger parent nest located outside in a live or dead tree, a firewood pile or lumber pile, or even in wood-based landscape materials. Infestations can also start in new construction, when the construction process disrupts an existing outdoor nest. Carpenter ants feed on dead and living insects, nectar, fruit juices and honeydew produced by plant-sucking insects, such as aphids.

Control of carpenter ants includes prevention, good sanitation, physical controls (exclusion) and chemical controls. Prevention includes not using wood-based mulches adjacent to structures, especially if the wood mulch touches wooden portions of the structure. Eliminate any wood-to-soil contact for any portions of the structure. Good sanitation includes removing any potential food sources in the structure, removing any piles of wood materials that may start decaying and provide nesting sites for carpenter ants on the property, and trimming any tree branches or shrubs that are in close of contact with the structure. Good sanitation also requires replacement of any decayed or damaged wood in the structure.

You must also correct whatever problem is causing the excess moisture which led to the decay. Increasing ventilation in damp areas can eliminate decay and discourage infestation. Exclusion methods include sealing off all potential access points in the structure. Openings, cracks, gaps or improperly covered vents in attics, substructures, garages, window frames, outbuildings or any other susceptible cellulose building materials may provide colonization sites. Chemical controls may be required. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators. Contact your local pesticide distributor for the latest information on products available for your site and situation. Remember that if you are planning to apply pesticides to the parent nest that is probably outside the structure in the landscape, you will need to have ornamental and turf certification also.

Conclusion

Prevention and exclusion are the best methods for control of wood-damaging pests. For most of these pests, moisture control and preventing wood decay will limit the infestations of these pests. Pesticides for the control of wood-destroying pests may only be applied by licensed pest control operators.

Prevention and exclusion are the best methods for control of wood-damaging pests.

Originally published in 1987 as Category 7c Structural Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

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Category 8: Public Health Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Public Health Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the concepts and significance of host, reservoir and vector in public health pest control.**
- ✓ **Explain management methods used to control and prevent diseases.**
- ✓ **List the common public health pests.**
- ✓ **Describe how disease is transmitted from arthropods to humans.**

Category 8, Public Health Pest Control

Recent changes in Nevada's legislation limit public health certified applicators to the following: homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

If you wish to apply pesticides to public properties you must now be a licensed government applicator.

Category 8, Public Health Pest Control, involves the management of insects and other animals that transmit diseases to humans.

Public health pest control involves the management of insects and other animals that transmit diseases to humans. It is important to understand a few terms and concepts.

Pathogen: A microscopic organism that causes disease in living things. Examples of pathogens in humans include bacteria, viruses, fungi, protozoa and rickettsiae.

Host: A living animal that provides sustenance to a parasite. For example, California ground squirrels are hosts for rodent fleas.

Reservoirs: A host animal that can harbor a disease-causing organism over an extended period of time without showing symptoms of the disease. The disease is spread when an insect feeds on the reservoir animal and then feeds on another animal later. Insects that spread diseases but are not affected by the disease are termed vectors. For example, birds are a reservoir for West Nile virus. West Nile virus is spread from the reservoir birds to horses and humans by mosquito vectors. Horses and humans become hosts, falling ill from the virus.

Vector: Generally an insect, such as a flea, mosquito or fly, or an arachnid, such as a tick, that transmits the disease or pathogen from one animal to another. Vectors may infect hosts directly or indirectly.

Indirect transmission is also referred to as mechanical transmission: the insect transports disease organisms on its body surfaces from one host, area or reservoir to another host. An example is dysentery bacteria transmitted on the feet, body hairs or other body surfaces of a fly to a human. In mechanical transmission, the insect vector is a passive or accidental transmitter of disease. The disease does not require the vector for development, just for transportation.

Another method of transmission is biological. Disease organisms need assistance moving from one host to another. Biological transmission occurs when the vectors acquire the disease organisms, the disease organism develops in the insect or arachnid vector’s body, and then is transmitted to a host. Within the vector, the disease may remain as it was, may further develop or may reproduce.

Some diseases require time within a specific vector to develop. These insects or arachnids are termed “obligatory vectors.” Malaria is an example of a disease that requires an obligatory vector. The malaria organism develops within the mosquito before being transferred to humans via the mosquito bite or sting. Without the mosquito vector, the malaria organism would die.

Just like all other pests, it is important to understand the life cycle of these public health pests. In the malaria example above, understanding the life cycle of the malaria organism has helped control spread of the disease. We recognize that we must control the mosquito vector to reduce or eradicate malaria.

Arthropods: This is the group of invertebrate animals that includes insects and arachnids, such as spiders, ticks and lice.

Arboviruses: These are the viruses transmitted by arthropods, including ticks or mosquitoes. The word is derived from “arthropod-borne viruses.” Examples of arboviruses are the West Nile virus (mosquito vector) and Colorado tick fever (tick vector).

Zoonotic diseases: These are infections caused by pathogens that are transmitted from animals to humans. The transmission can be direct, such as rabies, which is transmitted from one mammal to another. It may also be indirect, spread by an insect or arachnid vector from one vertebrate animal to another. Examples of indirect zoonotic transmissions include malaria from mosquitoes or rodent fleas that transmit plague.

Epizootic: An epidemic that caused a die-off in a wild animal population. Epizootics from plague periodically occur in rodent populations, such as the California ground squirrel.

Arthropods are the group of invertebrates that include insects and arachnids.

Arthropods can be vectors of disease between one animal and another, including humans.

Arboviruses are those viruses transmitted by arthropods.

Specific Diseases, Prevention and 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 antibiotics if diagnosed early. There are three main forms of plague infection in humans:

- **Bubonic plague** is infection of the lymphatic system. It results from a flea bite. It is the most common form, characterized by rapid onset of fever and painful swollen lymph glands. Mortality often exceeds 50 percent in untreated cases of bubonic plague.
- **Septicemic plague** is infection of the bloodstream. It is usually fatal if not treated.
- **Pneumonic plague** is infection of the lungs. It results in a pneumonia that is associated with the highest mortality and is 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 can transmit it to humans.

Plague is a bacterial infection vectored to humans by rodent fleas.

Precede rodent removal by flea control using an insecticide dust in the burrows to reduce populations of potentially infected host-seeking fleas.

Diseases vectored by ticks include:

- **Colorado tick fever**
- **Rocky Mountain spotted fever**
- **Lyme disease**
- **Relapsing fever**

Plague is characterized by continuing cycles of infection in native rodent species with rodent fleas serving 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 host species, such as ground squirrels, chipmunks, marmots and wild rabbits. Plague epizootics among susceptible species leave infected vector fleas seeking new hosts, providing potential risk to humans and domestic animals.

Plague prevention involves a comprehensive approach using habitat modification, sanitation, rodent proofing, trapping, toxic baits and public education. Precede rodent removal by flea control using an insecticide dust in the burrows to reduce populations of potentially infected host-seeking fleas. Follow label directions, including wearing the proper Personal Protective Equipment (PPE).

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 blood meals 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 nymph 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 including wearing long-sleeved shirts and long pants and prompt tick removal reduces the infection rate.

Soft ticks capable of vectoring relapsing fever are found in the nests of rodents, such as squirrels and chipmunks. If the nests are in the home and 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. The key to prevention is to rodent-proof buildings in areas where tick-borne relapsing fever is known to occur. Once an infestation has occurred, rodent nesting material should be removed. A crack-and-crevice pesticide treatment should also be performed in the nesting area to kill any remaining ticks.

Hantavirus is a zoonotic disease that was first identified in the Southwest in 1993. The particular strain of virus that causes disease in the West and 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 saliva, droppings and urine. People primarily become infected by inhaling the virus when entering or stirring up dust in a closed structure that contains infected mouse droppings and urine. Rarely, infection occurs through a mouse bite. Mortality rates for Sin Nombre virus remain high at about 40 percent. Since the discovery of Sin Nombre virus, other disease-causing strains of hantavirus have been found in New World rats and mice. For this reason, all rodent droppings should be considered potentially infectious.

Hantavirus is a zoonotic disease that can cause illness and death in humans. The reservoir of hantavirus is the deer mouse.

Rodent removal using snap traps is recommended, as human infection has occurred when using live traps and glue boards. Seal up any openings that allow mice to enter. If at all possible, allow the infested area to remain undisturbed for four to five days after the rodents have been removed. Research indicates that the virus does not remain viable after about three to four days. Before beginning to clean an infested area, open up the windows and doors and allow the area to air out for 30 minutes. This decreases the amount of air-borne virus in the enclosed space and decreases the risk of infection. Follow this with wet cleanup using a disinfectant or household bleach diluted 1:10 with water. Saturate the urine and droppings with the disinfectant or bleach solution and let the area soak for five to 10 minutes. For further information, consult the <u>Hanatvirus – An Update</u> chapter in the general section of this manual.

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 time.

Mosquito-borne viruses include:

- **St. Louis encephalitis**
- **Western equine encephalo-myelitis**
- **West Nile**

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 (kills larva) and adulticides (kills adults).

Rabies is a zoonotic disease that passes from mammal to mammal, including humans. It is found most commonly in bats in Nevada, but has also been identified in skunks, raccoons and foxes.

Bed bugs are not associated with disease, but they are an insect of concern throughout the United States.

Rabies is a zoonotic disease of public health concern in Nevada, primarily associated with bats and wild carnivores. 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, with symptoms typically developing 1 to 3 months after exposure. However, the time to develop symptoms can vary from less than 1 week to over 1 year. Since bats have very small teeth, a bite can be invisible. A victim is often unaware 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 some species of bats are protected. Young bats must be able to fly before an exclusion strategy will work. If you seal entry/exit points while young are present, they will die inside the building, resulting in additional problems. Make sure the bats have departed for the evening and then seal up all openings greater than one-quarter inch. This includes vents, chimneys and other openings in the roof, eves or soffits, gaps around windows or doors, gaps around conduit or pipes, and holes or gaps in window screens. For migratory species, the best time to implement exclusion measures is the fall or winter. No pesticides are registered for bat control.

Most bat bites occur when people handle or provoke them. Anyone doing work, such as bat removal and exclusion, should consider pre-exposure rabies vaccinations as a measure of personal protection. As with all animals, use caution and common sense when handling dead bats.

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 U.S. However, wild animal rabies remains a threat and is spreading in some areas.

Bed bugs are not associated with disease transmission in the United States. Bed bugs are small insects that range from a poppy seed to an apple seed in size. They are commonly brown in color and have a flat, oval shape when unfed. When not feeding, they can hide in a number of places, including the piping, seams and other areas of the mattress and box spring, in cracks of the bed frame and headboard, in clutter near the bed, under baseboards, in curtains and under loose wallpaper. These insects are considered a public health concern because they can be a terrible nuisance and are difficult to eradicate.

Bed bugs spread readily, moving from infested furniture, bedding, baggage, boxes and clothing to new sites. While they typically feed on blood every five to 10 days, they can go for more than a year without feeding. The ease with which they spread and their ability to live without food for over a year makes them difficult to eradicate once an infestation has occurred. Control of bedbugs requires that all bedding and clothing be removed and washed in hot water. Clutter that may provide additional hiding places for bed bugs should be removed. Thorough cleaning of infested areas is required to control an infestation. Insecticide sprays and/or dusts are used for control, but READ THE LABEL. Make sure the pesticide product you choose is labeled for indoor use and labeled for use on bed bugs. Applications should be made to cracks, crevices and other places where bed bugs hide. Do not overlook mattress seams and tufts, cracks along baseboards and moldings, loose carpet edges, loose wallpaper, and hollows in bed frames or other furniture.

Cockroaches are nuisance insects that may cause rare, isolated cases of food-borne illness and asthma. Cockroach control depends on maintaining strict cleanliness. Remove any crumbs, dirty dishes or food and drink spills, and fix leaking pipes or faucets to eliminate food and water sources for cockroaches. Use insecticide applications with products that are labeled for use inside a dwelling or kitchen to get rid of a cockroach infestation. Follow-up treatments may be needed as cockroaches continue to hatch after the initial treatment. If more than one application of a pesticide is required, use pesticides with different mechanisms of action to prevent development of resistance in cockroaches.

There are four species of importance.

- The German cockroach is the most common. Usually found outdoors, these cockroaches enter the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. The German cockroach has developed resistance to chlorinated hydrocarbons, so use one of the newer insecticides developed for cockroach control. Contact your local dealer for specific insecticides to control German cockroaches.
- The American cockroach is large and red. Like the German cockroach, the American cockroach is usually found outdoors and enters the premises in search of moisture. Limit food and water sources and eliminate access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific recommendations.
- The Oriental cockroach is black and shiny. Usually outside, these cockroaches also enter premises in search of moisture, like the German and American cockroaches. Limit food and water sources and eliminate

Nevada specific information on bed bugs can be found at http://westernbedbugipm.ucanr.edu/Audience_Specific_Resources/Nevada/

Bed bugs spread easily and are difficult to eradicate once an infestation has occurred.

Cockroach control depends on maintaining strict cleanliness. Remove any crumbs, dirty dishes and food and drink spills to eliminate food sources for cockroaches.

access to aid in control. A quick knockdown residual insecticide is generally used to control these pests. Contact your local dealer for specific insecticides.

- The brown banded cockroach is very common in certain areas. Unlike the other three species mentioned, brown banded cockroaches prefer warm and dry locations. They are found in structures generally away from water sources. Good sanitation is important. Eliminate food sources. Block entry points by filling in cracks, crevices and other entry sites at ducts, moldings or other openings. Baits and traps are used to control these pests, along with quick knockdown residual insecticides. Contact your local dealer for specific recommendations.

Clockwise from top left: German, brown banded, American and oriental cockroaches.
Art Cushman, USDA, Smithsonian Institution, Department of Entomology, Bugwood.org

Conclusion

Category 8, Public Health Pest Control, involves the management of insects and other animals that transmit diseases to humans. Cleanliness and good sanitation are very important in preventing or at least limiting infestations. Prevention and exclusion are the best methods of control for many of these pests.

For current information regarding public health and infectious diseases:

- Centers for Disease Control and Prevention, http://www.cdc.gov
- Washoe County Health District Vector Borne Disease Prevention Program, https://www.washoecounty.us/health/programs-and-services/environmental-health/vector-borne-diseases/index.php
- Southern Nevada Health District Vector Borne and Zoonotic Diseases, http://www.southernnevadahealthdistrict.org/stats-reports/zoonotic-diseases.php

Originally published in 1987 as Category 8, Public Health Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2013 by M. Hefner and S. Donaldson, University of Nevada Cooperative Extension, Jeff Jeppson, Washoe County District Health Department, and J. Carpenter, Nevada Department of Agriculture. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension and B. Allen and C. Moses, Nevada Department of Agriculture.

Category 9, Subcategories L1, L2, L3 and L4: Fumigation

Fumigation for Pest Control Learning Objectives

Fumigation pest control is subdivided into four subcategories as listed below. Each has its own exam.

- **L1 – Commodity fumigation**
- **L2 – Rodent burrow fumigation**
- **L3 – Soil fumigation**
- **L4 – Structural fumigation**

After studying this section, you should be able to:

✓ **Answer questions that are directly related to pesticide label instructions or the specified manual. Specific pesticide labels are detailed in the descriptions for each subcategory.**

Category 9, Fumigation Pest Control

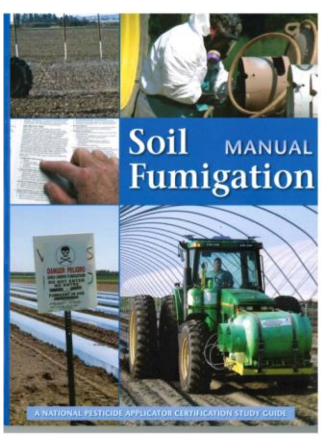
Category L, Fumigation is split into 4 subcategories: commodity fumigation (L1), rodent burrow fumigation (L2), soil fumigation (L3) and structural fumigation (L4). Starting in 2010, the U.S/ Environmental Protection Agency reclassified all fumigants as restricted-use pesticides due to human health concerns.

In Nevada, all structural fumigation (L4) must be done by or under the supervision of a licensed pest control operator. For this reason, the L4 structural fumigation subcategory is rarely used by certified applicators. Structural fumigation is a complex process and is best left to licensed professionals.

Category L, Fumigation, includes the application of fumigants to commodities (L1), rodent burrows (L2) and soil (L3). Separate certifications are required for each of the three fumigant subcategories.

Chemical formulations change regularly. Consult your local dealer for product recommendations for specific pests.

A significant change to soil fumigation applications is the requirement for a buffer zone. Refer to the Soil Fumigation Manual for criteria for establishing and documenting buffer zones.



Subcategory L1, Commodity Fumigation

Subcategory L1, commodity fumigation, involves the application of fumigants to stored commodities to protect them from damage from insect pests. The training material and study guide for testing in this subcategory is the Weevil-cide® Aluminum Phosphide Fumigant pesticide label and the Weevil-cide® applicator's manual. Both of these documents are included in this chapter and are current as of July 2018.

Subcategory L2, Rodent Burrow Fumigation

Subcategory L2, rodent burrow fumigation, involves the application of fumigants to rodent burrows to control vertebrate pests. The training material and study guide for testing in this subcategory is the Weevil-cide® Aluminum Phosphide Fumigant pesticide label and the Weevil-cide® applicators manual. Both of these documents are included in the back of this chapter and are current as of July 2018.

Subcategory L3, Soil Fumigation

NOTICE: The soil fumigation exam (L3) will be administered to PRIVATE APPLICATORS ONLY. Private applicators are individuals producing agricultural commodities on land owned or rented by them (farmers and ranchers). Other applicators must complete an approved EPA training course to obtain soil fumigation certification. Contact the Nevada Department of Agriculture for information related to EPA-approved, industry-sponsored soil fumigation training courses.

Subcategory L3, soil fumigation, involves the application of fumigants to the soil to control a number of soil-borne pests, including insects, nematodes, fungi, bacteria, weed seeds and germinating weed seedlings. The training material and study guide for testing in this subcategory is the Soil Fumigation Manual, a National Pesticide Applicator Certification Study Guide completed in 2012. A digital copy of the manual is posted online at www.unce.unr.edu/programs/sites/pesticide/files/pdf/FumigationManual.pdf. Printed copies are available from the Nevada Department of Agriculture.

Subcategory L4, Structural Fumigation

Structural fumigation is defined as:

The control of any industrial or institutional pest, wood-destroying fungi or wood-destroying pest, as defined in NAC 555.2535, 555.2577 and 555.258, which is in, on or around any structure, including, but not limited to, homes, apartments, dwelling units, storage sheds, warehouses, offices, casinos, motels, stores, hospitals, schools and similar institutions, and excluding commodity fumigation, rodent burrow fumigation and soil fumigation.

Subcategory L4, structural fumigation, deals with fumigation for control of wood-destroying pests. In Nevada, all structural fumigation must be done by or under the supervision of a licensed pest control operator. For this reason, the L4 structural fumigation subcategory is rarely used by certified applicators. Structural fumigation is a complex process and is best left to licensed professionals

Conclusion

All fumigants are restricted use products. In addition to obtaining the appropriate certification, always read, understand and follow label directions. Wear the proper protective equipment and use caution around children, pets, livestock, wildlife and water bodies.

Read, understand and follow label directions.

It is the law.

Originally published in 1987 as Category 9, Fumigation, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and
B. Allen and C. Moses, Nevada Department of Agriculture.

PRECAUTIONARY STATEMENTS

Hazards To Humans And Domestic Animals

DANGER: WEEVIL-CIDE® Tablets or dust may be fatal if swallowed. Do not get in eyes, on skin, or on clothing. Do not eat, drink or smoke while handling aluminum phosphide fumigants. When a sealed container is opened, allowing material to come in contact with moisture, water or acids, toxic phosphine gas will be released. If a garlic odor is detected, for appropriate monitoring procedures, refer to section on Industrial Hygiene Monitoring in the Applicator Manual. Pure phosphine gas is odorless: the odor is due to a contaminant. Since an odor may not be detected under certain circumstances, the absence of a garlic odor does not mean that phosphine gas is absent. Observe proper application, aeration, re-entry and disposal procedures specified elsewhere in the labeling to prevent overexposure.

ENVIRONMENTAL HAZARDS

This product is toxic to wildlife. Non-target organisms exposed to phosphine gas in burrows will be killed. Do not apply directly to water or wetlands (swamps, bogs, marshes, and potholes). Do not contaminate water by cleaning of equipment or disposal of wastes.

Physical and Chemical Hazards

Aluminum phosphide WEEVIL-CIDE® Tablets and partially spent dust will release phosphine gas if exposed to moisture from the air or if it comes into contact with water, acids and many other liquids. Piling of tablets or dust from their fragmentation may cause a temperature increase and confine the release of gas so that ignition could occur. It is recommended that opening of aluminum phosphide products be performed in open air or near a fan which exhausts outside immediately. Never open in a flammable atmosphere because on rare occasions a flash may occur. When opening, invert the container several times and then point the container away from the face and body and slowly loosen the cap. Since phosphine may ignite spontaneously at levels above its lower flammable limit of 1.8% v/v, it is important not to exceed this concentration. Ignition of high concentrations of phosphine can produce a very energetic reaction. Explosions can occur under these conditions and may cause severe personal injury. **Never allow the buildup of phosphine to exceed explosive concentrations.** Do not confine spent or partially spent metal phosphide fumigants as the slow release of phosphine from this material may result in formation of an explosive atmosphere. Aluminum phosphide WEEVIL-CIDE® Tablets outside the containers should not be stacked or piled up or contacted with liquid water. This may cause a temperature increase, increase the rate of gas production and confine the gas so that ignition could occur. These precautions will also reduce the fumigator's exposure to phosphine gas. Pure phosphine gas is practically insoluble in water, fats and oils, and is stable at normal fumigation temperatures. However, it may react with certain metals and cause corrosion, especially at higher temperatures and relative humidities. Metals such as copper, brass and other copper alloys, and precious metals such as gold and silver are susceptible to corrosion by phosphine. Thus, small electric motors, smoke detectors, brass sprinkler heads, batteries and battery chargers, fork lifts, temperature monitoring systems, switching gears, communication devices, computers, calculators and other electrical equipment should be protected or removed before fumigation. Phosphine will also react with certain metallic salts and, therefore, sensitive items such as photographic film, some inorganic pigments, etc., should not be exposed.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling. This product is for use against insects which infest stored commodities, and control of burrowing pests. THE USE OF THIS PRODUCT IS STRICTLY PROHIBITED ON SINGLE AND MULTI-FAMILY RESDIENTIAL PROPERTIES AND NURSING HOMES, SCHOOLS (EXCEPT ATHLETIC FIELDS), DAYCARE FACILITIES AND HOSPITALS.

General Information: WEEVIL-CIDE® is a fumigant which when applied according to label instructions is activated by atmospheric humidity. WEEVIL-CIDE® has been found effective against many stored products insects and their pre-adult stages - that is eggs, larvae, and pupae. Refer to the Applicator's Manual for specific commodities and burrowing pests species which may be fumigated. Refer to the Applicator's Manual for directions for use (e.g., pests controlled, specific commodities and sites) and precautions and restrictions.

THE COMPLETE LABEL FOR THIS PRODUCT CONSISTS OF THE CONTAINER LABEL AND APPLICATOR'S MANUAL WHICH MUST ACCOMPANY THE PRODUCT. READ AND UNDERSTAND THE ENTIRE LABELING AND APPLICATOR'S MANUAL. ALL PARTS OF THE LABELING AND APPLICATOR'S MANUAL ARE EQUALLY IMPORTANT FOR SAFE AND EFFECTIVE USE OF THE PRODUCT. A FUMIGATION MANAGEMENT PLAN MUST BE WRITTEN FOR ALL FUMIGATIONS PRIOR TO ACTUAL TREATMENT. CONSULT WITH YOUR STATE LEAD PESTICIDE REGULATORY AGENCY TO DETERMINE REGULATORY STATUS, REQUIREMENTS, AND RESTRICTIONS FOR FUMIGATION USE IN THAT STATE. CALL 1-800-438-6071 IF YOU HAVE ANY QUESTIONS OR DO NOT UNDERSTAND ANY PART OF THIS LABELING.

Rev. 4/10 147247 70506-13(062810-3788) Made in India.

RESTRICTED USE PESTICIDE

DUE TO ACUTE INHALATION TOXICITY OF PHOSPHINE GAS

For retail sale to Dealers and Certified Applicators only. For use by Certified Applicators or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification. Refer to the directions in the Applicator's Manual for requirements of the physical presence of a Certified Applicator.

TABLETS

WEEVIL-CIDE®

Aluminum Phosphide Fumigant

FOR USE AGAINST LISTED INSECTS WHICH INFEST STORED COMMODITIES AND CONTROL OF BURROWING PESTS

ACTIVE INGREDIENT - ALUMINUM PHOSPHIDE	60.0%
OTHER INGREDIENTS	40.0%
TOTAL	100.0%

THE USE OF THIS PRODUCT IS STRICTLY PROHIBITED ON SINGLE AND MULTI-FAMILY RESIDENTIAL PROPERTIES AND NURSING HOMES, SCHOOLS (EXCEPT ATHLETIC FIELDS) DAYCARE FACILITIES AND HOSPITALS.

PRECAUCION AL USUARIO: Si usted no leé ingles, no use este producto hasta que la etiqueta se le haya sido explicado ampliamente.
(**TO THE USER:** If you cannot read English, do not use this product until the label has been fully explained to you.)

KEEP OUT OF REACH OF CHILDREN

DANGER/PELIGRO - POISON

FIRST AID: Symptoms of exposure to this product are headaches, dizziness, nausea, difficult breathing, vomiting, and diarrhea. In all cases of overexposure get medical attention immediately. TRANSPORT victim to a doctor or emergency treatment facility.

IF INHALED: • Move person to fresh air. • If person is not breathing, call 911 or an ambulance, give artificial respiration immediately, preferably by mouth-to-mouth. • Keep warm and make sure person can breathe freely. • Contact a poison control center or doctor for treatment advice. **IF SWALLOWED:** • Call a Poison control center or doctor immediately for treatment advice. • DO NOT INDUCE VOMITING UNLESS TOLD TO DO SO BY A POISON CONTROL CENTER OR DOCTOR. VOMITING MAY OFF-GAS AND RELEASE PHOSPHINE, WHICH COULD POSE A RISK OF SECONDARY CONTAMINATION. • DO NOT GIVE WATER (POTENTIAL ADDITIONAL FORMATION OF PHOSPHINE) UNLESS AUTHORIZED BY A PHYSICIAN. • Do not give anything by mouth to an unconscious person. **IF ON SKIN OR CLOTHING:** • Brush or shake material off clothes and shoes in a well-ventilated area. • Allow clothes to aerate in a ventilated area prior to laundering. • Do not leave contaminated clothing in occupied and/or confined areas such as automobiles, vans, motel rooms, etc. • Wash contaminated skin thoroughly with soap and water. **IF IN EYES:** • Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.

FOR CHEMICAL EMERGENCY: SPILL, LEAK, FIRE EXPOSURE, OR ACCIDENT, CALL CHEMTREC 1-800-424-9300.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. Contact the Rocky Mountain Poison and Drug Center 866-673-6671 FOR ASSISTANCE WITH HUMAN OR ANIMAL MEDICAL EMERGENCIES

Note to Physician: Aluminum phosphide in WEEVIL-CIDE® Tablets reacts with moisture from the air, water, acids and many other liquids to release hydrogen phosphide (phosphine) gas. Mild exposure by inhalation causes malaise (indefinite feeling of sickness), ringing of ears, fatigue, nausea, and pressure in the chest, which is relieved by removal to fresh air. Moderate poisoning causes weakness, vomiting, pain just above the stomach, chest pain, diarrhea and dyspnea (difficulty in breathing). Symptoms of severe poisoning may occur within a few hours to several days, resulting in pulmonary edema (fluid in lungs) and may lead to dizziness, cyanosis (blue or purple skin color), unconsciousness, and death. In sufficient quantity, phosphine affects the liver, kidneys, lungs, nervous system and circulatory system. Inhalation can cause lung edema (fluid in lungs) and hyperemia (excess of blood in a body part), small perivascular brain hemorrhage and brain edema (fluid in brain). Ingestion can cause lung and brain symptoms but damage to the viscera (body cavity organs) is more common. Phosphine poisoning may result in (1) pulmonary edema, (2) liver elevated serum GOT, LDH and alkaline phosphatase, reduced prothrombin, hemorrhage and jaundice (yellow skin color) and (3) kidney hematuria (blood in urine) and anauria (abnormal lack of urination). Pathology is characterized by hypoxia (oxygen deficiency in blood tissue). Frequent exposure to subacute concentrations over a period of days or weeks may cause poisoning. Treatment is symptomatic.

See side panels for additional precautionary statements.

Manufactured for: **United Phosphorus, Inc.**
630 Freedom Business Center, Suite 402 • King of Prussia, PA 19406
1-800-438-6071 • www.upi-usa.com

Contents: 500 Tablets
Net Weight: 1500 g (3 lbs. 4.8 oz.)
Lot Number: ____________

EPA Reg. No. 70506-13
EPA Est. No. 41876-IND-001

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storing pesticides in the same areas used to store these commodities.

Storage Instructions

1. Store WEEVIL-CIDE® Tablets in a dry, well ventilated area away from heat, under lock and key. Post as a pesticide storage area.
2. Do not store in buildings where humans or domestic animals reside. Keep out of reach of children.
3. WEEVIL-CIDE® Tablets are supplied in gas-tight, resealable aluminum flasks. Do not expose the product to atmospheric moisture any longer than is necessary and seal tightly before returning flasks to storage.

Pesticide Disposal

Do not contaminate water, food or feed by storage or disposal.

Unreacted or partially reacted WEEVIL-CIDE® is acutely hazardous. Improper disposal of excess pesticide is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance. For specific instructions, see Disposal Instructions and Spill and Leak Procedures in the Applicator's Manual.

Some local and state waste disposal regulations may vary therefore disposal procedures must be reviewed with appropriate authorities to ensure compliance with these regulations. Contact your state Pesticide or Environmental Control Agency or Hazardous Waste Specialist at the nearest EPA Regional Office for guidance.

Container Disposal

Non-refillable container. Do Not reuse or refill this container. Offer for recycling. Triple rinse container (or equivalent) promptly after emptying.

Triple rinse flasks and stoppers with water as follows:

Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling, if available or offer for reconditioning, if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities. Rinsate may be disposed of in a sanitary landfill, by pouring it out onto the ground or by other approved procedures. It is permissible to remove lids and expose empty flasks to atmospheric conditions until residue in the flask is reacted. Then puncture and dispose of in a sanitary landfill or other approved site, or by other procedures approved by state and local authorities.

If properly exposed the residual dust remaining after a fumigation with WEEVIL-CIDE® Tablets will be a grayish-white powder and contain only a small amount of unreacted aluminum phosphide. However, residual dust from incompletely exposed WEEVIL-CIDE® Tablets may require special care.

Spill and Leak Procedures

General Precautions and Directions

A spill, other than incidental to application or normal handling, may produce high levels of gas and, therefore, attending personnel must wear SCBA or its equivalent when the concentration of hydrogen phosphide gas is unknown. Other NIOSH/MSHA approved respiratory protection may be worn if the concentration is known. Do not use water at any time to clean up a spill of WEEVIL-CIDE® Tablets. Water in contact with unreacted WEEVIL-CIDE® Tablets will greatly accelerate the production of hydrogen phosphide gas which could result in a toxic and/or fire hazard. Wear gloves of cotton or other material when handling aluminum phosphide.

Return all intact aluminum flasks to cardboard case or other suitable packaging which has been properly marked according to DOT regulations.

Notify consignee and shipper of damaged cases.

If aluminum flasks have been punctured or damaged so as to leak, the container may be temporarily repaired with aluminum tape or the WEEVIL-CIDE® Tablets may be transferred from the damaged flask to a sound metal container which should be sealed and properly labeled as aluminum phosphide. Transport the damaged containers to an area suitable for pesticide storage for inspection. Refer to the Applicator's Manual for more detailed Spill and Leak procedures.

NOTICE: Read the entire Directions for Use and Conditions of Sale and Limitation of Warranty and Liability in the Applicator's Manual before buying or using this product. If the terms are not acceptable, return the product at once, unopened, and the purchase price will be refunded.

RESTRICTED USE PESTICIDE

DUE TO THE HIGH ACUTE INHALATION TOXICITY OF PHOSPHINE GAS

For retail sale to Dealers and Certified Applicators only. For use by Certified Applicators or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification. Refer to the directions in this Applicator's Manual for requirements of the physical presence of a Certified Applicator.

THE COMPLETE LABEL FOR THIS PRODUCT CONSISTS OF THE CONTAINER LABEL AND THE APPLICATOR'S MANUAL WHICH MUST ACCOMPANY THE PRODUCT. READ AND UNDERSTAND THE ENTIRE LABELING AND APPLICATOR'S MANUAL.

A FUMIGATION MANAGEMENT PLAN MUST BE WRITTEN FOR ALL FUMIGATIONS PRIOR TO ACTUAL TREATMENT.

CONSULT WITH YOUR STATE LEAD PESTICIDE REGULATORY AGENCY TO DETERMINE REGULATORY STATUS, REQUIREMENTS, AND RESTRICTIONS FOR FUMIGATION USE IN THAT STATE. CALL 1-800-438-6071 IF YOU HAVE ANY QUESTIONS OR DO NOT UNDERSTAND ANY PART OF THIS LABELING.

APPLICATOR'S MANUAL FOR Aluminum Phosphide Fumigant Tablets, Pellets and Gas Bags

TABLETS - PELLETS - GAS BAGS

WEEVIL-CIDE®

Aluminum Phosphide Fumigant

FOR USE AGAINST INSECTS WHICH INFEST STORED COMMODITIES AND CONTROL OF BURROWING PESTS

Active Ingredient: Aluminum Phosphide	60.0%
Other Ingredients	40.0%
Total	100.0%

KEEP OUT OF REACH OF CHILDREN

DANGER - POISON – PELIGRO

THE USE OF THIS PRODUCT IS STRICTLY PROHIBITED ON SINGLE AND MULTI-FAMILY RESIDENTIAL PROPERTIES AND NURSING HOMES, SCHOOL (EXCEPT ATHLETIC FIELDS) DAYCARE FACILITIES AND HOSPITALS.

PRECAUCION AL USUARIO: Si usted no leé ingles, no use este producto hasta que la etiqueta se le haya sido explicado ampliamente. (**TO THE USER:** If you cannot read English, do not use this product until the label has been fully explained to you.)

FOR CHEMICAL EMERGENCY, SPILL, LEAK, FIRE, EXPOSURE OR ACCIDENT CALL CHEMTREC 1-800-424-9300

EPA Registration Nos. 70506-13, 70506-14, and 70506-15 **EPA Establishment No. 41876-IND-1**

UPI

Manufactured for:

United Phosphorus, Inc.

630 Freedom Business Center, Suite 402
King of Prussia, PA 19406
1-800-438-6071 • www.upi-usa.com

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SECTION 1

FIRST AID

FIRST AID: Symptoms of exposure to this product are headaches, dizziness, nausea, difficult breathing, vomiting, and diarrhea. In all cases of overexposure get medical attention immediately. Transport victim to a doctor or emergency treatment facility.

IF INHALED	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration immediately, preferably by mouth-to-mouth if possible. • Keep warm and make sure person can breathe freely. • Call a poison control center or doctor for further treatment advice.
IF SWALLOWED	• Call a poison control center or doctor immediately for treatment advice. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Vomiting may off-gas and release phosphine, which could pose a risk of secondary contamination. • Do not give water (potential additional formation of phosphine) unless authorized by a physician. • Do not give anything by mouth to an unconscious person.
IF ON SKIN OR CLOTHING	• Brush or shake material off clothes and shoes in a well-ventilated area. Allow clothes to aerate in a ventilated area prior to laundering. • Do not leave contaminated clothing in occupied and/or confined areas such as automobiles, vans, motel rooms, etc. • Wash contaminated skin thoroughly with soap and water.
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for further treatment advice.

EMERGENCY CONTACT NUMBER
CALL CHEMTREC 1-800-424-9300

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.

Contact the Rocky Mountain Poison Center 866-673-6671 for assistance with human or animal medical emergencies.

SECTION 2

NOTE TO PHYSICIAN

Aluminum phosphide in WEEVIL-CIDE® Tablets, Pellets and Gas Bags reacts with moisture from the air, water, acids and many other liquids to release phosphine gas. Mild inhalation exposure causes malaise (indefinite feeling of sickness), ringing of ears, fatigue, nausea, and pressure in the chest, which is relieved by removal to fresh air. Moderate poisoning causes weakness, vomiting, and pain just above the stomach, chest pain, diarrhea and dyspnea (difficulty in breathing). Symptoms of severe poisoning may occur within a few hours to several days, resulting in pulmonary edema (fluid in lungs) and may lead to dizziness, cyanosis (blue or purple skin color), unconsciousness, and death.

In sufficient quantity, phosphine affects the liver, kidneys, lungs, nervous system, and circulatory system. Inhalation can cause lung edema (fluid in lungs) and hyperemia (fluid in brain). Ingestion can cause lung and brain symptoms but damage to the viscera (body cavity organs) is more common. Phosphine poisoning may result in (1) pulmonary edema, (2) liver elevated serum GOT, LDH and alkaline phosphatase, reduced prothrombin, hemorrhage and jaundice (yellow skin color) and (3) kidney hematuria (blood in urine) and anuria (abnormal lack of urination). Pathology is characterized by hypoxia (oxygen deficiency in body tissue). Frequent exposure to subacute concentrations over a period of days or weeks may cause poisoning. Treatment is symptomatic.

SECTION 3

INTRODUCTION

WEEVIL-CIDE® products are used to protect stored commodities from damage by insects. In limited areas, applications of WEEVIL-CIDE® may be made to control burrowing vertebrate pests. The use of this product is strictly prohibited on single and multi-family residential properties and nursing homes, schools (except athletic fields), daycare facilities and hospitals. For a list of approved sites see Section 22.

Fumigation of stored products with WEEVIL-CIDE® in the manner prescribed in the labeling does not contaminate the marketed commodity.

WEEVIL-CIDE® metal fumigants are acted upon by atmospheric moisture to produce phosphine (PH_3) gas.

WEEVIL-CIDE® Tablets, Pellets and Gas Bags contain aluminum phosphide (AlP) as their active ingredient and will liberate phosphine via the following chemical reaction:

$$AlP + 3H_2O \rightarrow Al(OH)_3 + PH_3$$

Phosphine gas is highly toxic to insects, burrowing pests, humans, and other forms of animal life. In addition to its toxic properties, the gas will corrode certain metals and may ignite spontaneously in air at concentrations above its lower flammable limit of 1.8% (v/v). These hazards will be described in greater detail in Section 4 of this Applicator's Manual.

WEEVIL-CIDE® Tablets and Pellets also contain ammonium carbamate, which liberates ammonia and carbon dioxide as follows:

$$NH_2COONH_4 \rightarrow 2NH_3 + CO_2$$

These gases are essentially nonflammable and act as inerting agents to reduce fire hazards.

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WEEVIL-CIDE® is prepared in three forms: Tablets, Pellets and Gas Bags. The rounded Tablets weigh approximately 3 grams and release 1 gram of phosphine gas. They are about 16.5 mm in diameter and are bulk packaged in resealable aluminum flasks containing 500 tablets.

The Pellets weigh approximately 0.6 gram and release 0.2 gram of phosphine gas. They are about 9.5 mm in diameter and are also packaged in resealable flasks containing either 1660 or 2500 pellets.

Each Gas Bag contains 34 grams in a sachet and releases 11 grams of phosphine gas. The sachets, or Gas Bags, are packaged in metal containers of six, ten or one hundred gas bags to the container. Other package sizes may be available. The Gas Bags are packaged in an inert environment.

Upon exposure to air, WEEVIL-CIDE® Tablets, Pellets, and Gas Bags begin to react with atmospheric moisture to produce small quantities of phosphine gas. This reaction starts slowly, gradually accelerates and then tapers off again as the aluminum phosphide is spent. WEEVIL-CIDE® Pellets react somewhat faster than Tablets and the pellets and tablets react somewhat faster than do the Gas Bags. The rates of decomposition of the Tablets, Pellets and Gas Bags will vary depending upon moisture and temperature conditions. For example, when moisture and temperature of the fumigated commodity are high, decomposition of WEEVIL-CIDE® may be complete in less than 3 days. However, at lower ambient temperatures and humidity levels, decomposition of WEEVIL-CIDE® may require 5 days or more. After decomposition, WEEVIL-CIDE® leaves a gray-white powder composed almost entirely of aluminum hydroxide and other approved inert ingredients. This will cause no problems if the fumigant has been added directly to a commodity such as grain. However, the spent powder must usually be retrieved for disposal after space fumigations. If properly exposed, the spent WEEVIL-CIDE® will normally contain only a small amount of unreacted aluminum phosphide and may be disposed of without hazard. While WEEVIL-CIDE® is not considered a hazardous waste, partially spent residual dusts from incompletely exposed WEEVIL-CIDE® will require special care. Precautions and instructions for further deactivation and disposal are given in Section 24 of this Applicator's Manual.

WEEVIL-CIDE® Tablets, Pellets and Gas Bags are supplied in gas-tight containers and their shelf life is unlimited as long as the packaging remains intact. Once opened for fumigation, the aluminum flasks of Tablets or Pellets may be tightly resealed and stored for future use. The WEEVIL-CIDE Gas Bags container cannot be resealed for future use. Storage and handling instructions will be given in detail later in Sections 19 and 22 of the Applicator's Manual.

SECTION 4

PRECAUTIONARY STATEMENTS

4.1 HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER: Aluminum phosphide from WEEVIL-CIDE® Tablets, Pellets, Gas Bags or dust may be fatal if swallowed. Do not get in eyes, on skin or on clothing. Do not eat, drink or smoke while handling aluminum phosphide fumigants. If a sealed container is opened, or if the material comes into contact with moisture, water or acids, these products will release phosphine which is an extremely toxic gas. If a garlic odor is detected, refer to the Industrial Hygiene Monitoring in Section 15.6 of this Applicator's Manual for appropriate monitoring procedures. Pure phosphine gas is odorless; the garlic odor is due to a contaminant. Since the odor of phosphine may not be detected under some circumstances, the absence of a garlic odor does not mean that dangerous levels of phosphine gas are absent. Observe proper reentry procedures specified in Section 15.4 to prevent overexposure.

4.2 ENVIRONMENTAL HAZARDS

This product is toxic to wildlife. Many non-target organisms exposed to phosphine gas in burrows will be killed. Do not apply directly to water or wetlands (swamps, bogs, marshes, and potholes). Do not contaminate water by cleaning of equipment or disposal of wastes.

4.3 PHYSICAL AND CHEMICAL HAZARDS

Aluminum phosphide in Tablets, Pellets, Gas Bags and partially spent dust will release phosphine if exposed to moisture from the air or if it comes into contact with water, acids and many other liquids. Since phosphine may ignite spontaneously at levels above its lower flammable limit of 1.8% v/v (18,000 ppm), it is important not to exceed this concentration. Ignition of high concentrations of phosphine can produce a very energetic reaction. Explosions can occur under these conditions and may cause severe personal injury. **Never allow the buildup of phosphine to exceed explosive concentrations.** Do not confine spent or partially spent metal phosphide fumigants as the slow release of phosphine from this material may result in formation of an explosive atmosphere. Aluminum phosphide Tablets, Pellets and Gas Bags outside the containers should not be stacked or piled up or contacted with liquid water. This may cause a temperature increase, accelerate the rate of gas production and confine the gas so that ignition could occur.

It is preferable to open containers of aluminum phosphide products in open air because under certain conditions, they may flash upon opening. Containers may also be opened near a fan or other appropriate ventilation that will rapidly exhaust contaminated air. When opening, invert the container several times then point the container away from the face and body and slowly loosen the cap. Although the chances for a flash are very remote, never open these containers in a flammable atmosphere. These precautions will also reduce the fumigator's exposure to phosphine gas. If containers are opened inside the structure to be fumigated, air monitoring must be conducted to ensure worker's exposure to phosphine gas does not exceed the allowable limit of 8 hour Time Weighted Average (TWA) of 0.3 ppm or the 15 minute Short Term Exposure Limit (STEL) of 1.0 ppm Phosphine.

Pure phosphine gas is practically insoluble in water, fats and oils, and is stable at normal fumigation temperatures. However, it may react with certain metals and cause corrosion, especially at higher temperatures and relative humidities. Metals such as copper, brass and other copper alloys, and precious metals such as gold and silver are susceptible to corrosion by phosphine. Thus, small electric motors, smoke detectors, brass sprinkler heads, batteries and battery chargers, fork lifts, temperature monitoring systems, switching gears, communication devices, computers, calculators and other electrical equipment should be protected or removed before fumigation. Phosphine gas will also react with certain metallic salts and, therefore, sensitive items such as photographic film, some inorganic pigments, etc., should not be exposed. Immediately after addition of phosphine to the structure, turn off any lights and unessential electric equipment.

WEEVIL-CIDE® Tablets, Pellets and Gas Bags are Restricted Use Pesticides due to the acute inhalation toxicity of phosphine gas. Read and follow the complete label, which contains instructions for the authorized use(s) of the pesticide.

Additional copies of this Manual are available from:

United Phosphorus, Inc.
630 Freedom Business Center
King of Prussia, PA 19406
Telephone: 1 610-491-2800/1-800-438-6071
Fax: 1-610-491-2810
Web site: www.upi-usa.com

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SECTION 5

DIRECTIONS FOR USE

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

SECTION 6

PESTS CONTROLLED

WEEVIL-CIDE® has been found to be effective against vertebrate and the following: (insects and their pre-adult stages, that is, eggs, larvae and pupae)

almond moth
Angoumois grain moth
bean weevil
bees
Cadelle
cereal leaf beetle
cigarette beetle
confused flour beetle
dermestid beetles
dried fruit beetle
dried fruit moth
European grain moth
flat grain beetle
fruit flies
granary weevil
greater wax moth
hairy fungus beetle
Hessian fly
Indian meal moth
Khapra beetle
lesser grain borer
maize weevil
Mediterranean flour moth
Pea Weevil
pink bollworm
raisin moth
red flour beetle
rice weevil
rusty grain beetle
saw-toothed grain beetle
spider beetle
tobacco moth
yellow meal worm
Africanized bees & honeybees infested with/tracheal mites

Vertebrate pests

Chipmunks
Ground squirrels
Mice
Moles
Norway rats
Pocket gophers
Prairie dogs (except Utah prairie dogs, *Cynomys Parvidens*)
Roof rats
Voles
Woodchucks
Yellowbelly marmots (rockchucks)

Although it is possible to achieve total control of the listed burrowing and insect pests, this is frequently not realized in actual practice. Factors contributing to less than 100% control include leaks, poor gas distribution, unfavorable exposure conditions, etc. In addition, some insects are less susceptible to phosphine than others. If maximum control is to be attained, extreme care must be taken in sealing, higher dosages must be used, exposure periods lengthened, proper application procedures followed, and temperature and humidity conditions must be favorable.

SECTION 7

COMMODITIES WHICH MAY BE FUMIGATED WITH WEEVIL-CIDE®

WEEVIL-CIDE® may be used for the fumigation of listed raw agricultural commodities, animal feed and feed ingredients, processed foods, tobacco and certain other nonfood items when their commodity temperature is above 40°F (5°C).

7.1 RAW AGRICULTURAL COMMODITIES, ANIMAL FEED AND FEED INGREDIENTS

WEEVIL-CIDE® Tablets, Pellets and Gas Bags may be added directly to animal feed, feed ingredients and raw agricultural commodities stored in bulk. For these commodities not stored in bulk, WEEVIL-CIDE® may be placed in moisture-permeable envelopes, on trays, etc., and fumigated as with processed foods.

Raw Agricultural Commodities and Animal Feed and Feed Ingredients Which May Be Fumigated with WEEVIL-CIDE®

almonds
animal feed & feed ingredients
barley
Brazil nuts
cashews
cocoa beans
coffee beans
corn
cottonseed
dates
filberts
flower seed
grass seed
millet
oats
peanuts
pecans
pistachio nuts
popcorn
rice
rye
safflower seed
seed & pod vegetables
sesame seed
sorghum
soybeans
sunflower seeds
triticale
vegetable seeds
walnuts
wheat

7.2 PROCESSED FOODS

The listed processed foods may be fumigated with WEEVIL-CIDE®. Under no condition shall any processed food or bagged commodity come in contact with WEEVIL-CIDE® Tablets, Pellets or Gas Bags or residual dust except that WEEVIL-CIDE® may be added directly to processed brewer's rice, malt, and corn grits for use in the manufacture of beer.

Processed Foods Which May Be Fumigated With WEEVIL-CIDE®

Processed candy and sugar
Cereal flours and bakery mixes
Cereal foods (including cookies, crackers, macaroni, noodles, pasta, pretzels, snack foods and spaghetti)
Processed cereals (including milled fractions and packaged cereals)
Cheese and cheese byproducts
Chocolate and chocolate products (such as assorted chocolate, chocolate liquor, cocoa, cocoa powder, dark chocolate coating and milk chocolate products)
Processed coffee
Corn grits
Cured, dried and processed meat products and dried fish
Dates and figs
Dried eggs and egg yolk solids
Dried milk, dried powdered milk, nondairy creamers, and nonfat dried milk
Dried or dehydrated fruits (such as apples, dates, figs, peaches, pears, prunes, raisins, citrus and sultanas)
Processed herbs, spices, seasonings and condiments
Malt
Processed nuts (such as almonds, apricot kernels, brazil nuts, cashews, filberts, macadamia nuts, peanuts, pecans, pistachio nuts, walnuts and other processed nuts)
Processed oats (including oatmeal)
Rice (brewer's rice grits, enriched and polished)
Soybean flour and milled fractions
Processed tea
Dried and dehydrated vegetables (such as beans, carrots, lentils, peas, potato flour, potato products and spinach)
Yeast (including primary yeast)
Wild rice
Other processed foods

7.3 NONFOOD COMMODITIES, INCLUDING TOBACCO

The listed nonfood items that may be fumigated with WEEVIL-CIDE® Tablets, Pellets, Gas Bags or residual dust should not contact tobacco and certain other nonfood commodities.

Nonfood Commodities Which May Be Fumigated With WEEVIL-CIDE®

Processed or unprocessed cotton, wool and other natural fibers or cloth, clothing
Straw and hay
Feathers
Human hair, rubberized hair, vulcanized hair, mohair
Leather products, animal hides and furs
Tires (for mosquito control)
Tobacco
Wood, cut trees, wood chips, wood and bamboo products
Paper and paper products
Dried plants and flowers
Seeds (such as grass seed, ornamental herbaceous plant seed and vegetable seed)
Other nonfood commodities

The use of this product is strictly prohibited on single and multi-family residential properties and nursing homes, schools (except athletic fields), daycare facilities and hospitals. For a list of approved sites, see Section 22.

SECTION 8

EXPOSURE CONDITIONS FOR ALL FUMIGATIONS

The following table may be used as a guide in determining the minimum length of the exposure period at the indicated temperatures:

Minimum Exposure Periods for WEEVIL-CIDE®

Temperature	Pellets	Tablets	Gas Bags
40°F (5°C)	Do not fumigate	Do not fumigate	Do not fumigate
40°- 53°F (5-12°C)	8 days (192 hours)	10 days (240 hours)	14 days (336 hours)
54°- 59°F (12-15°C)	4 days (96 hours)	5 days (120 hours)	9 days (216 hours)
60°- 68°F (16-20°C)	3 days (72 hours)	4 days (96 hours)	6 days (144 hours)
above 68°F (20°C)	2 days (48 hours)	3 days (72 hours)	4 days (96 hours)
above 77°F (25°C)	---	---	3 days (72 hours)

The fumigation must be long enough so as to provide for adequate control of the insect pests that infest the commodity being treated. Additionally, the fumigation period should be long enough to allow for more or less complete reaction of WEEVIL-CIDE® with moisture so that little or no unreacted aluminum phosphide remains. This will minimize worker exposures during further storage and/or processing of the treated bulk commodity as well as reduce hazards during the disposal of partially spent aluminum phosphide products remaining after space fumigations. The proper length of the fumigation period will vary with exposure conditions since, in general, insects are more difficult to control at lower temperatures, and the rate of phosphine gas production by WEEVIL-CIDE® is lower at lower temperatures and humidities.

It should be noted that there is little to be gained by extending the exposure period if the structure to be fumigated has not been carefully sealed or if the distribution of gas is poor and insects are not subjected to lethal concentrations of phosphine. Careful sealing is required to ensure that adequate gas levels are retained and proper application procedures must be followed to provide satisfactory distribution of phosphine gas. Application of additional WEEVIL-CIDE® is recommended if the concentration of phosphine drops below an effective level. If reentry into the treated structure is required, follow the requirements for respiratory protection usage found in Section 11 of this Manual. Some structures can only be treated when completely tarped while others cannot be properly sealed by any means and should not be fumigated. Exposure times must be lengthened to allow for penetration of gas throughout the commodity when the fumigant is not uniformly added to the commodity mass, for example, by surface application or shallow probing. This is particularly important in the fumigation of bulk commodities contained in large storage areas.

Remember, exposure periods recommended in the table are minimum periods and may not be adequate to control all stored products pests under all conditions nor will they always provide for total reaction of WEEVIL-CIDE®.

It is permissible and often desirable to use a low-flow recirculation system for phosphine gas in certain bulk storages. This method may be used in ship's holds, various types of flat storage and vertical storage bins. Recirculation usually involves the application of fumigant to the surface of the commodity. The phosphine gas is then continuously or intermittently drawn out of the over-space and blown into the bottom of the storage using specially designed low volume fans and duct work. This method facilitates the quick and uniform penetration of phosphine gas throughout the commodity. In some instances a reduced dosage may be used.

Please contact United Phosphorus if assistance is required in designing recirculation systems.

SECTION 9

DOSAGE RATES

Dosage Rates

Phosphine is a mobile gas and will penetrate to all parts of the storage structure. Therefore, dosage must be based upon the total volume of the space being treated and not on the amount of commodity it contains. The same amount of WEEVIL-CIDE® is required to treat a 30,000-bushel silo whether it is empty or full of grain unless, of course, a tarpaulin seals off the surface of the commodity. The following dosage ranges are recommended for bulk (per 1,000 bushels) and space fumigations (per 1,000 cu. ft.):

9.1 MAXIMUM ALLOWABLE DOSAGE FOR FUMIGATION WITH WEEVIL-CIDE®

Product	No. per 1,000 cu. ft.*	No. per 1,000 bu.*
Pellets	725	900
Tablets	145	180
Gas Bags	13	16

*NOTE: The Maximum Dosage allowed for dates and nuts is 4 bags per 1,000 cu. ft.

The maximum dosage for dried fruits is 200 pellets, 40 tablets, 4 gas bags/1,000 cu. ft. (250 pellets, 50 tablets, 6 gas bags/1,000 bu.).

Maximum allowable dosage rate for rodent burrows is 10-20 pellets per burrow, 2-4 tablets per burrow.

Maximum allowable dosage rate for commodity in small containers is 1-2 pellets per 10 cu. ft.

The above dosages are not to be exceeded. It is important to be aware that a shortened exposure period cannot be fully compensated for with an increased dosage of phosphine.

Somewhat higher dosages, not to exceed the maximum dosage, are usually recommended under cooler, drier conditions or where exposure periods are relatively short. However, the major factor in selection of dosage is the ability of the structure to hold phosphine gas during the fumigation. A good illustration of this point is comparison of the low dosages required to treat modern, well-sealed warehouses with the higher range doses used for poorly constructed buildings that cannot be sealed adequately. In certain other fumigations, proper distribution of insecticidal concentrations of gas to reach all parts of the structure becomes a very important factor in dose selection. An example where this may occur is in the treatment of grain stored in tall silos. Poor gas distribution frequently results when the fumigant is added on top of the grain. In such cases, use of a low flow recirculation system is recommended under these circumstances. Please contact United Phosphorus if assistance is required in designing the recirculation system.

9.2 WEEVIL-CIDE® ADVISORY DOSAGE RATES FOR VARIOUS TYPES OF FUMIGATION

One (1) WEEVIL-CIDE® Tablet and five (5) Pellets will produce a concentration of 25 parts per million (ppm) of phosphine gas (PH_3) in a volume of 1,000 cu. ft. (1 g PH_3/1,000 cu. ft. equivalent to 25 ppm). One (1) WEEVIL-CIDE ® Gas Bag will produce a concentration of 275 parts per million (11 g PH_3/1,000 cu. ft. equivalent to 275 ppm).

Although it is permissible to use the maximum dosage listed in Section 9.2, the following table lists a range of dosages which can be used as a guideline for various types of fumigation.

The higher rate under conditions of severe infestation, lower temperature and other applicable variables.

Dosage Range

Type of Fumigation	No. of Pellets	No. of Tablets	No. of Gas Bags
1. Vertical Storages (such as silos, concrete bins, steel bins, tanks, etc.)	200-900/1,000 bu. 150-700/1,000 cu. ft.	40-80/1,000 bu. 30-140/1,000 cu. ft.	4-7/1,000 bu. 3-6/1,000 cu. ft.
2. Farm Bins (Butler Type)	450-900/1,000 bu. 350-725/1,000 cu. ft.	90-180/1,000 bu. 70-145/1,000 cu. ft.	8-16/1,000 bu. 6-13/1,000 cu. ft.
3. Bulk stored commodities in flat storage, bunkers and commodities stored on ground loosely piled under gas tight covering.	450-900/1,000 bu. 350-725/1,000 cu. ft.	90-180/1,000 bu. 70-145/1,000 cu. ft.	6-16/1,000 bu. 5-13/1,000 cu. ft.
4. Packaged commodities (bagged grain, process foods, etc.) in sealable enclosures.	150-450/1,000 cu. ft.	30-90/1,000 cu. ft.	3-6/1,000 cu. ft.
5. Nuts, dates or dried fruit in storage boxes.	100-200/1,000 cu. ft.	20-40/1,000 cu. ft.	2-4/1,000 cu. ft.
6. Nuts, dates or dried fruit in bulk.	125-250/1,000 bu. 100-200/1,000 cu. ft.	25-50/1,000 bu. 20-40/1,000 cu. ft.	2-4/1,000 cu. ft.
7. Railcars, containers, trucks, vans and other transport vehicles	225-500/1,000 cu. ft.	45-145/1,000 cu. ft.	3-6/1,000 cu. ft.
8. Space fumigation such as cereal mills, feed mills, food processing plants & warehouses	100-300/1,000 cu. ft.	20-60/1,000 cu. ft.	2-6/1,000 cu. ft.
9. Stored Tobacco	100-250/1,000 cu. ft.	20-50/1,000 cu. ft.	2-4/1,000 cu. ft.
10. Non-food products	150-450/1,000 cu. ft.	30-90/1,000 cu. ft.	---
11. Stored beehives, supers and other beekeeping equipment for wax moth control and Africanized honeybees with tracheal mites and foulbrood.	150-225/1,000 cu. ft.	30-45/1,000 cu. ft.	3-4/1,000 cu. ft.
12. Barges	300-900/1,000 bu. 250-725/1,000 cu. ft.	60-80/1,000 bu. 50-145/1,000 cu. ft.	4-9/1,000 bu. 3-7/1,000 cu. ft.
13. Shipholds	200-400/1,000 bu. 150-330/1,000 cu. ft.	40-80/1,000 bu. 30-66/1,000 cu. ft.	4-7/1,000 bu. 3-6/1,000 cu. ft.
14. Commodity in small containers	1-2 pellets per 1.4 to 10 cu. ft.	---	1 bag per 77-500 cu. ft.
15. Rodent burrows	10-20 per burrow	2-4 per burrow	---

Use higher dosages in structures that are of loose construction and in the fumigation of bulk stored commodities in which diffusion will be slowed and result in poor distribution of phosphine gas.

SECTION 10

PROTECTIVE CLOTHING

10.1 GLOVES

Wear dry gloves of cotton or other material if contact with tablets, pellets, or dust is likely. Gloves should remain dry during use. Wash hands thoroughly after handling aluminum phosphide products. Aerate used gloves and other clothing that may be contaminated in a well-ventilated area prior to laundering.

SECTION 11

RESPIRATORY PROTECTION

11.1 WHEN RESPIRATORY PROTECTION MUST BE WORN

Respiratory protection is required when concentration levels of phosphine are unknown

11.2 PERMISSIBLE GAS CONCENTRATION RANGES FOR RESPIRATORY PROTECTION DEVICES

A NIOSH/MSHA approved full-face gas mask - phosphine canister combination may be used at levels up to 15 ppm or following manufacturer's use conditions instructions for escape. Above 15 ppm or in situations where the phosphine concentration is unknown, a NIOSH/MSHA approved, self-contained breathing apparatus (SCBA) must be worn. The NIOSH/OSHA Pocket Guide DHHS (NIOSH) 97-140 or the NIOSH ALERT – Preventing Phosphine Poisoning and Explosions During Fumigation lists these and other types of approved respirators and the concentration limits at which they may be used.

11.3 REQUIREMENTS FOR AVAILABILITY OF RESPIRATORY PROTECTION

If WEEVIL-CIDE® is to be applied from within the structure to be fumigated, an approved full-face gas mask - phosphine canister combination or SCBA or its equivalent must be available at the site of application in case it is needed. Respiratory protection must also be available for applications from outside the area to be fumigated such as addition of tablets or pellets or automatic dispensing devices, outdoor applications, etc.

SECTION 12

REQUIREMENTS FOR CERTIFIED APPLICATOR'S PRESENCE AND TRAINING FOR RECEIPT OF IN-TRANSIT VEHICLES UNDER FUMIGATION

12.1 The requirements for the presence of a Certified Applicator and their responsibility for all workers are as follows:

1. A Certified Applicator must be physically present, responsible for, and maintain visual and/or voice contact with all fumigation workers during the opening of the container and during the application of the fumigant. Once the application is complete and the structure has been made secure the certified applicator does not need to be physically present at the site.
2. A Certified Applicator must be physically present, responsible for and maintain visual and/or voice contact with all fumigation workers during the initial opening of the fumigation structure for aeration. Once the aeration process is secured and monitoring has established that aeration can be completed safely the certified applicator does not need to be physically present and trained person(s) can complete the process and remove the placards.
3. Persons with documented training in the handling of Phosphine products must be responsible for receiving, aerating and removal of placards from vehicles, which have been fumigated in transit. Refer to Section 12.2 for training requirements.

12.2 Training requirements for receipt of in-transit vehicles under fumigation:

The trained person(s) must be trained by a Certified Applicator following the EPA accepted product applicator's manual that must precede or be attached to the outside of a transport vehicle; or by other training which is accepted by local and or state authorities. When training has been completed and the employee demonstrates safety knowledge proficiency, the training date must be logged and maintained in the employee's safety training record for a minimum of three years. Refresher training must be done on an annual basis.

This training must cover the following items, each of which may be found in this manual:

a. How to aerate the vehicle and verify that it contains no more than 0.3-ppm phosphine.

OR

b. How to transfer the commodity to another storage area without prior aeration and ensure that worker safety limits are not being exceeded during the transfer.

c. How to determine when respiratory protection must be worn.

d. How to protect workers and nearby persons from exposure to levels above the 8-hour time weighted average (TWA) of 0.3 ppm or the 15 minute TWA short-term exposure limit (STEL) of 1.0 ppm phosphine.

e. Proper removal of placards from the vehicle.

f. How to follow proper residual disposal instruction.

SECTION 13

GAS DETECTION EQUIPMENT

There are a number of devices on the market for the measurement of phosphine gas at both industrial hygiene and fumigation levels. Glass detection tubes used in conjunction with the appropriate hand-operated air sampling pumps are widely used. These devices are portable, simple to use, do not require extensive training and are relatively rapid, inexpensive and accurate. Electronic devices are also available for both low level and high phosphine gas readings. Such devices should be used in full compliance with manufacturers' recommendations.

SECTION 14

NOTIFICATION REQUIREMENTS

14.1 AUTHORITIES AND ON-SITE WORKERS

As required by local regulations, notify the appropriate local officials (fire department, police department, etc.) of the impending fumigation. Provide the officials an MSDS and complete label for the product and any other technical information deemed useful. Offer to review this information with the local official(s).

14.2 INCIDENTS INVOLVING THESE PRODUCTS

Registrants must be informed of any incident involving the use of this product. Please call 1-800-438-6071 so United Phosphorus, Inc. can report the incident to Federal and State Authorities.

14.3 THEFT OF PRODUCTS

Immediately report to the local police department thefts of metal phosphide fumigants.

SECTION 15

APPLICATOR AND WORKER EXPOSURE

Approved respiratory protection must be worn if concentrations exceed the allowable limits, or when concentrations are unknown.

15.1 EXPOSURE LIMITS

Exposure to phosphine must not exceed the 8-hour TWA (Time Weighted Average) of 0.3 ppm or the 15 minute TWA short-term exposure limit (STEL) of 1.0 ppm phosphine. All persons are covered by these exposure standards.

15.2 APPLICATION OF FUMIGANT

At least two persons, a certified applicator and trained person, or two trained persons under the direct supervision of the certified applicator must be present during fumigation of structures when entry into the structure for application of the fumigant is required. Depending upon temperature and humidity, WEEVIL-CIDE® Tablets, Pellets and Gas Bags release phosphine gas slowly upon exposure to moisture from the air. In most cases, this release is slow enough to permit applicators to deposit fumigant in the desired areas and then vacate the premises without significant exposure to the gas. Monitoring must be conducted to determine exposure limits and determine the applicator's exposure. See Section 11 for respiratory protection requirements.

15.3 LEAKAGE FROM FUMIGATED SITES

Phosphine is highly mobile and given enough time may penetrate seemingly gas-tight materials such as concrete and cinder block. Therefore, adjacent, enclosed areas likely to be occupied should be examined to ensure that significant leakage has not occurred. Sealing of the fumigated site and/or airflow in the occupied areas must be sufficient to bring down the phosphine concentration to a safe level of 0.3 ppm or below.

15.4 AERATION AND REENTRY

If the structure is to be entered after fumigation, it must be aerated until the level of phosphine gas is 0.3 ppm or below. The area or site must be monitored to ensure that liberation of gas from the treated commodity does not result in the development of unacceptable levels i.e., over industrial hygiene levels of phosphine. Do not allow reentry into treated structures by any person before the level of phosphine reaches 0.3 ppm or below unless protected by an approved respirator.

15.5 HANDLING UNAERATED COMMODITIES

Transfer of incompletely aerated commodity via bulk handling equipment such as augers, drag conveyors and conveyor belts to a new storage structure is permissible. A Certified Applicator is responsible for training workers who handle the transfer of incompletely aerated listed commodities, and appropriate measures must be taken (i.e., ventilation or respiratory protection) to prevent exposures from exceeding the exposure limits for phosphine. The new storage structure must be placarded if it contains more than 0.3 ppm phosphine. If the fumigation structure must be entered to complete the transfer, at least two trained persons, wearing proper respiratory protection may enter the structure. A certified applicator must be physically present during the entry into the structure.

REMEMBER transporting containers or vehicles under fumigation over public roads is prohibited.

15.6 INDUSTRIAL HYGIENE MONITORING

Phosphine exposures must be documented in an operations log or manual at each fumigation site and operation where exposures may occur. Monitor airborne phosphine concentrations in all indoor areas to which fumigators and other workers have had access during fumigation and aeration. Perform such monitoring in workers' breathing zones. This monitoring is mandatory and is performed to determine when and where respiratory protection is required. Once exposures have been adequately characterized, spot checks must be made, especially if conditions change significantly or if an unexpected garlic odor is detected or a change in phosphine level is suspected.

15.7 ENGINEERING CONTROLS AND WORK PRACTICES

If monitoring shows that workers may be exposed to concentrations in excess of the permitted limits, then engineering controls (such as forced air ventilation) and/or appropriate work practices must be used to reduce exposure to within permitted limits. Appropriate respiratory protection must be worn if phosphine exposure limits are exceeded or concentrations are unknown.

SECTION 16

PLACARDING OF FUMIGATED AREAS

All entrances to the fumigated structure must be placarded, including areas containing rodent burrows being fumigated. Placards must be made of substantial material that can be expected to withstand adverse weather conditions and must bear the wording as follows:

1. The signal word DANGER/PELIGRO and the SKULL AND CROSSBONES symbol in red.
2. The statement "Area/Structure and/or commodity under fumigation, DO NOT ENTER/NO ENTRE".
3. The Statement, "This sign may only be removed by a certified applicator or a person with documented training after the commodity is completely aerated (contains 0.3 ppm or less of phosphine gas). If incompletely aerated commodity is transferred to a new structure, the new structure must also be placarded if it contains more than 0.3 ppm. Worker exposure during this transfer must not exceed allowable limits".
4. The date the fumigation begins.
5. Trade name of the fumigant used and EPA Registration Number.
6. Name, address and telephone number of the fumigation company and/or applicator.
7. A 24-hour emergency response telephone number.

All entrances to a fumigated structure must be placarded. Where possible, placards should be placed in advance of the fumigation to keep unauthorized persons away. For railroad hopper cars, placards must be placed on both sides of the car near the ladders and next to the top hatches into which the fumigant is introduced.

Do not remove placards until the treated commodity is aerated down to 0.3 ppm phosphine or less. To determine whether aeration is complete, each fumigated structure or vehicle must be monitored and shown to contain 0.3 ppm or less phosphine gas in the air space around and, if feasible, in the mass of the commodity.

SECTION 17

SEALING OF STRUCTURES

The structure to be fumigated must first be inspected to determine if it can be made sufficiently gas tight. Careful sealing is required so that adequate gas levels are retained. Turn off all ventilation, supply air, air conditioning, and any other air moving systems which could negatively affect the fumigation. Thoroughly inspect the structure to be fumigated and seal cracks, holes and openings. These areas could include, but are not limited to: windows, doors, vents, chimneys, open pipes and structural flaws. Sealing techniques can vary, but most often include polyethylene sheeting, adhesive tapes and adhesive sprays. Expandable foam or caulking material can work well on structural flaws. Proper sealing will insure sufficient gas levels within the fumigated structure and will decrease the chance of unwanted exposures outside of the fumigated area.

As with all fumigations, it is required that sealing be inspected for leaks. If phosphine above 0.3 ppm is found in an area where exposure to workers or bystanders may occur, the fumigator, using proper respiratory protection equipment must attempt to seal the leak from the exterior of the structure. Failing this, the fumigators, following proper procedures to prevent accidental poisoning, may enter the structure and seal the leaks from the interior. If the concentration inside the structure has decreased below the target level as a result of the leakage, additional fumigant may be added following the sealing repairs.

DO NOT FUMIGATE A STRUCTURE THAT CANNOT BE SEALED SUFFICIENTLY GAS-TIGHT.

SECTION 18

AERATION OF FUMIGATED COMMODITIES

As an alternative to the aeration time periods listed below, each container of the treated commodity may be analyzed for residues using accepted analytical methods.

18.1 FOODS AND FEEDS

Tolerances for phosphine residues have been established at 0.1 ppm for animal feeds and 0.01 ppm for processed foods. To guarantee compliance with these tolerances, it is necessary to aerate these commodities for a minimum of 48 hours prior to offering them to the end consumer.

18.2 NON-FOOD COMMODITIES

Aerate all non-food commodities to 0.3 ppm or less of phosphine. Monitor densely packed commodities to ensure that aeration is complete.

18.3 TOBACCO

Tobacco must be aerated for at least three days (72 hours) when fumigated in hogsheads and for at least two days (48 hours) when fumigated in other containers or until concentration is below 0.3 ppm. When plastic liners are used, longer aeration periods will probably be required to aerate the commodity down to 0.3 ppm.

SECTION 19

STORAGE INSTRUCTIONS

Store WEEVIL-CIDE® Tablets, Pellets and Gas Bags in a dry, well-ventilated area away from heat, under lock and key. Post as a pesticide storage area. Do not store in buildings where humans or domestic animals may reside. Keep out of reach of children. WEEVIL-CIDE® tablets and pellets are supplied in gas-tight, resealable aluminum flasks. Do not expose product to atmospheric moisture any longer than is necessary and seal tightly before returning flasks to storage.

Do not contaminate food, water or feed by storing pesticides in the same areas used to store these commodities.

19.1 LABELING OF STORAGE

The labeling of the storage area should take into account the needs of a variety of organizations. These should include, but not be limited to: corporate policy, insurance carrier, Occupational Safety and Health Administration (OSHA), Emergency Planning and Community Right to Know and local emergency response professionals. At a minimum, the storage must be marked with the following signs and should be locked:

1. Danger, Poison (with skull and cross bones)
2. Authorized Personnel Only
3. Pesticide Storage NFPA Hazard Identification Symbols

The National Fire Protection Association (NFPA) has developed Hazard Identification Symbols. This standardized system is designed to provide, at a glance, the information regarding the health, fire and reactivity hazards associated with hazardous materials. The following are the hazard categories and degree of hazard for aluminum phosphide:

Category	Degree of Hazard
Health	4 (Severe Hazard)
Flammability	4 (Severe Hazard)
Reactivity	2 (Moderate)
Special Notice Key	~~W~~

NOTE: When using the NFPA Hazard Identification System, the characteristics of all hazardous materials stored in a particular area must be considered. The local fire protection district should be consulted for guidance on the selection and placement of such signs.

SECTION 20

TRANSPORTATION INSTRUCTIONS

The United States Department of Transportation (DOT) classifies aluminum phosphide as Dangerous When Wet material and it must be transported in accordance with DOT regulations.

20.1 TRANSPORT DESIGNATIONS

The following transport designations apply to aluminum phosphide:

Proper Shipping Name:	Aluminum phosphide
Hazard Class:	4.3
Identification No.:	UN 1397
Packing Group:	PG I
Shipping Label:	Dangerous When Wet/Poison
Shipping Placard:	Dangerous When Wet

20.2 TRANSPORTATION EXEMPTION

UPI Special Permit: DOT-SP 13307

Purpose and Limitation: "...The motor vehicles used under the terms of this exemption are not required to be placarded..."

Modes of Transportation Authorized: Motor vehicle (Only private motor vehicles used in pest control operations are authorized to transport the packages covered by the terms of this exemption.)

NOTE: You must have a copy of this special permit with you during transportation. For a copy of this special permit contact United Phosphorus, Inc., 630 Freedom Business Center, King of Prussia, PA 19406; Telephone: (610) 491-2800/1-800-438-6071.

SECTION 21

REQUIRED WRITTEN FUMIGATION MANAGEMENT PLAN

The certified applicator is responsible for working with the owners and/or responsible employees of the structure and/or area to be fumigated to develop and follow a Fumigation Management Plan (FMP). State, County, and local authorities may also have specific requirements. The FMP must be written PRIOR TO EVERY treatment including fumigation for burrowing pests. The FMP must address characterization of the site, and include appropriate monitoring and notification requirements, consistent with, but not limited to, the following:

1. The use of this product is strictly prohibited on single and multi-family residential properties and nursing homes, schools (except athletic fields), daycare facilities and hospitals. For a list of approved sites see Section 22.
2. Inspect the structure and/or area to determine its suitability for fumigation.
3. When sealing is required, consult previous records for any changes to the structure, seal leaks, and monitor any occupied adjacent buildings to ensure safety.

4. Prior to each fumigation, review any existing FMP, MSDS, Applicator's Manual and other relevant safety procedures with company officials and appropriate employees.
5. Consult company officials in the development of procedures and appropriate safety measures for nearby workers that will be in and around the area during application and aeration.
6. Consult with company officials to develop an appropriate monitoring plan that will confirm that nearby workers and bystanders are not exposed to levels above the allowed limits during application, fumigation and aeration. This plan must also demonstrate that nearby residents will not be exposed to concentrations above the allowable limits.
7. Consult with company officials to develop procedures for local authorities to notify nearby residents in the event of an emergency.
8. Confirm the placement of placards to secure entrance into any structure under fumigation.
9. Confirm the required safety equipment is in place and the necessary manpower is available to complete a safe effective fumigation.
10. Written notification must be provided to the receiver of a vehicle that is fumigated in transit.

These factors **must** be considered in putting together an FMP. It is important to note that some plans will be more comprehensive than others. All plans should reflect the experience and expertise of the applicator and circumstances at and around the site.

In addition to the plan, the applicator must read the entire label and must follow its directions carefully and abide by all restrictions. If the applicator has any questions about the development of a FMP, contact United Phosphorus, Inc. for further assistance.

The FMP and related documentation, including monitoring records, must be maintained for a minimum of 2 years.

STEPS FOR PREPARATION OF THE REQUIRED WRITTEN FUMIGATION MANAGEMENT PLAN

21.1 PURPOSE

A Fumigation Management Plan (FMP) is an organized, written description of the required steps involved to help ensure a safe, legal, and effective fumigation. It will also assist you and others in complying with pesticide product label requirements. The guidance that follows is designed to help assist you in addressing all the necessary factors involved in preparing for and fumigating a site.

This guidance is intended to help you organize any fumigation that you might perform PRIOR TO ACTUAL TREATMENT. It is meant to be somewhat prescriptive, yet flexible enough to allow the experience and expertise of the fumigator to make changes based on circumstances which may exist in the field. By following a step-by-step procedure, yet allowing for flexibility, safe and effective fumigation can be performed.

Before any fumigation begins, carefully read and review the complete label, which include the container label and the Applicator's Manual. This information must also be given to the appropriate company officials (supervisors, foreman, safety officer, etc.) in charge of the site. Preparation is the key to any successful fumigation. If you do not find specific instructions for the type of fumigation that you are to perform listed in this Guidance Document, you will want to construct a similar set of procedures using this document as your guide or contact United Phosphorus for assistance. Finally, before any fumigation begins you must be familiar with and comply with all applicable federal, state and local laws. The success and future of fumigation are not only dependent on your ability to do your job but also by carefully following all rules, regulations, and procedures required by governmental agencies.

21.2 A CHECKLIST GUIDE FOR A FUMIGATION MANAGEMENT PLAN

This checklist is provided to help you take into account factors that must be addressed prior to performing all fumigations. It emphasizes safety steps to protect people and property. The checklist is general in nature and cannot be expected to apply to all types of fumigation situations. It is to be used as a guide to prepare the required plan. Each item must be considered. However, it is understood that each fumigation is different and not all items will be necessary for each fumigation site.

A. PRELIMINARY PLANNING AND PREPARATION

1. Determine the purpose of the fumigation.
   a. Elimination of insect infestation
   b. Elimination of rodent infestation
   c. Plant pest quarantine.
2. Determine the type of fumigation, for example
   a. Space: tarp, mill, warehouse, food plant
   b. Vehicle: railcar, truck, van, container
   c. Commodity: raw agricultural or processed foods
   d. Type of Storage: vertical silo, farm storage, flat storage
   e. Vessels: ship or barge. In addition to the Applicator's Manual, read the US Coast Guard Regulations 46 CFR 147A.
3. Fully acquaint yourself with the site and commodity to be fumigated, including.
   a. The general structure layout, construction (materials, design, age, maintenance) of the structure, fire or combustibility hazards, connecting structures and escape routes, above and below ground, and other unique hazards or structure characteristics. Prepare, with the owner/operator/person in charge. Draw or have a drawing or sketch of structure to be fumigated, delineating features, hazards, and other structural issues.
   b. The number and identification of persons who routinely enter the area to be fumigated (i.e., employees, visitors, customers, etc.)
   c. The specific commodity to be fumigated, its mode of storage, and its condition.
   d. The previous treatment history of the commodity, if available.
   e. Accessibility of utility service connections.
   f. Nearest telephone or other means of communication, and mark the location of these items on the drawing/sketch.
   g. Emergency shut-off stations for electricity water and gas. Mark the location of these items on the drawing/sketch.
   h. Current emergency telephone numbers of local Health, Fire, Police, Hospital and Physician responders.
   i. Name and phone number (both day and night) of appropriate company officials.
   j. Check, mark and prepare the points of fumigation application locations if the job involves entry into the structure for fumigation.
   k. Review entire label, which includes the container label and Applicator's Manual.
   l. Exposure time considerations.
      1. Product (Tablet, Pellet or Gas Bag) to be used.
      2. Minimum fumigation period, as defined and described in the use directions of the Applicator's Manual.
      3. Down time required to be available
      4. Aeration requirements
      5. Cleanup requirements, including dry or wet deactivation methods, equipment, and personnel needs, if necessary.

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6. Measured and recorded commodity temperature and moisture.

m. Determination of dosage

1. Cubic footage or other appropriate space/location calculations.
2. Structure sealing capability and methods.
3. Maximum Allowable Dose Rates
4. Temperature, humidity, wind
5. Commodity/space volume
6. Past history of fumigation of structure
7. Exposure time.

B. PERSONNEL

1. Confirm in writing that all personnel in and around the structure to be fumigated have been notified prior to application of the fumigant. Consider using a checklist that each employee initials indicating they have been notified.
2. Instruct all fumigation personnel to read the Applicator's Manual and about the hazards that may be encountered and about the selection of personal protection devices, including detection equipment.
3. Confirm that all personnel are aware of and know how to proceed in case of an emergency situation.
4. Instruct all personnel on how to report any accident and/or incidents related to fumigant exposure. Provide a telephone number for emergency response reporting.
5. Instruct all personnel to report to proper authorities any theft of fumigant and/or equipment related to fumigation.
6. Establish a meeting area for all personnel in case of emergency.

C. MONITORING

1. Safety
   a. Monitoring of phosphine conditions must be conducted in areas to prevent excessive exposure and to determine where exposure may occur. Document where monitoring will occur.
   b. Keep a log or manual of monitoring records for each fumigation site. This log must at a minimum contain the timing, number of readings taken and level of concentrations found in each location.
   c. When monitoring, document even if there is no phosphine present above the safe levels. In such cases, subsequent monitoring is not routinely required. However spot checks must be made occasionally, especially if conditions significantly change.
2. Efficacy
   a. For stationary structures, phosphine readings MUST be taken from within the fumigated structure to insure proper gas concentrations. If the phosphine levels have fallen below the targeted level, the fumigators, following proper entry procedures may reenter the structure and add additional product.
   b. All phosphine readings must be documented.

D. NOTIFICATION

1. Confirm the appropriate local authorities (fire departments, police departments, etc.) have been notified as per label instructions, local ordinances , or instructions of the client.
2. Prepare written procedure ("Emergency Response Plan") which contains explicit instructions, names, and telephone numbers so as to be able to notify local authorities if phosphine levels are exceeded in an area that could be dangerous to bystanders and or domestic animals.
3. Confirm that the receivers of in-transit vehicles under fumigation have been notified and are trained according to Section 12 of this applicator manual.

E. SEALING PROCEDURES

1. Sealing must be adequate to control the pests. Care should be taken to insure that sealing materials will remain intact until the fumigation is complete.
2. If the site has been fumigated before, review the previous FMP for previous sealing information.
3. Make sure that construction/remodeling has not changed the building in a manner that will affect the fumigation.
4. Warning placards must be placed on every possible entrance to the fumigation site.

F. APPLICATION PROCEDURES AND FUMIGATION PERIOD

1. Plan carefully and apply the product in accordance with the label requirements.
2. When entering into the area under fumigation always work with two or more people under the direct supervision of a certified applicator wearing appropriate respirators.
3. Apply fumigant from the outside where appropriate.
4. Provide watchmen when entry into the fumigation site by unauthorized persons cannot otherwise be assured.
5. When entering structures always follow OSHA rules for confined spaces.
6. Document that the receiver of in-transit vehicles/containers under fumigation has been notified.
7. Turn off any electric lights in the fumigated area of the structure as well as all nonessential electrical motors.

G. POST-APPLICATION OPERATIONS

1. Provide watchmen when you cannot secure the fumigation site from entry by unauthorized persons during the aeration process.
2. Aerate in accordance with structural limitations.
3. Turn on ventilating or aerating fans where appropriate.
4. Use a suitable gas detector before reentry into a fumigated structure to determine fumigant concentration.
5. Keep written records of monitoring to document completion of aeration.
6. Consider temperature when aerating.
7. Ensure aeration is complete before moving a treated vehicle onto public roads.
8. Remove warning placards when aeration is complete.
9. Inform business/client that employees/other persons may return to work or otherwise be allowed to re-enter the aerated structure.

SECTION 22

APPLICATION PROCEDURES

An FMP MUST BE WRITTEN PRIOR to all applications.

An FMP must be devised to cover application and exposure period, aeration and disposal of the fumigant so as to keep to a minimum any human exposures to phosphine and to help assure adequate control of the insect pests.

22.1 FARM BINS

Leakage is the single most important cause of failures in the treatment of farm storages. Since these storages are often small, they usually have a higher leakage area in proportion to their capacity. Most wooden storage structures are so porous that they cannot be successfully fumigated unless they are completely tarped. Do not fumigate a storage that will be entered by humans or animals prior to aeration. Do not fumigate areas which house sensitive equipment containing copper or other metals likely to be corroded by phosphine gas.

1. Read the entire label, MDS and related safety material.
2. An appropriate Fumigation Management Plan must be developed for all Farm Bin applications.
3. Inspect the bin to determine if you can fumigate effectively.
4. If the bin is located in an area where nearby workers and/or bystanders or domestic animals would be exposed to phosphine gas because of leakage from the bin:
   (i) Develop a monitoring procedure that will confirm if leakage from the bin is above the allowable limits in an area that would affect nearby workers or bystanders.
   (ii) Advise local authorities when and where you will be fumigating. Provide and review with them the MSDS, Applicator's Manual and other relevant safety information.
5. If the bin is in an isolated area on private property (i) and (ii) above are not required.
6. Seal the bin as tightly as possible. It is recommended that the surface of the grain be covered with polyethylene sheets after WEEVIL-CIDE® has been applied. Tarping the grain surface will greatly reduce the leak rate of the gas as well as reduce the amount of WEEVIL-CIDE® required. Only the volume below the tarp must be dosed. If not tarped, the entire volume of the storage must be treated, whether full or empty.
7. Using the Applicator's Manual, calculate the dosage of Tablets, Pellets or Gas Bags to be applied based on type of structure, its sealing properties, content type, weather, commodity temperature and moisture content of the commodity and length of fumigation.
8. WEEVIL-CIDE® Tablets, Pellets and Gas Bags required for the fumigation may be scattered over the surface. Tablets and pellets can be probed into the grain using a rigid PVC pipe about 5 to 7 feet in length and having a diameter of 1-1/4 inches. Use about 20-50 tablets or 100-250 pellets per probe. Probe the dosage uniformly over the surface.
9. Immediately cover the surface of the grain with a plastic tarpaulin.
10. Place no more than 25 percent of the total dose at the bottom if the bin is equipped with aeration fans. **Caution:** Make sure that the aeration duct is dry before adding WEEVIL-CIDE®. Addition of WEEVIL-CIDE® to water in an aeration duct may result in a fire.
11. Seal the aeration fan with 4-mil plastic sheeting.
12. Place placards on all entrances to the bin and near the ladder.
13. Following aeration of the bin, the surface of the grain may be sprayed with an approved protectant to discourage reinfestation.

Note: If monitoring equipment is not available, an approved canister respirator must be worn during application from within an enclosed area.

22.2 FLAT STORAGES

Treatment of these types of storages often requires considerable time and physical effort. Therefore, sufficient manpower should be available to complete the work rapidly enough to prevent excessive exposure to phosphine gas. Vent flasks outside the storage, conduct fumigations during cooler periods, and employ other work practices to minimize exposures. It is likely that respiratory protection will be required during application of fumigant to flat storages. Refer to Sections on Applicator and Worker Exposure and Respiratory Protection.

1. Inspect the site to determine its suitability for fumigation.
2. Determine if the structure is in an area where leakage during fumigation or aeration would adversely affect nearby workers or bystanders if concentrations were above the permitted exposure levels.
3. Develop an appropriate Fumigation Management Plan. (Refer to FMP guidelines.)
4. Consult previous records for any changes to the structure. Seal vents, cracks and other sources of leaks.
5. Using the Applicator's Manual, determine the length of the fumigation and calculate the dosage of tablets, pellets or gas bags to be applied based upon volume of the building, contents, air and/or commodity temperature and the general tightness of the structure.
6. Apply tablets, pellets or gas bags by surface application. Tablets and pellets may be applied by shallow probing, deep probing or uniform addition as the bin is filled.

   Storages requiring more than 24 hours to fill should not be treated by addition of fumigant to the commodity stream as large quantities of phosphine may escape before the flat storage is completely sealed.

   Probes should be inserted vertically at intervals along the length and width of the flat storage. Pellets or tablets may be dropped into the probe at intervals as it is withdrawn.

   Surface application may be used if the bin can be made sufficiently gas tight to contain the fumigant gas long enough for it to penetrate the commodity. In this instance, it is advisable to place about 25 percent of the dosage in the floor level aeration ducts. Check the ducts prior to addition of WEEVIL-CIDE® to make sure that they contain no liquid water.
7. Placement of plastic tarp over the surface of the commodity is often advisable, particularly if the overhead of the storage cannot be well sealed.
8. Lock all entrances to the storage and post fumigation warning placards.

22.3 VERTICAL STORAGES (concrete upright bins and other silos in which grain can be rapidly transferred)

1. Inspect the site to determine its suitability for fumigation.
2. Determine if the structure is in an area where leakage during fumigation or aeration would expose nearby workers or bystanders to concentrations above the permitted levels.
3. Develop an appropriate Fumigation Management Plan (Refer to FMP guidelines).
4. Consult previous records for any changes to the structure. Close openings and seal cracks to make the structure as airtight as possible. Prior to the fumigation, seal the vents near the bin top which connect to adjacent bins.
5. Determine the length of the fumigation and calculate the dosage of Tablets, Pellets or Gas Bags to be applied based upon volume of the building, air and/or commodity temperature and the general tightness of the structure.
6. Pellets and Tablets may be applied continuously by hand or by an automatic dispenser on the headhouse/gallery belt or into the fill opening as the commodity is loaded into the bin. An automatic dispenser may also be used to add WEEVIL-CIDE® tablets and pellets into the commodity stream in the up leg of the elevator.
7. Seal the bin deck openings after the fumigation has been completed.
8. Bins requiring more than 24 hours to fill should not be fumigated by continuous addition into the commodity stream. These bins may be fumigated by probing, surface application, or other appropriate means. Exposure periods should be lengthened to allow for diffusion of gas to all parts of the bin if WEEVIL-CIDE® has not been applied uniformly throughout the commodity mass.
9. Place warning placards on the discharge gate and on all entrances.

22.4 MILLS, FOOD PROCESSING PLANTS AND WAREHOUSES

1. Inspect the site to determine its suitability for fumigation.
2. Determine if the structure is in an area where leakage during fumigation or aeration would expose nearby workers or bystanders if concentrations were above the permitted exposure levels.
3. Develop an appropriate Fumigation Management Plan. (Refer to Steps for Preparation of a Fumigation Management Plan.)
4. Determine the length of the fumigation and calculate the dosage of tablets, pellets or gas bags to be applied based upon volume of the building, air and/or commodity temperature and the general tightness of the structure.
5. Read the directions found under Section 4.3 Physical and Chemical Hazards and remove or cover any of the listed items that can become damaged from exposure to phosphine gas.
6. Consult previous records for any changes in the structure. Carefully seal and placard the space to be fumigated.
7. Place trays or sheets of Kraft paper or foil, up to 12-sq. ft. (1.1 sq. M) in area, on the floor throughout the structure.
8. Spread WEEVIL-CIDE® on the sheets at a density no greater than 30 tablets per sq. ft. or 150 pellets per sq. ft. or 3 gas bags per sq. ft. This corresponds to slightly more than 3/4ths of a flask containing 2500 tablets or 3/4ths of a flask containing 1600 pellets per 3'x4' sheet. Check to see that WEEVIL-CIDE® has not piled up and that it is spread out evenly to minimize contact between the individual tablets or pellets. Gas bags may be placed directly on the floor.
9. Turn off any lights within the treated area and shut off all electrical motors not essential to operations of the storage. Doors leading to the fumigated space must be closed, sealed, and placarded with warning signs.
10. Upon completion of the exposure period, open windows, doors, vents, etc., allow the fumigated structure to aerate. Do not enter the structure without proper Personal Protective Equipment (PPE) unless gas readings have been taken and the concentration is below the allowable limits. Gas concentration readings may be taken using low level detector tubes or similar devices to ensure safety of personnel who reenter the treated area.
11. Collect the spent WEEVIL-CIDE® dust and dispose of it, with or without further deactivation. Refer to Disposal Instructions in Section 24 of this Manual.
12. Remove fumigation warning placards from the aerated structure.

22.5 RAILCARS, CONTAINERS, TRUCKS, VANS, AND OTHER TRANSPORT VEHICLES

Develop an appropriate Fumigation Management Plan.

Railcars and containers, trucks, vans, and other transport vehicles shipped piggyback by rail may be fumigated in-transit. However, the aeration of railcars, railroad boxcars, containers and other vehicles is prohibited en-route. It is not legal to move trucks, trailers, containers, vans, etc., over public roads or highways until they have been aerated.

Do NOT USE WEEVIL-CIDE® tablets, pellets or gas bags in cars or other personal vehicles.

Transport vehicles loaded with bulk commodities to which WEEVIL-CIDE® Tablets, Pellets or Gas Bags may be added directly are treated in essentially the same way as any other flat storage facility. WEEVIL-CIDE® may be added as the vehicle is being filled. The dose may be scattered over the surface after loading has been completed or the tablets or pellets may be probed below the surface. Carefully seal any vents, cracks or other leaks, particularly if the fumigation is to be carried out in-transit. See Section 16 of this Applicator's Manual for recommendations on placarding.

The Shipper and/or the fumigator must provide written notification to the receiver of railcars, railroad boxcars, shipping containers and other vehicles, which have been fumigated in-transit. A copy of the Applicator's Manual must precede or accompany all transportation containers or vehicles which are fumigated in-transit. If the Applicator's Manual is sent with the transport vehicle it must be placed securely on the outside of the vehicle.

Proper handling of treated railcars at their destination is the responsibility of the consignee. Upon receipt of the railcar, railroad boxcars, shipping containers and other vehicles a certified applicator and/or persons with documented authorized training must supervise the aeration process and removal of the placards.

22.5.1 Gas Bags

WEEVIL-CIDE Gas Bags are suited to fumigation of package commodities or bulk processed foods. The Gas Bags are not to be placed in or attached directly to commodity packages containing processed food. If placement of Gas Bags on the floor of a boxcar is not convenient, or if the vehicle is being fumigated in-transit, the Gas Bags may be attached to a wall or other support. They may also be applied by taping the Gas Bags on cardboard with spacing between the Gas Bags. Tape across the Gas Bag ends only. Specially designed cardboard discs or boards are available for this purpose. If the boards or discs are used, taping of the Gas Bags is not necessary. Instructions that follow give specific procedures for treatment of rail cars when direct addition to the commodity is not permitted (see Sections 7.2 Processed Foods and Section 7.3 Nonfood Commodities Including Tobacco in this Manual).

21.5.2 Procedures for Hopper Rail Cars – Round Hatch

1. Close and secure all hatch covers except those being utilized for the fumigation.
2. Seal all other openings. Pay particular attention to vents.
3. Clean the flange lip of hatch (or hatches) being utilized. If the commodity extends into the throat of the hatch, force it away to the extent possible.
4. Determine the length of the fumigation and, using the Applicator's Manual, calculate the dosage of gas bags to be applied based upon volume of the car, air and/or commodity temperature and the general tightness of the rail car.
5. Open cans, insert gas bags into the pockets or tape the gas bags on the disc. Gas Bags must not be folded.
6. Secure the disc into place with tape. Place the loaded disc into position with the Gas Bag side in the up position.
7. Cover the hatch opening with poly sheeting before closing the cover.
8. Lower the cover into place and secure. Insert the placard into a clear plastic bag, and affix it to the hatch cover. Affix placards near the ladder on each side of the car.

22.5.3 Procedures for Hopper Rail Cars – Slot Hatch

1. Fold the edges of a board to form a tray. The board is designed to "hang" in the hatch opening.
2. Determine the length of the fumigation and, using the Applicator's Manual, calculate the dosage of gas bags to be applied based upon volume of the car, air and/or commodity temperature and the general tightness of the rail car.
3. Open containers and insert Gas Bags into the pockets of the board. Gas Bags must not be folded.
4. Place the loaded board into position with the Gas Bag side up.
5. Secure the board in place with tape.
6. Cover the entire hatch opening with poly sheeting before closing the cover.

7. Lower the hatch covers.
8. Insert the placard into a clear plastic bag, and affix it to the hatch cover. Affix placards near the ladder on each side of the car.

22.5.4 Procedures for Box Cars

1. Close and secure one of the doors. Seal all openings and joints. If needed, caulk joints and drape entire doorway with poly film, securing the edges to the inner wall, floor and ceiling with tape or suitable adhesive.
2. Inspect the roof, floor and walls for holes and/or cracks. Seal all openings with either tape or caulking compound.
3. If needed, drape remaining doorway with polyethylene film before door is closed. Secure edges to door jams and floor. Close door and secure. If doorway is draped with poly, it may not be necessary to seal the door from the outside. If doorway is not draped, seal all cracks, openings and leaky joints with masking tape and/or caulking compound from the outside.
4. Determine the length of the fumigation and, using the Applicator's Manual, calculate the dosage of Gas Bags to be applied based upon volume of the car, air and/or commodity temperature and the general tightness of the rail car.
5. Open containers and insert Gas Bags into the pockets of the disc or board or use tape to secure the Gas Bags.
6. Place the loaded disc or board onto the load, with the Gas Bag side up. Secure the board in place with tape or nail it to the wall.
7. Post placards into a clear plastic bag, and affix it to the doors of the cars.

22.6 TARPAULIN AND BUNKER FUMIGATIONS

Use of plastic sheeting or tarpaulins to cover commodities is one of the easiest and least expensive means for providing relatively gas tight enclosures which are very well suited for fumigation. Polyethylene (poly) tarps are penetrated only very slowly by phosphine gas, and tight coverings are readily formed from the sheets. The volume of these enclosures may vary widely from a few cubic feet (for example, a fumigation tarpaulin placed over a small stack of bagged commodity) to a plastic bunker storage capable of holding 600,000 bushels of grain or more.

1. Develop an enclosure suitable for fumigation by covering bulk or packaged commodities with poly sheeting. The sheets may be taped together to provide a sufficient width of material to ensure that adequate sealing is obtained. If the flooring upon which the commodity rests is of wood or other porous material, the commodity to be fumigated should be repositioned onto poly prior to covering for fumigation. The plastic covering of the pile may be sealed to the floor using sand or water snakes, by shoveling soil or sand onto the ends of the plastic covering or by other suitable procedures. The poly covering should be reinforced by tape or other means around any sharp corners or edges in the stack so as to reduce the risk of tearing. Thinner poly, about 2 mil, is suitable for most indoor tarp fumigations and for sealing of windows, doors and other openings in structures. However, 4 mil poly or thicker is more suitable for outdoor applications where wind or other mechanical stresses are likely to be encountered.
2. Determine if the enclosure is in an area where leakage during fumigation or aeration would affect nearby workers or bystanders .
3. Develop an appropriate Fumigant Management Plan. (Refer to Section 21 Fumigation Management Plan.)
4. Using the guidance given under Section 8 Exposure Conditions, determine the length of the fumigation and calculate the dosage of tablets, pellets or gas bags to be applied based upon volume of the space under the tarp, air and commodity temperature.
5. Tablets, Pellets and Gas Bags may be applied to the tarped stack or bunker storage of bulk commodity through slits in the poly covering. Probing or other means of dosing may be used. Avoid application of large amounts of WEEVIL-CIDE® at any one point. The WEEVIL-CIDE® should be added below the surface of the commodity if condensation or other source of moisture is likely to form beneath the poly. The slits in the covering should be carefully taped to prevent loss of gas once the dose has been applied and to prevent the introduction of water from rain. Care should be taken to see that the poly is not allowed to cover the WEEVIL-CIDE® and prevent contact with moist air or confine the gas.
6. Distribution of phosphine gas is generally not a problem in the treatment of bagged commodities and processed foods. However, fumigation of larger bunker storages containing bulk commodity will require proper application procedures to obtain adequate results.
7. Place warning placards at conspicuous points on the enclosure.

22.7 IN-TRANSIT SHIPHOLDS

22.7.1 General Information

Important – In-transit ship or shiphold fumigation is also governed by U.S. Coast Guard Regulation 46 CFR 147A, Interim Regulations for Shipboard Fumigation. Refer to this regulation prior to fumigation. For further information contact:

Commandant U.S. Coast Guard
Hazardous Materials Standards Division GMSO-3
Washington, DC 20593-0001

22.7.2 Pre-Voyage Fumigation Procedures – A FMP must be written for all fumigations PRIOR TO ACTUAL TREATMENT.

1. Prior to fumigating a vessel for in-transit cargo fumigation, the master of the vessel, or his representative, and the certified applicator must determine whether the vessel is suitably designed and configured so as to allow for safe occupancy by the ship's crew throughout the duration of the fumigation. If it is determined that the design and configuration of the vessel does not allow for safe occupancy by the ship's crew throughout the duration of the fumigation, then the vessel will not be fumigated unless all crew members are removed from the vessel. The crew members will not be allowed to reoccupy the vessel until the vessel has been properly aerated and the master of the vessel and the certified applicator has made a determination that the vessel is safe for occupancy.
2. The certified applicator must notify the master of the vessel, or his representative, of the requirements relating to personal protection equipment*, detection equipment, and that a person qualified in the use of this equipment must accompany the vessel with cargo under fumigation. Emergency procedures, cargo ventilation, periodic monitoring and inspections, and first aid measures must be discussed with and understood by the master of the vessel or his representative.

   **Note: Personal protection equipment means a NIOSH/MSHA approved respirator or gas mask fitted with an approved canister for phosphine. The canister is approved for use up to 15 ppm. SCBA or its equivalent must be used above 15 ppm or at unknown concentrations.*
3. Seal all openings to the cargo hold or tank and lock or otherwise secure all openings, manways, etc., which might be used to enter the hold. The overspace pressure relief system of each tank aboard tankers must be sealed by closing the appropriate valves and sealing the openings into the overspace with gas-tight materials.

4. Using the label, determine the length of the fumigation and calculate the dosage of tablets, pellets or gas bags to be applied based upon volume of the vessel, air and/or commodity temperature and the general tightness of the vessel.
5. Placard all entrances to the treated spaces with fumigation warning signs.
6. If the fumigation is not completed and the vessel aerated before the manned vessel leaves port, the person in charge of the vessel shall ensure that at least two units of personal protection equipment and one gas or vapor detection device, and a person qualified in their operation be on board the vessel during the voyage.
7. During the fumigation, or until a manned vessel leaves port or the cargo is aerated, the certified applicator shall ensure that a qualified person using phosphine gas detection equipment tests spaces adjacent to areas containing fumigated cargo as well as all regularly occupied spaces for fumigant leakage. If leakage of the fumigant is detected, the person in charge of the fumigation shall take action to correct the leakage, or shall inform the master of the vessel, or his representative, of the leakage so that corrective action can be taken.
8. Review with the master, or his representative, the precautions and procedures to follow during the voyage of a shiphold in-transit fumigation.

22.7.3 Application Procedures for Bulk Dry Cargo Vessels and Tankers

1. Apply tablets or pellets by scattering uniformly over the commodity surface, or they may be shallow or deep probed into the commodity mass. Gas bags may be placed on the surface of the commodity.
2. Immediately after application of the fumigant, close and secure all hatch covers, tank tops, butterworth valves, manways, etc.

22.7.4 In-transit Fumigation of Transport Units (Containers) Aboard Ships

In-transit fumigation of transport units on ships is also governed by DOT RSPA 49 CFR 176.76(i) Transport Vehicles, Freight Containers, and Portable Tanks Containing Hazardous Materials and International Maritime Dangerous Goods Code P9025-1 Amdt. 27-94. Application procedures for fumigation of raw commodities or processed foods in transport units (containers) are described in Section 22.5 of this Manual.

22.7.5 Precautions and Procedures During Voyage

1. Using appropriate gas detection equipment, monitor spaces adjacent to areas containing fumigated cargo and all regularly occupied areas for fumigant leakage. If leakage is detected, the area should be evacuated of all personnel, ventilated, and action taken to correct the leakage before allowing the area to be occupied.
2. Do not enter fumigated areas except under emergency conditions. If necessary to enter a fumigated area, appropriate personal protection equipment must be used. Never enter fumigated areas alone. At least one other person, wearing personal protection equipment, should be available to assist in case of an emergency.

22.7.6 Precautions and Procedures During Discharge

If necessary to enter holds prior to discharge, test spaces directly above grain surface for fumigant concentration using appropriate gas detection and personal safety equipment. Do not allow entry to fumigated areas without personal safety equipment, unless fumigant concentrations are at safe levels, as indicated by a suitable detector.

22.7.7 Barges

Barge fumigation is also regulated by U.S. Coast Guard Regulation 46 CFR 147A as modified by U.S. Coast Guard Special Permit 2-75. This permit which must be obtained prior to the fumigation is available from:

Commandant U.S. Coast Guard
Hazardous Materials Standards Division GMSO-3
Washington, DC 20593-0001

Leaks are a common cause of failures in the treatment of commodities aboard barges. Carefully inspect all hatch covers prior to application of WEEVIL-CIDE® and seal, if necessary. Placard the barge. Notify consignee if the barge is to be fumigated in-transit and provide safety instructions for receipt and unloading.

22.8 SMALL SEALABLE ENCLOSURES

Develop an appropriate Fumigation Management Plan.

Excellent results may be attained in the treatment of small enclosures since it is often possible to control the temperature during fumigation and also to make the enclosure virtually gas tight. Take care not to overdose during these fumigations. A single WEEVIL-CIDE® pellet will treat a space of 1.4 to 10 cubic feet. A single WEEVIL-CIDE® tablet will treat a space of 6.9 to 50 cubic feet. A single WEEVIL-CIDE® gas bag will treat a space of 77 to 500 cubic feet.

22.9 BEEHIVES, SUPERS AND OTHER BEE KEEPING EQUIPMENT

Develop an appropriate Fumigation Management Plan.

WEEVIL-CIDE® Tablets, Pellets and Gas Bags may be used for the control of the Greater Wax Moth in stored beehives, supers, and other bee keeping equipment and for the destruction of bees, Africanized bees, and diseased bees including those infested with tracheal mites and foulbrood. The recommended dosage for this use is 30-45 tablets, 150-225 pellets or 3-4 gas bags per 1,000 cu. ft.

Fumigations may be performed in chambers at atmospheric pressure, under tarpaulins, etc., by using gas bags or by placing the tablets or pellets onto trays or into moisture permeable envelopes. Do not add more than 2 tablets or 10 pellets onto trays or into each envelope. Honey from treated hives or supers may only be used for bee food.

22.10 BURROWING PEST CONTROL

The use of this product is strictly prohibited on single and multi-family residential properties and nursing homes, schools (except athletic fields), daycare facilities and hospitals.

A Fumigation Management Plan must be written for all burrowing pest fumigations.

22.10.1 Use Restrictions

THIS PRODUCT MUST NOT BE APPLIED INTO A BURROW SYSTEM THAT IS WITHIN 100 FEET OF A BUILDING THAT IS, OR MAY BE, OCCUPIED BY HUMANS, AND/OR DOMESTIC ANIMALS.

This product must be applied to underground burrow systems located in noncrop areas, crop areas, or orchards occupied by woodchucks, yellowbelly marmots (rockchucks), prairie dogs (except Utah prairie dogs, *Cynomys Parvidens*), roof rats, mice, ground squirrels, moles, voles, pocket gophers or chipmunks.

All treatments for control of these species in burrows must be made outdoors. Pellets or tablets must be applied directly to underground burrow systems. Before using WEEVIL-CIDE® tablets or pellets for burrowing pest control, read the applicable restrictions under Environmental Hazards and Endangered Species below.

This product must be used out of doors only for control of burrowing pests and for use ONLY on agricultural areas, orchards, non-crop areas (such as pasture and rangeland), golf courses, athletic fields, airports, cemeteries, rights-of way, earthen dams, parks and recreational areas and other non-residential institutional or industrial sites.

a. When this product is used in athletic fields or parks, the applicator shall post a sign at entrances to the treated site containing the signal word DANGER/PELIGRO skull and crossbones, the words: DO NOT ENTER/NO ENTRE, FIELD NOT FOR USE, the name and EPA registration number of the fumigant, and a 24 hour emergency response number. Placards may be removed 2 days after the final treatment.

b. When this product is used out-of-doors to a site other than an athletic field or park, the applicator shall post a sign at the application site containing the signal word DANGER/PELIGRO skull and crossbones, the name and EPA registration number of the fumigant, and a 24-hour emergency response number. Signs may be removed 2 days after the final treatment.

Document any burrows that open under or into occupied buildings, and do not apply to these burrows. In addition, check for any other source through which the gas may enter into occupied buildings as a result of application to burrows. If there is any way gas can move through pipes, conduits etc., from burrows, do not treat these burrows.

Prior to treating a rodent burrow the applicator must provide the customer with a copy of the Fumigation Management Plan.

22.10.2 Application Directions for Control of Burrowing Pests

For use by a certified applicator or person under the direct supervision and who have been trained specifically for use of this product in burrowing pest control.

Use application procedures appropriate to the type of burrow system being treated. DOSAGE RATES MUST NOT BE EXCEEDED UNDER ANY CIRCUMSTANCES.

1. For species with open burrow systems, locate all entrances to each burrow system. Treatment of more than one entrance in a system is often desirable as systems often overlap and are not defined. Treat all entrances except for those entrances you are sure connect to already treated entrances. Insert 2 to 4 tablets or 10 to 20 pellets into each burrow entrance to be treated. Use the lower rates for smaller burrows and/or when soil moisture is high. Use the higher rates for larger burrow systems and when soil moisture is relatively low. Pack the treated entrance with crumpled paper and shovel soil to completely cover the paper. Using crumpled paper will prevent soil from covering the tablets or pellets and slowing down their action. Rocks, clods of soil, cardboard, etc. may be used for this purpose. Be sure to seal all untreated entrances by shoveling and packing soil and/or sod to completely seal the opening. Inspect treated areas 1 or 2 days following treatment for signs of residual activity of target species. Treat all reopened burrow openings in the manner prescribed above.

   THIS PRODUCT MUST NOT BE APPLIED INTO A BURROW SYSTEM THAT IS WITHIN 100 FEET IF A BUILDING THAT IS, OR MAY BE, OCCUPIED BY HUMANS, AND/OR DOMESTIC ANIMALS.

2. For species with closed burrow systems, (pocket gophers and moles in some situations). Locate the main underground runway by probing with a smooth-sided rod 12 to 18 inches from a fresh mound. For pocket gophers, begin probing on the flat side of the mound. A sudden reduction in soil resistance to the probe indicates that the main runway has been located. Once the main runway is located, remove the probe and apply 2 to 4 tablets or 10 to 20 pellets through the probe hole. Adjust treatment rate according to the level of soil moisture, using more pellets or tablets if the soil is relatively dry. Do not treat if soil is extremely dry or if there are no signs of recent gopher or mole activity. Make a tight seal to close probe hole by using a clod of soil or a sod plug to cover the hole or by using the heel of your shoe to push sod and/or soil over the surface opening. If the probe hole is more than one inch in diameter, place crumpled paper in the hole before closing it with soil and/or sod. Two days after treatment, you may check area for residual pest activity by poking holes in main runways of burrow systems, flagging holes and inspecting them two days later. You should retreat all reclosed burrow openings, on both sides of the plug.

   THIS PRODUCT MUST NOT BE APPLIED INTO A BURROW SYSTEM THAT IS WITHIN 100 FEET IF A BUILDING THAT IS, OR MAY BE, OCCUPIED BY HUMANS, AND/OR DOMESTIC ANIMALS.

SECTION 23

ENDANGERED SPECIES RESTRICTIONS

The use of WEEVIL-CIDE® in a manner that may kill or otherwise harm an endangered or threatened species or adversely modify their habitat is a violation of Federal laws. This product is toxic to wildlife. Many non-target organisms exposed to phosphine gas in burrows will be killed. Do not apply directly to water or wetlands (swamps, bogs, marshes, and potholes). Do not contaminate water by cleaning of equipment or disposal of wastes. Before using this pesticide on range and/or pastureland you must obtain the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES for the county in which the product is to be used. The bulletin is available from your County Extension Agent, State Fish and Game Office, or your pesticide dealer. Use of this product in a manner inconsistent with the PESTICIDE USE BULLETIN FOR PROTECTION OF ENDANGERED SPECIES is a violation of Federal laws.

Even if applicable county bulletins do not prohibit the use of this product at the intended site of application, you may not use this product for control of prairie dogs in the states of Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah or Wyoming unless a pre-control survey has been conducted. Contact the nearest U.S. Fish and Wildlife Service Endangered Species Specialist to determine survey requirements in your area. This survey must be in compliance with the Black-Footed Ferret Survey Guidelines, developed by the U.S. Fish and Wildlife Service, and a determination must be made in accordance with the Guidelines that black-footed ferrets are not present in the treatment area.

CALIFORNIA (all endangered species)

Fresno, Inyo, Kern, Kings, Madera, Merced, Monterey, San Benito, San Luis Obispo, Santa Barbara, Stanislaus and Tulare

See the U.S. EPA Interim Measures Bulletin for your county. To obtain a copy of the bulletin, contact your county agricultural commissioner or visit the following website: http://www.cdpr.ca.gov/docs/es/index.htm. If there is no current bulletin available for your county, contact the U.S. Fish and Wildlife Service office in Portland, OR to determine whether there are endangered species that might be adversely affected by your proposed use of WEEVIL-CIDE® and the steps you should take to mitigate any such risks.

FLORIDA

Statewide

GEORGIA

Appling, Atkinson, Bacon, Baker, Ben Hill, Bleckley, Berrien, Brantley, Brooks, Bryan, Bullock, Calhoun, Camden, Chandler, Charlton, Chatham, Clinch, Coffee, Colquitt, Cook, Crisp, Decatur, Dodge, Dooly, Dougherty, Early, Echols, Effingham, Emanuel, Evans, Glynn, Grady, Irwin, Jeff Davis, Jenkins, Johnson, Lanier, Laurens, Lee, Liberty, Long, Lowndes, Macon, McClintosh, Miller, Mitchell, Montgomery, Pierce, Pulaski, Screven, Seminole, Telfair, Tattnall, Thomas, Tift, Toombs, Treutlen, Turner, Ware, Wayne, Wheeler, Wilcox and Worth.

NEW MEXICO

Hidalgo

UTAH

Beaver, Garfield, Iron, Kane, Piute, Sevier, Washington and Wayne

WYOMING

Albany

Special Local Restrictions

1. NORTH CAROLINA

WEEVIL-CIDE® Tablets and Pellets may only be used for control of rats in the State of North Carolina. Use against other burrowing (not insect pests) pests is not permitted.

2. OKLAHOMA

A special permit for black-tailed prairie dog control by poisoning is required in Oklahoma. Contact the Oklahoma State Department of Wildlife Conservation to obtain this permit.

3. WISCONSIN

A state permit is required for use of pesticides in Wisconsin to control small mammals, except rats. Contact your local Department of Natural Resources office for information.

4. INDIANA

Use of WEEVIL-CIDE® Tablets or Pellets for mole control is not legal in the State of Indiana.

5. MISSOURI

A state permit is required for use of pesticides in Missouri to control small mammals, except rats. Please contact the Missouri Department of Conservation for information.

6. KANSAS

A special permit for black-tailed prairie dog control by poisoning is required in Kansas. Contact the Kansas Fish and Game Commission to obtain this permit.

7. CALIFORNIA

Use of WEEVIL-CIDE® Tablets and Pellets for chipmunk control is not legal in the State of California.

SECTION 24

DISPOSAL INSTRUCTIONS

24.1 GENERAL

Do not contaminate water, food or feed by storage or disposal.

Unreacted or partially reacted WEEVIL-CIDE® is acutely hazardous. Improper disposal of excess pesticide is a violation of Federal Law. If these wastes cannot be disposed of by use according to the Applicator's Manual instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance. For specific instructions, see Disposal Instructions (Section 24) and the Spill and Leak Procedures (Section 25) of this Manual.

Some local and state waste disposal regulations may vary therefore disposal procedures must be reviewed with appropriate authorities to ensure compliance with local regulations. Contact your state Pesticide or Environmental Control Agency or Hazardous Waste Specialist at the nearest EPA Regional Office for guidance.

24.2 DISPOSAL OF ALUMINUM FLASKS

Non-refillable containers. Do not reuse or refill this container. Offer for recycling. Triple rinse container (or equivalent) promptly after emptying. Triple rinse flasks and stoppers with water as follows:

Empty the remaining contents into application equipment or a mix tank. Fill the container 1/4 full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling, if available or offer for reconditioning, if appropriate, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities. Rinsate may be disposed of in a sanitary landfill, by pouring it out onto the ground or by other approved procedures. It is permissible to remove lids and expose empty flasks to atmospheric conditions until residue in the flask is reacted. Then puncture and dispose of in a sanitary landfill or other approved site, or by other procedures approved by state and local authorities.

If properly exposed the residual dust remaining after fumigation with WEEVIL-CIDE® Tablet or Pellets will be a grayish-white powder and contain only a small amount of unreacted aluminum phosphide. However, residual dust from incompletely exposed WEEVIL-CIDE® Tablets or Pellets may require special care.

24.3 DIRECTIONS FOR DISPOSAL OF RESIDUAL DUST FROM WEEVIL-CIDE® – PELLETS AND TABLETS

If properly exposed, the residual dust remaining after a fumigation with WEEVIL-CIDE® will be a grayish-white powder. This will be a nonhazardous waste and contain only a small amount of unreacted aluminum phosphide. However, residual dust from incompletely exposed WEEVIL-CIDE®, (so called green dust) requires special care.

Confinement of partially spent residual dust (as in a closed container) or collection and storage of large quantities of dust may result in a fire hazard. Small amounts of phosphine may be given off from unreacted aluminum phosphide, and confinement of the gas may result in a flash.

In open areas, small amounts of residual dust, up to about 5 to 8 kg may be disposed of on site by burial or by spreading over the land surface away from inhabited buildings.

Spent residual dust from WEEVIL-CIDE® may also be collected and disposed of at a sanitary landfill, incinerator or other approved sites or by other procedures approved by Federal, State or Local authorities. "Green dust" must be further deactivated before disposal at a landfill.

From 2 to 3 kg (4 to 7 lbs.) of spent dust from 2 to 3 flasks of WEEVIL-CIDE® may be collected for disposal in a 1-gallon bucket. Larger amounts, up to about one-half case, may be collected in burlap, cotton or other types of porous cloth bags for transportation in an open vehicle to the disposal site. Do not collect dust from more than 7 flasks of tablets or 10 flasks of pellets (about 11 kg or 25 lbs.) in a single bag. Do not pile cloth bags together. Do not use this method for partially spent or "green" dust. **Caution: Do not collect dust in large drums, dumpsters, plastic bags or other containers where confinement may occur.**

24.4 DIRECTIONS FOR DEACTIVATION OF PARTIALLY SPENT RESIDUAL DUST FROM WEEVIL-CIDE® – PELLETS AND TABLETS

Partially spent dust must be deactivated further prior to ultimate disposal. This is especially true in cases of incomplete exposure that has resulted in so-called "green dust" or following a fumigation that has produced large quantities of partially spent material.

Caution: Wear a NIOSH/MSHA approved full-face gas mask – phosphine canister combination (if exposed to levels between 0.3 ppm and 15 ppm) or a Self Contained Breathing Apparatus (SCBA) (if exposure is unknown or above 15 ppm) during wet deactivation of partially spent material. Do not cover the container being used for wet deactivation. Do not dispose of WEEVIL-CIDE® dust in a toilet.

Residual dust from WEEVIL-CIDE® Tablets and Pellets may be deactivated as follows using the "Wet Method."

1. Deactivating solution is prepared by adding the appropriate amount of low sudsing detergent or surface-active agent to water in a drum or other suitable container. A 2% solution (or 4 cups in 30 gallons) of detergent is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. Residual dust is poured slowly into the deactivating solution and stirred so as to thoroughly wet all of the particles. This should be done in the open air and not in the fumigated structure. Do not cover the container being used for wet deactivation. Dust from WEEVIL-CIDE® Tablets or Pellets should be mixed into no less than about 10 gallons of water-detergent solution for each case of material used. Wear appropriate respiratory protection during wet deactivation of partially spent dust.
3. Dispose of the deactivated dust-water suspension, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, the slurry may be poured out onto the ground. If the slurry has been held for 36 hours or more, it may be poured into a storm sewer.

Residual dust from WEEVIL-CIDE® Tablets and Pellets may also be deactivated as follows using the "Dry Method."

1. Extension of the fumigation period is the simplest method for further deactivation of "green" or partially spent dust prior to ultimate disposal.
2. Small amounts of partially spent dust, from 2 to 3 kg (4 to 7 lbs.) may be further deactivated by storage in a 1-gallon bucket. Larger amounts of dust (about 11 kg or 25 lbs.) may be held for deactivation in porous cloth bags (burlap, cotton, etc.). Caution: Transport these bags in open vehicles. Do not pile up the bags. Do not store "green dust" in bags.

24.5 DIRECTIONS FOR DEACTIVATION OF PARTIALLY SPENT RESIDUAL DUST FROM WEEVIL-CIDE® – GAS BAGS

Unless it can be determined with certainty that the gas bags are spent, they must be deactivated using the Dry Deactivation or Wet Deactivation methods as described below prior to disposal.

Caution: Wear a NIOSH/MSHA approved full-face gas mask – phosphine canister combination (if exposed to levels between 0.3 ppm and 15 ppm) or a Self Contained Breathing Apparatus (SCBA) (if exposure is unknown or above 15 ppm) during wet deactivation of partially spent material. Do not cover the container being used for wet deactivation. Do not dispose of WEEVIL-CIDE® dust in a toilet.

Residual dust from WEEVIL-CIDE® Gas Bags may be deactivated using the "Wet Method."

1. Deactivating solution is prepared by adding the appropriate amount of low sudsing detergent or surface-active agent to water in a drum or other suitable container. A 2% solution (or 4 cups in 30 gallons) of detergent is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. Submerge intact gas bags for 36 hours. A metal grid works well to keep gas bags submerged. This should be done in the open air and not in the fumigated structure. Do not cover the container being used for wet deactivation. Use no less than 1 gallon of water/detergent solution for 60 gas bags. Wear appropriate respiratory protection during wet deactivation of partially spent gas bags.
3. Dispose of the deactivated dust-water suspension, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, the slurry may be poured out onto the ground. If the slurry has been held for 36 hours or more, it may be poured into a storm sewer.
4. Collect spent gas bags and dispose of them in a sanitary landfill, approved pesticide incinerator or other approved sites or by other procedures approved by federal, state and local authorities.

Residual dust from WEEVIL-CIDE® Gas Bags may be deactivated using the "Dry Method."

Extension of the fumigation period is the simplest method for further deactivation of "green" or partially spent dust in Gas Bags prior to ultimate disposal.

1. Collect gas bags and place them into a secure, ventilated holding container. Store the gas bags until they are spent. Caution: Transport these bags in open vehicles. Do not pile up the bags. Do not store "green dust" in bags. Ignition can occur if large numbers of incompletely reacted gas bags are contacted by liquid water. This can occur in open or perforated storage containers. Storage should be out of doors in a relatively isolated area, protected from rain.
2. Collect spent gas bags and dispose of them in a sanitary landfill, approved pesticide incinerator or other approved sites or by other procedures approved by federal, state and local authorities.

SECTION 25

SPILL AND LEAK PROCEDURES

25.1 GENERAL PRECAUTIONS AND DIRECTIONS

A spill, other than incidental to application or normal handling, may produce high levels of gas and, therefore, attending personnel must wear SCBA or its equivalent when the concentration of hydrogen phosphide gas is unknown. Other NIOSH/MSA approved respiratory protection may be worn if the concentration is known. Do not use water at any time to clean up a spill of WEEVIL-CIDE® product. Water in contact with unreacted WEEVIL-CIDE® product will greatly accelerate the production of hydrogen phosphide gas which could result in a toxic and/or fire hazard. Wear gloves of cotton or other material when handling aluminum phosphide.

Return all intact aluminum flasks to cardboard case or other suitable packaging which has been properly marked according to DOT regulations. Notify consignee and shipper of damaged cases.

If aluminum flasks have been punctured or damaged so as to leak, the container may be temporarily repaired with aluminum tape or the WEEVIL-CIDE® product may be transferred from the damaged flask to a sound metal container which should be sealed and properly labeled as aluminum phosphide. Transport the damaged containers to an area suitable for pesticide storage for inspection. Further instructions and recommendations may be obtained, if required, from UPI or from your distributor.

Never place tablets, pellets, or dust in a closed container such as a dumpster, sealed drum, plastic bag, etc., as flammable concentrations and a flash of phosphine gas are likely to develop.

If a spill has occurred which is only a few minutes old, collect the tablets and pellets and place them back into the original flasks, if they are intact, and stopper tightly. Place the collected tablets and pellets in a sound metal container if the original flasks are damaged. **Caution:** These flasks may flash upon opening at some later time.

If the age of the spill is unknown or if the Tablets, Pellets or Gas Bags have been contaminated with soil, debris, water, etc., gather up the spillage and place it into small open buckets having a capacity no larger than about 1 gallon. Do not add more than about one flask of spilled material, 1 to 1.5 kg (2 to 3 lbs.), to the bucket. If on-site, wet deactivation is not feasible, these open containers should be transported in open vehicles to a suitable area. Wet deactivation may then be carried out as described in Sections 24.4 and 24.5 of this Manual. Alternatively, small amounts of spillage from 4 to 5 flasks (4 to 8 kg, 9 to 18 lbs.) may be spread out in an open area away from inhabited buildings to be deactivated by atmospheric moisture.

25.2 DIRECTIONS FOR DEACTIVATION BY WET METHOD

Caution: Wear a NIOSH/MSHA approved full-face gas mask – phosphine canister combination (if exposed to levels between 0.3 ppm and 15 ppm) or a Self Contained Breathing Apparatus (SCBA) (if exposure is unknown or above 15 ppm) during wet deactivation of partially spent material. Do not cover the container being used for wet deactivation. Do not dispose of WEEVIL-CIDE® dust in a toilet.

If the contaminated material is not to be held until completely reacted by exposure to atmospheric moisture, deactivate the Tablets and Pellets by the "Wet Method" as follows:

1. Deactivating solution is prepared by adding low sudsing detergent or surface-active agent to water in a drum or other suitable container. A 2% solution or 4 cups in 30 gallons is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. The Tablets or Pellets should be poured slowly into the deactivating solution and stirred so as to thoroughly wet all of the WEEVIL-CIDE®. This should be done in the open air. Do not cover the container being used for wet deactivation. WEEVIL-CIDE® Tablets or Pellets should be mixed into no less than about 15 gallons of water-detergent solution for each case of material. Wear appropriate respiratory protection during wet deactivation.
3. Allow the mixture to stand, with occasional stirring, for about 36 hours. The resultant slurry will then be safe for disposal. Dispose of the slurry of deactivated material, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, this slurry may be poured into a storm sewer or out onto the ground.

The following procedure is used to deactivate Gas Bags using the "Wet Method.":

1. Deactivating solution is prepared by adding the appropriate amount of low sudsing detergent or surface-active agent to water in a drum or other suitable container. A 2% solution (or 4 cups in 30 gallons) of detergent is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. Submerge intact gas bags for 36 hours. A metal grid works well to keep gas bags submerged. This should be done in the open air and not in the fumigated structure. Do not cover the container being used for wet deactivation. Use no less than 1 gallon of water/detergent solution for 60 gas bags. Wear appropriate respiratory protection during wet deactivation of partially spent gas bags.
3. Dispose of the deactivated dust-water suspension, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, the slurry may be poured out onto the ground. If the slurry has been held for 36 hours or more, it may be poured into a storm sewer.
4. Collect spent gas bags and dispose of them in a sanitary landfill, approved pesticide incinerator or other approved sites or by other procedures approved by federal, state and local authorities.

FOR CHEMICAL EMERGENCY, SPILL,
LEAK, FIRE, EXPOSURE OR ACCIDENT
CALL CHEMTREC 1-800-424-9300

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READ BEFORE USING PRODUCT

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Category 10: Mosquito Pest Control

IF YOU WISH TO APPLY PESTICIDES TO PUBLIC PROPERTIES YOU MUST NOW BE A LICENSED GOVERNMENT APPLICATOR.

Mosquito Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe the life cycle of mosquitoes and the best time during their life cycle to institute control.**
- ✓ **Identify the most common species of mosquitoes in Nevada.**
- ✓ **Describe West Nile virus (WNV) and those species of animals it affects.**
- ✓ **Detail precautions to take to reduce the possibility of contracting WNV.**
- ✓ **Describe methods to reduce the mosquito population around homes and other structures.**

Category 10, Mosquito Pest Control

Recent changes in Nevada's legislation limit certified applicators to the following: residential landscapers, homeowners, commercial establishments with their own pest control staff (hotels, casinos, resorts, restaurants, etc.), home owner association (HOA) employees, private golf courses or clubs with their own pest control staff, Nevada mine staff and Tribes.

As of July 1, 2017, pesticide applications at public buildings, public schools, all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator or a licensed pest control company. The new requirements are detailed in the Pesticides and the Law chapter of this manual. Additional information can be found at http://agri.nv.gov/Pest-Control/ .

Category 10, Mosquito Pest Control, involves the management of mosquitoes to reduce infestations and control mosquito-transmitted diseases in humans and other animals.

Mosquitoes undergo complete metamorphosis: egg to larva to pupa to adult.

Mosquito larvae are called "wrigglers."

Mosquito pupae are called "tumblers."

Controlling mosquitoes is most effective in the early life stages.

Category 10, Mosquito Pest Control, involves the management of mosquitoes to reduce infestations and control mosquito-transmitted diseases in humans and other animals. Mosquitoes are flies, members of the order Diptera. They are pests to humans and other animals. They act as vectors of several diseases, including malaria, filariasis, yellow fever, dengue fever, West Nile virus, St. Louis encephalitis, Western equine encephalitis, Eastern equine encephalitis and dog heartworm. In addition to being the vector of many diseases, they are annoying and can reduce property values.

Mosquito Life Cycle

Mosquitoes undergo complete metamorphosis. The female lays eggs on or near water. Eggs of mosquitoes may be laid singly on water or in mud, in rafts on the water surface, or attached to aquatic plants. The incubation period varies between species and is detailed later in the individual species discussion. In general, the incubation period lasts 16 to 24 hours. The eggs hatch and the mosquito larvae are aquatic, living in water and breathing by surfacing or via a breathing tube or siphon. The larvae, also called wrigglers, do not depend on the oxygen in the water. Large numbers of larvae can survive in a small amount of water, even stagnant water. The larvae feed on algae and other organic material in the water. Controlling mosquitoes is most effective in the early life stages.

Mosquito larvae go through four instars or molts. After the fourth molt, the larvae pupate. The adult mosquito develops within the pupa case. The pupal stage varies among species and also varies with water temperature, but it is usually between two and four days. The pupae, also called tumblers, are comma-shaped and breathe through a pair of siphon tubes located on the sides of the thorax. The pupae do not feed but do remain active and will avoid predators by tumbling through the water, similar to larvae.

Because they are active feeders and their development is sensitive to water chemistry, larvae are easy to control using biological or chemical methods. Because pupae do not feed, control at this stage is limited to disrupting the surface tension of the water where pupae raise to the surface to breath. This is generally less effective than controlling larval populations.

The adult mosquito emerges and rests on the water surface until its skin hardens and its wings dry. At this point it is able to fly and will disperse. Male and female mosquitoes may feed on the nectar of flowers after emerging from the water surface, depending on the species. Females typically require a blood meal as a protein source before they are able to develop eggs.

The length of the metamorphosis cycle and the overwintering life stage varies from species to species. *Aedes* species generally overwinter as eggs on the soil surface. *Anopheles, Culex* and *Culiseta* species typically overwinter as adults. During the active season, generation times can vary from five days to several weeks depending on both the species and average daily temperatures.

Species of Mosquitoes in Nevada

There are 37 species of mosquitoes in Nevada. The most important species are:

- *Aedes dorsalis:* a major pest mosquito often produced through flood irrigation; feeds anytime but mainly during the day and early evening; females live up to three months; over-winters as eggs.
- *Aedes melanimon:* another major pest mosquito; six to seven day larval period during warm days; also associated with irrigated pastures and fields.
- *Aedes nigromaculis:* daytime biter; will not enter houses; can vector encephalitis; very tolerant to alkaline water; five day larval period.
- *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.
- *Aedes vexans*: day and evening biter; does not enter houses; found in swamps, stream overflows and borrow pits. Occasionally breeds in open pastures.
- *Anopheles freeborni*: main vector of malaria; night biter; enters houses; found in permanent open water.
- *Culex pipiens quinquefasciatus* (the southern house mosquito): southern Nevada species; birds are principle hosts, but does attack humans and readily invades homes; breeds in artificial pools and ponds, catch basins, waste treatment ponds, and roadside ditches.
- *Culex pipiens pipiens* is ecologically very similar to the southern house mosquito but occurs in northern regions.
- *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.
- *Culiseta inomata*: primarily feeds on cattle; they are large; survive well in cool weather; found in duck clubs, pastures and ditches.

There are 37 species of mosquitoes found in Nevada.

Malaria remains the world's most prolific and devastating mosquito-borne disease, infecting as many as 274 million people each year.

Mosquito Control History

Malaria remains the world's most prolific and devastating mosquito-borne disease, infecting as many as 274 million people annually. During the 1800s, malaria was introduced into much of North America by settlers who spread across the continent. Today, the disease in North America is limited to sporadic, contained introductions that result from people traveling to regions where malaria is indigenous. The first active mosquito control efforts in the United States began early in the 20th century and by 1921, malaria was virtually eliminated. Before the advent of chemical controls, mosquito-contaminated water sources were often drained and eliminated. This is referred to as source reduction. The use of predatory fish as biological controls was also common before the advent of chemical controls.

By 1945, chemical controls became widely available. Among them was DDT, which was used to control a wide variety of insect pests in addition to mosquitoes. Evidence of resistance to DDT and other hydrocarbon-based chemicals became apparent by 1954. From 1954 to 1964, mosquito control relied on organophosphate products, but by 1964, resistance to organophosphates began to develop. In 1979, there were 270 cases of imported malaria in North America and increases in malaria worldwide. This resulted from mosquito resistance to "older" pesticides, first to the chlorinated hydrocarbons, then to the organophosphorus compounds, and finally, cross-resistance developed. Resistance does not occur overnight. This problem has been widespread among types of mosquitoes, including populations of *Aedes nigromaculis, Culex tarsalis* and *C. pipiens quinquefasciatus*.

Today, source reduction has again become an invaluable tool for controlling mosquito populations as the costs of chemical controls are increasing along with greater public environmental awareness. Effective mosquito control should use a diverse array of tools, including source reduction, surveillance and responsible, effective chemical controls when necessary.

The primary goal of mosquito control is the elimination or treatment of the water source or breeding area.

Mosquito Control

The primary goal of mosquito control is the elimination or treatment of the water source where larvae develop. First, determine the primary species. Next, sources must be determined, mapped and monitored regularly. This should first be attempted through the use of cultural controls (source reduction) or biological controls. Cultural controls may include draining, filling, flushing and lining swamps, ponds and ditches. In general, source reduction should eliminate the water source or alter the habitat by improving water flow and making the habitat less conducive to mosquito development. Biological controls include *Gambusia affinis* (mosquito fish) and some biological insecticides, such as *Bacillus thuringiensis* var. *israelensis* (Bti) or *Bacillus sphaericus*.

Mosquito fish have been used very successfully in a wide variety of sources, from large ponds to small urban water features. When relocating mosquito fish, you must use locally adapted stock and notify the Nevada Department of Wildlife before moving the fish.

Bacillus thuringiensis var. *israelensis* (Bti) and *Bacillus sphaericus* are bacterial biological control products. They 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 to control 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.

Chemical controls that target adult mosquitoes are called adulticides. Adulticides are usually applied as fogs, sprays, and as sprays from ULV (Ultra-Low Volume) sprayers.

Chemical controls that target mosquito larvae are called larvicides. Larvicides can be applied as liquids, granules or pellets. The granular and pellet formulations are best for areas with thick vegetation cover. The granules readily settle through vegetation, whereas liquids will not.

Pesticide formulations change often. Consult your local dealer for the latest pesticide formulations that will control the particular species of mosquito on the specific site. Given the history of pesticide resistance developing in mosquitoes, alternating chemicals throughout the season is always advisable.

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 to other birds, animals and people. West Nile virus (WNV) 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.

Chemical controls that target adult mosquitoes are called "adulticides."

Chemical controls that target mosquito larvae are called "larvacides."

West Nile virus (WNV) infection is a mosquito-borne virus closely related to St. Louis encephalitis virus.

WNV is passed by mosquitoes from infected birds to other birds, animals and humans.

West Nile virus is not spread by person-to-person contact.

There is no human vaccine for WNV, nor is there one for dogs or cats. There is a vaccine for horses.

There are no recommendations to limit outdoor activity, but there are precautions people can take in areas where WNV is a problem.

Common symptoms of mild infections include 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 10 days.

There is no human vaccine or treatment for the WNV infection. Most people fully recover from the viral infection, but 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 information.

Unexplained bird deaths may indicate the presence of West Nile virus. If dead birds of a susceptible species, such as crows or jays, are found, contact the county health department. The bird must have died within 24 hours. 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 it 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 zip-top 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 outdoor activity when mosquitoes are most active in the evening.
- When outdoors, wear mosquito repellant.
- Repellants containing 20 to 30 percent DEET for adults and no more than 10 percent for children are effective. Do not use repellant containing DEET on children under three. Non-DEET based products have also become widely available and effective.
- Spray repellant on the 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 mosquitoes.
- Clean clogged roof gutters on an annual basis. Roof gutters are easily overlooked and can be ideal mosquito breeding sources.
- 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.

Endangered Species

If you are conducting pest control activities in eastern Clark County, be aware that there are several endangered species in this county. There may be restrictions on the chemicals that can be used and where they can be sprayed. This information can be obtained from the pesticide label.

Conclusion

For more information go to the following websites:

- American Mosquito Control Association: http://www.mosquito.org/
- Centers for Disease Control and Prevention (CDC): https://www.cdc.gov
- Nevada Department of Agriculture, Division of Animal Industry: http://agri.nv.gov/Animals/Animal_Home/
- Nevada Department of Health and Human Services, http://dhhs.nv.gov
- Southern Nevada Health District: http://www.southernnevadahealthdistrict.org/
- Washoe District Health Department: http://www.co.washoe.nv.us/health

Originally published in 1987 as Category 10, Mosquito Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. .
Updated in 2013 by M. Hefner and S. Donaldson, University of Nevada Cooperative Extension,
Will Lumpkin, Washoe County District Health Department and
J. Carpenter, Nevada Department of Agriculture.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and
B. Allen and C. Moses, Nevada Department of Agriculture.

Reducing mosquito populations around homes or other structures requires eliminating breeding sites, usually water sources.

If you are conducting pest control activities in eastern Clark County, be aware that there are several endangered species in this county. There may be restrictions on the chemicals that can be used and where they can be sprayed.

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Category 11: Nursery and Greenhouse Pest Control

Nursery and Greenhouse Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **List the sites covered under the Worker Protection Standard (WPS).**
- ✓ **List routes of exposure for pesticides.**
- ✓ **Explain where information about Personal Protective Equipment (PPE) is found.**
- ✓ **List Signal Words and their toxicity levels.**
- ✓ **Describe common diseases in the nursery or greenhouse setting.**
- ✓ **Describe typical plant symptoms of insect pests in a nursery or greenhouse setting.**
- ✓ **Detail weed control methods for the nursery or greenhouse setting.**

Category 11, Nursery and Greenhouse Pest Control

Category 11, Nursery and Greenhouse Pest Control, addresses pests, pest control and safe use of pesticides in nurseries or greenhouses. 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 diseases, insects, weeds and vertebrate pests. Disinfectants used to sterilize plant containers, working surfaces and equipment are also considered pesticides. Plant growth regulators are used to keep potted flowering plants compact and are also considered pesticides.

Pesticides come in many forms: liquids, granules, powders or gases. Some are 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

Category 11, Nursery and Greenhouse Pest Control, addresses pests, pest control and the safe use of pesticides in nurseries or greenhouses.

The Worker Protection Standard (WPS) applies to workers on farms, forests, nurseries and greenhouses.

For further information on the WPS, consult the U.S. EPA web publication "How To Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Employers Need To Know" at http://pesticideresources.org/wps/htc/htcmanual.pdf

and attractive. Since your job makes it necessary for you to occasionally work around pesticides and 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.

Worker Protection Standard

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use pesticides or (2) employ workers or pesticide handlers who are exposed to pesticides. If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide the following to your employees and, in some cases, to yourself and to others:

Information about exposure to pesticides: To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training for workers and pesticide handlers.
- A pesticide safety poster be displayed for workers and pesticide handlers.
- Access to pesticide labeling information for pesticide handlers and early-entry workers.
- Access to centrally-located information detailing pesticide applications that have occurred on the establishment.

Protection against exposures to pesticides: To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying a pesticide in a way that will expose workers or other persons to pesticides.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI, including providing special instructions related to the correct use of personal protective equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.

- Protect handlers during handling tasks, including monitoring while handling highly toxic pesticides and providing special instructions related to the correct use of PPE.

Mitigation of pesticide exposures: To mitigate pesticide exposures that employees receive, the WPS requires that:

- Decontamination supplies are available to all workers. Employers must provide pesticide handlers and workers with an ample supply of water, soap and towels for routine washing and emergency decontamination.
- Emergency assistance information is available to all workers. Employers must provide transportation to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and must provide information about the pesticide(s) to which the person may have been exposed.

In 2015 the EPA revised the WPS; the new regulations became effective January 1, 2018. These most recent changes are outlined below:

- Mandatory annual training to inform employees about the required protections, including instructions on reducing take-home exposure from pesticide work clothing.
- Requirement that only certified applicators or an individual that completes an EPA-approved "train the trainer" program are authorized to conduct the mandatory training.
- Anyone under 18 years of age is prohibited from being a pesticide handler or doing early-entry work during a REI.
- Expanded mandatory posting of no-entry signs for outdoor production if the REI is greater than 48 hours.
- New application exclusion zones of up to 100 feet surrounding pesticide application equipment.
- If the label requires a respirator, the employer must provide a medical evaluation, fit testing and respirator training in compliance with the Occupational Health and Safety Administration (OSHA) respiratory protection standard.
- If the label requires protective eyewear, the employer must provide water for emergency eye washing at pesticide mixing/loading sites.
- Mandatory record-keeping to improve states' ability to follow up on pesticide violations and enforce compliance.
- Anti-retaliation provisions comparable to the U.S. Department of Labor's.

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.

NDA has a list of pesticides not illegal to use on marijuana or medical marijuana at http://agri.nv.gov/ Plant/ Environmental_ Services/Pesticide _Use_on_ Medical_Marijuana/

Routes of Exposure:

- **Dermal (skin and eyes)**
- **Oral (by mouth)**
- **Inhalation (through the lungs)**

Nevada Revised Statutes (NRS) Chapter 586: Pesticides used on Marijuana and Medical Marijuana

The legalization of marijuana in Nevada has caused some confusion regarding pesticides that can be used for pests control on this crop. Because marijuana is not legal federally, no pesticides are labelled for use on marijuana. In response to this, the Nevada legislature enacted Nevada Revised Statutes (NRS) 586, which mandates the following:

A marijuana establishment or medical Marijuana establishment may use a pesticide in the cultivation and production of marijuana, edible marijuana products, marijuana products and marijuana-infused products if the pesticide:

- Is exempt from registration (25b) product or is allowed to be used on Crop Group 19, hops or unspecified crops or plants
- Has a label that allows the pesticide to be used at the intended site of application
- Has a label that allows the pesticide to be used on crops or plants intended for human consumption.
- The Nevada Department of Agriculture (NDA) will establish and publish a list of pesticides not illegal to use on marijuana or medical marijuana. NDA will accept requests from pesticide manufacturers and marijuana establishments to add pesticides to the list. This list is updated periodically and can be found at http://agri.nv.gov/Plant/Environmental_Services/Pesticide_Use_on_Medical_Marijuana/

Keeping Safe Around Pesticides

Nursery and greenhouse employees often have a great deal of direct contact with the plants. When a pesticide is applied in the nursery or greenhouse, label instructions require that workers stay out of the treated area for a period of time. This time period is called the "Restricted Entry Interval" or REI. When it is not safe to enter a treated area, there may be a warning sign telling employees 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. Follow safety procedures and report your exposure to your supervisor.

Individuals exposed to pesticides may experience a variety of symptoms, including headache, skin rash, blurred vision, nausea and dizziness. Severity of symptoms depends on many factors, including the amount and toxicity of pesticide to which they were exposed. The amount of time that the individual was exposed is also a factor.

Routes of pesticide entry: There are three major ways that a pesticide can enter the body:

Through the skin or	Skin absorption is the most common route of poisoning from pesticides. Absorption will continue as long as the skin remains in contact with the pesticide.
Through the mouth (oral)	Most severe poisonings usually result when pesticides are taken through the mouth. Oral exposure most often occurs when pesticides are taken out of their original containers and stored in food containers.
Through the lungs (respiratory or inhalation)	Powders, airborne droplets or gases may be inhaled in sufficient amounts to cause damage to nose, throat and lung tissues. Gases produced by fumigants pose the greatest risk.

Pesticide labels and SDS (Safety Data Sheets, formerly MSDS (Materials Safety Data Sheets)) include a section on first aid. Specific first aid instructions are listed for each route of pesticide exposure. Have the product container or label with you when calling the poison control center or the doctor, and when going in for treatment.

The most common route of pesticide exposure for greenhouse and nursery workers is through their skin. 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. Any opening in the skin, such as a cut, is especially vulnerable to absorbing pesticides.

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. This is called the Restricted Entry Interval or REI. 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 dusts 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 water line unless you know it has not been used for applying pesticides.

Greenhouse and nursery workers are most commonly exposed to pesticides through their skin.

Avoid low level, ongoing exposure to pesticides by washing your hands after handling treated plants, equipment or surfaces, and 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 again until they are laundered.

Signal Words:

CAUTION: least toxic

WARNING: moderately toxic

DANGER: very toxic

DANGER – POISON: extremely toxic

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 a pesticide, even a very small exposure may cause an allergic reaction. Some of the least toxic materials are responsible for many pesticide-related injuries. For example, the commonly used herbicide glyphosate (Roundup®) 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. 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. Always wash before you eat, drink, smoke, apply make-up or use the restroom. Always change your clothes at the end of every working day. Do not wear those clothes again until they are laundered. Launder pesticide-contaminated clothing separate from other clothing.

Sometimes new evidence may show that a pesticide previously thought to be safe can cause serious long-term health effects. Do not be careless, and never encourage your employees or fellow workers to be careless, when working around any pesticide.

Handling 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 or co-worker – to explain it to you. **Always read the pesticide label yourself.** Don't use the product until you have read and understand the whole pesticide label.

Signal Words

All pesticide labels have a signal word that describes immediate (acute) toxicity. Signal words help alert users to the risks of a pesticide product.

Signal Word	Level of Acute Toxicity
Caution	The pesticide is **slightly toxic** if eaten, absorbed through the skin or inhaled, or it causes **slight** eye irritation.
Warning	The pesticide is **moderately toxic** if eaten, absorbed through the skin or inhaled, or it causes **moderate** eye irritation.
Danger	The pesticide is **highly toxic** through **at least one route** of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.
Danger-Poison (with skull and crossbones)	The pesticide is **highly toxic** through **more than one route** of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.

Personal Protective Equipment

The pesticide label tells you the type of Personal Protective Equipment (PPE) you must wear. It also tells 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 document and you must comply with label instructions.

Most pesticides require the use of chemical-resistant gloves. The required minimum amount of protection includes a long-sleeved shirt, long pants, eye protection, boots and socks.

If you are applying pesticides overhead, for instance, in 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 properly fitted respirator when the label indicates the need for respiratory protection. Protect your eyes with goggles, safety glasses or a face mask. Regular glasses or sunglasses are never considered adequate for the purposes of protecting your eyes.

Applying Pesticides in the Nursery

When applying pesticides in the nursery, applicators must read and follow label directions. This ensures that the pesticides are applied in a safe and effective manner. 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 a retail nursery, pesticide

Personal Protective Equipment, or PPE, is specified on the label. The required PPE for mixing the pesticide may differ from the required PPE for applying the pesticide, so always read the label carefully.

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.

Try to mix only as much pesticide solution as you will need for the application. Dispose of any excess according to the label directions.

Application of pesticides in a greenhouse requires some special considerations. See the adjacent list on this page.

applications should take place during non-business hours when there is less potential for a customer to be exposed to the pesticide. Curious customers may wander into the application area. Never sell plants that have 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 important 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 can contaminate adjacent areas, workers, customers and the environment. Do not allow pesticides to drift onto ponds, lakes, creeks and/or rivers.

Leftover pesticides should never be dumped on the ground, as they could easily end up in ground or surface water, creating a danger for people, pets, livestock and wildlife. Try to mix only as much pesticide solution as you need for the application. Dispose of any excess according to label directions.

Special Considerations for Greenhouse Applications

When you apply pesticides:

- Follow all label directions.
- Follow all requirements of the Worker Protection Standard.
- Before you start, consider the conditions in the greenhouse. Wait until later if you need to apply a pesticide to the leaves of plants that are wet from recent watering, as 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 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 in such a way that 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 may be 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, but 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 must turn off the greenhouse ventilation, 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 a 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. This is often necessary in a hot greenhouse to provide air circulation and cooling, and prevent heat stress.

Fumigants require the greatest number of precautions during their use

When a pesticide is applied as a fumigant, workers and other persons are prohibited in the entire greenhouse plus any adjacent structure that cannot be sealed off from the treated area until ventilation criteria are met. Ventilation criteria for fumigant use in greenhouses can be found in the EPA manual “How to Comply With the 2015 Revised Worker Protection Standard (WPS) for Agricultural Pesticides,” http://pesticideresources.org/wps/htc/htcmanual.pdf.

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 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 pesticide handlers who are equipped

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.

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 (PPE).

Pest exclusion, or preventing pests from becoming established, is the most important step in avoiding pest problems.

with the required personal protective equipment (PPE). This includes those handlers who 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

Poor plant health and plant damage can often be attributed to living plant pests. However, many plant problems are often caused by non-living (abiotic) factors. The following sections discuss plant pests (biotic) and abiotic causes of plant damage in nurseries and greenhouses.

Living organisms that cause damage include:

- Disease-causing organisms
    - Fungi
    - Bacteria
    - Viruses
    - Nematodes
- Arthropods: Typical damage is caused by feeding or spreading disease-causing organisms.
    - Insects
    - Mites
- Vertebrate pests: Damage in nurseries may be caused by feeding, chewing, burrowing and fecal contamination.
    - Voles
    - Gophers
    - Ground squirrels
    - Mice
    - Birds (pigeons, starlings, sparrows)

The Importance of Preventing Pest Problems

Pest exclusion, or preventing pests from becoming established, is the most important step in avoiding pest problems. Never accept infested stock from suppliers. Isolate or destroy plants that become infested. Install greenhouse screening and plastic drapes over entrances to keep 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 detected, the pest and the associated plants must be correctly identified. Contact University of Nevada Cooperative Extension professionals, professionals from the Nevada Department of Agriculture, or other nursery and greenhouse professionals for assistance. Consult books, trade publications and fact sheets for help in identifying pests.

After identifying the cause, determine 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 (Non-living) Factors:

Many non-living factors cause plant problems and most of these problems 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!

Common Abiotic Factors That Can Damage Plants

- Frost/freeze damage
- Water quality: pH, salinity and toxic element concentrations
- Under-watering
- Over-watering (contributes to root disease)
- Low soil aeration
- Poor drainage (contributes to root disease)
- Wind damage
- Improper maintenance

Abiotic problems are those caused by non-living factors.

Pesticides will not "cure" damage caused by abiotic factors!

In Nevada, fungi and bacteria cause most infectious diseases.

To avoid establishment of leaf spot diseases, prevent conditions that encourage extended periods of wet leaves.

- Limited root volume: "j" roots, circling roots, girdling roots
- Soil compaction
- Hail damage
- High/low temperatures in air or soil
- Over-fertilization
- Nutrient deficiency
- Chemical injury
- High/low soil pH

Diseases

In Nevada, fungi and bacteria cause most infectious diseases. Viruses and nematodes also cause diseases. Some disease organisms attack and invade healthy plants. The majority, however, only invade stressed plants.

Diagnosing the causal agent is often difficult and may require culturing the organism in a laboratory. Check to see which diseases commonly affect the 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 for 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. Prune out infected portions of trees and shrubs. Do not leave infected pruned materials, plants or soil in a greenhouse or nursery. Dispose of them immediately. When using pesticides, rotate products to decrease the chances of developing resistance.

Typical disease symptoms include:

Leaf Spots: Leaf spots are localized infections of leaves. Most are caused 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, such as those that produce tar spot, produce spots that are uniformly dark. Others develop as circular areas with dark margins. Fungi produce tiny fruiting structures. Many are dark and visible with a hand 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 and may 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 at 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.

Rusts are fungal diseases that form yellow to reddish spore masses on plant surfaces.

Canker: Cankers are localized dead areas on twigs, branches and trunks. 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, while others are perennial. Some are capable of attacking healthy plants, while others attack only plants under stress.

Cankers caused by disease organisms appear as sunken areas on branches and trunks.

The key to controlling canker diseases is to prevent them from becoming established. Select plants that are well-adapted to the proposed planting site. 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 6 to 8 inches below any sign of the infection. Disinfect pruning equipment between cuts and between plants. Common canker diseases include 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

The above-ground symptoms of root rot 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.

Viruses are readily transmitted by knives or pruning tools.

Powdery mildew is a common disease in Nevada. This fungal disease has a wide host range.

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. A laboratory analysis is needed to identify a specific root rot pathogen.

Root rots can be avoided by using soil mixes that drain well. Avoid overwatering which causes soggy soils. Reduce 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.

Viral Diseases: Viral 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 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 viruses, such as tobacco mosaic virus, to healthy plants. Viruses are readily transmitted by knives or pruning tools. Because there is generally no cure for viral diseases, the plants must be destroyed. Tomato spotted wilt (TomSWV), tomato mosaic (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 viral diseases is the best control strategy.

Other Diseases: Other diseases include blights, scabs, powdery mildew, smuts, galls and storage rots (commonly found on stored bulbs, corms, 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 themselves 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 (brownish spots) 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 fungal diseases, the spores do not need free water to germinate. Powdery mildew overwinters on evergreens 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 Managing 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 plant varieties.
- Select plants that are well-adapted to Nevada's climate.
- Avoid injuring plants.
- Practice good sanitation.
- Control weeds.

Become familiar with the common diseases of nursery and greenhouse plants. Inspect plants often and act quickly to eliminate diseased plants.

Insects and Other Arthropods

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 in close quarters. Abiotic stresses or other injuries make plants more susceptible to insect attack.

Effective insect pest control measures require correct identification and a thorough understanding of the pest's lifecycle and biology.

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 causal insect. However, the insects you find 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. It is important to become familiar with insect pests commonly found on plants in the nursery and greenhouse. Effective control measures require correct

Collecting pests for identification.

Eric Coombs, Oregon Dept. of Agriculture, Bugwood.org

identification and a thorough understanding of the pest's life cycle and biology.

Typical Symptoms of Insect and Arthropod Attacks

Leaf Spots: Leaf spots are most frequently caused by plant pathogens. Sucking insects, such as leafhoppers, may also cause leaf spots. 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 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, borers 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 insect damage makes the leaves look like lacy skeletons. Elm leaf beetle and pear slugs are two examples of leaf skeletonizers. Most caterpillars 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 or scale insects can also 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 that are 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, such as chrysanthemums and cineraria, and on landscape trees, such as birch, alder and poplar.

Leaf miner damage

Whitney Cranshaw, CSU, Bugwood.org

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 galls 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. Injury by these pests often provides a route for disease to enter and infect the plant.

Many natural enemies for greenhouse pests are available commercially.

Biological control using natural enemies in greenhouses is widely practiced throughout the world.

Controlling Insects in the Nursery and Greenhouse

Predators, parasites and pathogens keep insect pests under control naturally. Ladybird beetles, lacewings, predatory 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 life stages of 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 sufficient control of insect pests. 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 or beneficial insects. Whenever possible, use the least toxic pesticide available, such as horticultural spray oils, microbial insecticides (Bt) or insecticidal soaps.

Even though an insecticide has been applied, the application may not be effective. Below are reasons why insecticide applications may not result in adequate 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 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. The product you use must be labeled for use in nurseries and/or greenhouses.

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 target organisms and carrying insecticides into sensitive areas that should not be treated. It's usually best to apply insecticides when temperatures are above 50°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.

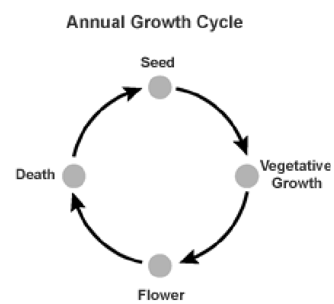
Control weeds while they are small and immature, before they go to seed or develop extensive root systems. If allowed to produce seeds, more weeds will grow next season. Weed seeds can survive for years in the soil. Some seeds require light in order to germinate and grow. Disturbing the soil can bring 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. Whitson, Editor, which provides an identification key and detailed color photos of hundreds of weeds found in Nevada.

Annual weeds sprout, grow, produce seed 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 fall or late winter following rainfall. They grow rapidly and go to seed in spring. Summer annual weeds germinate in spring when soil temperatures rise and produce seed from summer into late fall, depending upon the species. Destroy annual weeds to avoid competition and seed production. Common annual weeds include cheatgrass, 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 during winter. Biennials typically form a short leafy rosette of leaves the first season, store



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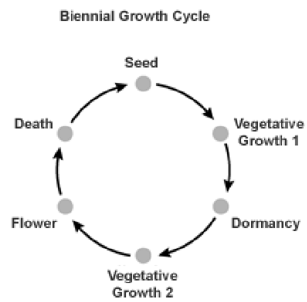

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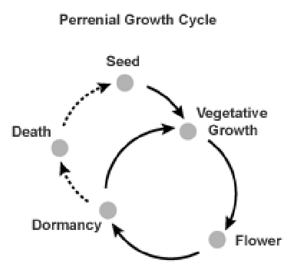

OSU Extension Service

Organic and inorganic mulches help control weeds. They prevent light from reaching weed seeds or seedlings.

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.

<u>Perennial</u> 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 parts, is removed or unless new growth is removed frequently and repeatedly until all root reserves are used up. Cultivation often spreads underground parts that sprout and spread the weed colony. Canada thistle, tall whitetop, bindweed (morningglory) and quackgrass are perennial weeds.

Weed Control Methods

There are five basic methods used for weed control: prevention or exclusion, cultural, mechanical, biological, and chemical.

<u>Prevention or exclusion</u> control methods are those that prevent weeds from becoming established. Don't accept plant material or other items that are infested with weeds or weed seeds or roots. One of the most useful methods in the nursery and greenhouse setting for controlling weeds is the use of 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. However, weeds can grow between rocks.
- 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 four to six inches from trunks to ensure good air circulation and reduce the potential for crown diseases.
- Woven plastic landscape fabrics can be used as weed barriers 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 breakdown 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.

Cultural Control: Cultural controls for weeds include the strategies and methods we use to grow and maintain healthy plants. Cultural practices, such as proper fertilizer application, appropriate watering, soil management, rotating plantings and good sanitation, will help reduce the incidence of weeds and other pests.

Mechanical Control: Physical removal or incorporation of weeds reduces weed competition and improves appearance. The main disadvantage is the amount of time, effort and money it takes if weeds are well-established and numerous. Weeding on a regular schedule will help reduce the amount of effort needed.

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. If the soil is hard and dry, postpone weed pulling until the day after an irrigation cycle or rain has occurred. 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 kept sharp. Hold the blade parallel to the soil and cut weeds right at the soil line, disturbing the soil as little as possible. This avoids bringing buried weed seeds to the soil surface, where they may sprout. 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 in hard, dry soils.

Most annual weeds 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 from underground plant parts and are best controlled by other (non-mechanical) means.

Weed hoes, mowers and tractor-pulled or driver cultivators effectively bury, cut, disk or incorporate weeds. Again, for effective control, cultivate weed-infested areas when the weeds are small. Do not cultivate if the weeds are

Weeds are much easier to control while they are small seedlings before their roots become fully established.

At present, there are no methods for using biological control of <u>weeds</u> in nursery and greenhouse production

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.

perennials that will produce new plants from the cut parts of the original plant, as plants will regrow from root fragments.

<u>Biological Control</u>: Biocontrol of weeds is most successful in sites such as rangeland or pasture land, rather than nurseries and greenhouses. Numerous weed-feeding insect species have been introduced into the United States to control specific weed species. To be effective, there must be a large enough weed population to allow insects to feed, reproduce and spread. Recent work with plant pathogens has demonstrated some potential for weed control. For example, a newly discovered variety of the fungus *Verticillium dahliae* attacks seedlings of velvetleaf, a common Midwest weed.

<u>Chemical Control</u>: The effectiveness of herbicides is 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 to damage 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 on clay soils. Groundwater contamination has occurred when soil-applied herbicides are used on sandy soils.

The age or growth cycle of a plant can affect 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 an herbicide for an application or site that is not included on the label.**

Types of Herbicides

Herbicides are classified into types based upon their use and mode of action.

<u>Preemergence herbicides</u> are often referred to as "weed preventers". They kill germinating weed seeds or seedling weeds. Most have little effect on established plants, but some can damage existing plants. They often 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. Preemergence weed killers are applied prior to the appearance of weeds or after established weeds are killed or removed.

Most preemergence 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 preemergence herbicide is also disturbed and weed seeds can germinate and grow. The length of control provided by different preemergence herbicide varies from a few weeks to several months or even years.

Preemergence weed killers are most often 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.

Preemergence "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.

Longer-lasting preemergence herbicides are often called soil sterilants. These 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). Soil sterilants should never be applied to areas where you plan to plant in the future. Because they last so long, there is greater risk that these products will contaminate water supplies. Although they are useful for weed control in 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.

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 systemic. Contact herbicides kill only those plant parts with which they make contact. Systemic

Never use or recommend a herbicide for an application or site that is not included on the label.

Soil sterilants should never be applied to areas where you plan to plant in the future.

Contact herbicides kill only those plant parts with which they make contact.

Systemic herbicides are absorbed by roots, stems or leaves and are moved throughout the plant.

Selective herbicides are designed to kill only certain plants.

Non-selective herbicides are toxic to all susceptible plants.

Because it is very difficult to remove all herbicide residues from sprayers, even with repeated rinsing, use one sprayer only for applying herbicides and a separate sprayer for other pesticides.

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. Systemic herbicides provide control of perennial weeds because the chemical moves into and kills plant roots.

Selective herbicides are designed to kill only certain plants, leaving others undamaged. For example, some products may only be effective on broadleaf weeds, while others may only kill grasses. 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 sensitive desirable vegetation, or applying it before plant root systems have become established.

Non-selective herbicides are toxic to all susceptible 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 them in an established landscape, special application methods or equipment, such as wipers, can be used. Desirable plants can also be covered to prevent the herbicide from contacting them. Diquat and glyphosate (Roundup®) are examples of non-selective herbicides.

Because it is very difficult to remove all herbicide residues from sprayers, even with repeated rinsing, use one sprayer only for applying herbicides and another, separate sprayer for all other pesticides.

Making Weed Control Decisions

- Identify the weeds or types of weeds present.
- Identify all plants in the treatment area.
- 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.
- If an herbicide is selected, READ THE ENTIRE LABEL and follow all label instructions and precautions.
- Follow all safety procedures when handling the pesticide. Apply on a calm, cool day to prevent drift and volatilization from injuring non-target plants.
- Make sure you have the necessary application equipment to apply the herbicide correctly and that the equipment is in good condition.

Vertebrate Pests

Vertebrate pests can occasionally be a problem in the greenhouse or nursery setting. Refer to the General Knowledge: General Pest Problems chapter of this manual for information on controlling specific vertebrate pests.

Conclusion

Category 11, Nursery and Greenhouse Pest Control, involves both the management of pesticides and controlling pests in nurseries and greenhouses. The Worker Protection Standard (WPS) applies to nurseries and greenhouses. Pest control in nurseries and greenhouses is complicated by the density of plantings, the presence of work personnel and the possible presence of customers or other members of the public. Consider these additional factors when planning pest control programs in these areas.

Originally published in 1987 as Category 11, Nursery and Greenhouse Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

READ THE ENTIRE PESTICIDE LABEL and follow all label instructions and precautions.

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Category 12: Wood Preservatives

Wood Preservatives Learning Objectives

After studying this section, you should be able to:

- ✓ **List common wood-destroying fungi.**
- ✓ **Describe common wood-destroying insect pests.**
- ✓ **Describe control methods for common wood-destroying diseases and pests.**
- ✓ **Explain methods for applying wood preservatives.**
- ✓ **Describe the safety measures to use during the application of wood preservatives.**

Category 12 Wood Preservatives

Category 12, Wood Preservatives, involves the management and preservation of items and structures constructed of wood. Almost everywhere that wood is used today, it's made to last longer through the use of chemical preservatives. Preservatives protect wood in telephone poles and signs, wood bridges, piers and pilings, railroad ties, and fences, walls and buildings.

Category 12, Wood Preservatives, involves the management and preservation of items and structures constructed of wood.

The wood preservative industry extends from the chemical plants where chemical preservatives are manufactured to the shops and millworks where they are applied. Every day, 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. There are many 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.

Wood can be damaged or destroyed by fungi, insect pests and marine borers.

These pests cause damage by using wood as both a food source and a shelter.

Fungi require favorable temperatures of 50 F to 90 F and a moisture content of about 30 percent.

Brown rot fungi are probably the most important cause of decay of softwood species used in above-ground construction in the United States.

Pests That Damage Wood

Under proper use conditions, wood can give many years 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 many 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.

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 and 90 degrees F
- Adequate moisture: 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 required by the fungus.

Wood decay fungi can be grouped into three major groups:

- Brown Rot Fungi: This type of fungus breaks down the cellulose component of wood for food, leaving a brown residue of lignin. Affected wood can be greatly weakened, even before the 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. The term dry rot is misleading, as wood must have high moisture content for fungi to cause decay. The final stage of wood decay caused by brown rot fungi can be identified by:
  - the dark brown color of the wood
    - excessive shrinkage
    - cross-grain cracking
    - the ease with which the dry wood rotted areas can be crushed to powder
- White Rot Fungi: This fungus breaks down both lignin and cellulose and has a bleaching effect that may make the damaged wood appear whiter than normal.
- Soft Rot Fungi: This fungus usually attacks green (water-saturated)

wood, causing a gradual softening from the surface inward that resembles brown rot.

- Other wood-inhabiting fungi:
    - 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.
    - 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.

Insects: Insects pests that destroy wood fall into three basic groups: termites, carpenter ants and beetles.

Termites use wood for food and shelter and are the most destructive of all wood insects.

- Subterranean Termites: These pests 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. Evidence of the presence of subterranean termites may be noted by:
    - The swarming of winged forms and discarded wings observed after swarming.
    - Earthen shelter tubes built over masonry or other foundations to a source of wood.
    - The presence of white workers when termite shelter tubes are broken open.
    - The hollowed-out condition of badly infested wood products.
- 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.

Wood destroying insects fall into three groups:

- **Termites**
- **Carpenter ants**
- **Beetles**

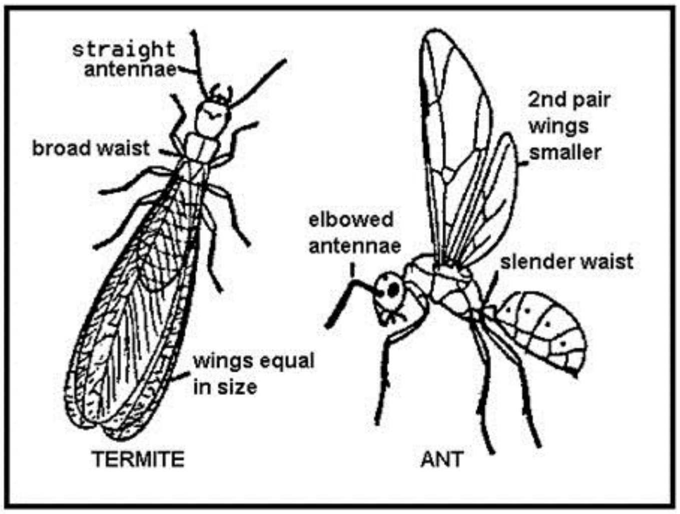
Termites use wood for food and shelter and are the most destructive of all wood insects.

Carpenter ants use wood for shelter, not for food.

Powder post beetles attack both freshly cut and seasoned wood.

- <u>Dampwood Termites</u>: These pests are a serious problem along the Pacific Coast and do not require contact with soil, but they do require wood with high moisture content.

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.



How to tell winged ants from termites. U Ark Extension

General physical differences between ants and termites:

- Ants have elbowed antennae; termites do not.
- Ants have a "wasp" or narrow waist, where termites are broad.
- Ants' wings have few veins and their hind wings are different in shape and size. Termite wings have many veins and the front and hind wings are similar in size and shape.

Beetles are another common wood-damaging insect that can cause serious damage.

- <u>Powder Post or Lyctus Beetles</u> attack both freshly cut and seasoned hardwoods and softwoods. Adults lay eggs in the wood pores. 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.

- Anobiid Beetles attack softwoods in damp and poorly ventilated spaces beneath buildings.
- 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.
- 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.

Marine Borers cause extensive damage to submerged portions of marine pilings, wharf timbers and wooden boats. They include:

- Shipworm
- Pholad mollusks
- 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 controlling moisture content, using a wood that is naturally resistant to the pests, and chemical treatment.

Moisture Control: The moisture content of living trees and the wood products obtained from them is often very high, and moisture must be removed to:

- Reduce oxygen content and temperatures necessary for growth of fungi.
- Reduce damage by insects.
- Reduce shrinkage.
- Reduce weight and increase strength.
- Prepare wood for chemical preservative treatment.

Use of Naturally Resistant Wood: The sapwood of all native tree species and the heartwood of most species have natural resistance to decay. The heartwood of cedar, junipers, redwood, locusts and post oak are resistant to,

Roundhead borers damage seasoned wood in buildings.

Controlling the moisture content of wood will help control wood damaging pest problems.

but not immune to, attack by decay fungi and insects.

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.

Types of Wood Preservatives fall into three broad categories: creosote and creosote solutions, oil-borne preservatives and waterborne preservatives (inorganic arsenicals).

- Creosote and Creosote Solutions are an oily byproduct of making coke from bituminous coal. It is used for railroad ties, large timbers, fence posts, poles and pilings.
  - Advantages:
    - toxic to wood-destroying fungi, insects and some marine borers
    - low volatility
    - ease of handling and applying
  - Disadvantages:
    - yields a dark colored, oily, unpaintable surface
    - has a strong odor
    - tends to bleed from wood surfaces
    - cannot be used in houses and other living areas due to toxic fumes
- Oilborne Preservatives: tributyltin, copper and zinc napthenate are generally insoluble in water and are dissolved in petroleum or other organic solvents. They are used commercially to treat poles, lumber, cross arms, timbers and fence posts. This group also includes pentachlorophenol.
  - Advantages:
    - toxic to fungi, insects
    - can be dissolved in oils with a wide range of viscosities, vapor pressures and colors
    - low solubility
    - can be glued
    - easy to use and handle
  - 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

Chemical wood preservatives fall into three main categories:

- **Creosote**
- **Oilborne**
- **Waterborne**

fumes
        - toxic and irritating to plants, animals and humans
- Waterborne Preservatives: Borates are primarily used for lumber, plywood, fence posts, poles, pilings and timbers.
    - 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
    - Disadvantages:
        - unless wood is re-dried after treatment, it is subject to warping
        - does not protect from weathering
- Alternative Preservatives (to address health effects):
    - Collectively, all of the Ammoniacal Copper Quat (ACQ) products are sometimes referred to as alkaline copper quaternary preservatives.
        - Ammoniacal Copper Quat (ACQ, Types A, B and C): Wood treated using this water-based preservative is paintable.
        - Amine Copper Quat (ACQ-D) – Similar active ingredients to ACQ-type A but uses ethanolamine instead of ammonia to act as the treating solution carrier.
    - Copper Boron Azole-Type A (CBA-A) – Another new-generation wood preservative that contains copper and boric acid. The wood is greenish-brown and has little or no odor.
    - Borate Oxide (SBX).–.A class of wood preservatives that contain non-toxic 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 in constant water contact.

An overview of wood preservative chemicals can be found at https://www.epa.gov/ingredients-used-pesticide-products/overview-wood-preservative-chemicals. Help in selecting treated wood is available at American Wood Protection Association, http://www.awpa.com/.

Alternative wood preservatives include:

- **Alkaline copper quat**
- **Copper azole**
- **Borate oxide**

Methods of Applying Wood Preservatives

Methods of applying wood preservatives fall into two broad categories:

- **Pressure processes**
- **Non-pressure processes**

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. There are basically two pressure treatment processes:

- Full-Cell
- Empty-Cell

Non-Pressure Processes:

- Brushing, spraying and pouring treatments
- Creosote: Oil-borne or water-borne salts are applied to the surfaces of the wood product to be treated.
- Dipping: Immersing wood in a preservative solution for several seconds to minutes.
- Cold Soaking: Soaking dried wood for two to seven days in a vat containing an unheated liquid oil preservative.
- Steeping: Submerging wood into a tank full of an inorganic, arsenical salt at atmospheric temperature for several days or weeks.
- 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 immersion into a tank of cold solution.

Wood preservatives are considered pesticides and are subject to the same rules and regulations as all other pesticides.

Like all pesticides, users of wood preservatives must read, understand and follow all label instructions for mixing, applying, storing and disposing of wood preservatives.

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:

- Creosote
- Pentachlorophenol
- Inorganic Arsenicals: EPA approved labels on pesticide products, including wood preservatives, are the primary source of information on regulations affecting the worker. On March 17, 2003, residential uses of chromated copper arsenate (CCA)-treated wood were voluntarily cancelled. Alternatives include using wood that has been pressure-treated with ammoniacal copper quat (ACQ) or copper boron azole (CBA), or using cedar, redwood, metal or plastic materials.

The wood preservative label covers:

- application methods
- precautions for workers
- emergency first aid for high-level exposure
- 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 who are responsible should be familiar with the label's contents. Other sources of information include the material safety data sheets (MSDS) that are supplied by the manufacturer.

Handlers of wood preservatives should know:

- The health risks in working with these chemicals and the symptoms of overexposure.
- Basic safety, personal hygiene and personal protection requirements to minimize or eliminate exposure risks.
- Environmental concerns and best management practices, including proper waste disposal.
- What to do when accidents do happen, including emergency first aid and emergency spill response.

Health Effects

Basic to understanding health risks is knowing routes of exposure. Wood preservatives can enter the body in one of three ways:

- through the skin
- by breathing it into the lungs
- by swallowing it

Nearly every inch of your body is covered and protected by skin. But, the skin is like a sponge and absorbs surprising amounts of what it touches. When the skin is sweaty, it absorbs even more.

The 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, and anything in the air 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. However, when ingested, less than a cup can cause death.

The most likely routes of exposure are from:

- skin contact
- inhalation of vapors, dust or particles

Exposure occurs 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.

- headaches

The eyes are especially vulnerable to damage from contact with chemical preservatives. Injury to the eyes often may be permanent.

The most likely routes of exposure are through the skin or by inhalation (through the lungs).

All three types of chemical wood preservatives produce the following exposure symptoms:

- Headache
- Nausea
- Increased perspiration

In addition to the shared symptoms, each preservative also has specific symptoms. These are listed on the page to the right.

- nausea
- increased perspiration

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, called chronic symptoms, emerge only after a prolonged time or repeated exposure. Chronic exposure can also aggravate existing health problems related to the skin, kidneys, liver or lungs. Being aware 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.

- **Creosote: Use had been phased out**, but existing treated materials are still in use.
  - Acute Symptoms: Irritates the skin, may burn like a sunburn. Vapors and fumes may irritate the respiratory system.
  - 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.
- **Pentachlorophenol (Penta)**
  - 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.
  - 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.
- **Inorganic Arsenicals: These have been phased out**.
  - Acute Symptoms: If swallowed, high concentrations may cause nausea, headaches, diarrhea and abdominal pain. Extreme symptoms include dizziness, muscle spasms, delirium and convulsions.
  - 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.

Personal Protection

Wood preservatives are classified "restricted-use" based on the potential human risk from chronic (repeated) exposure over time. Applicators as a group are most likely to be exposed repeatedly. Consequently, applicators must 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:

- during mixing and handling of chemicals
- while working around spray or dip operations
- when handling freshly treated wood
- when cleaning and servicing equipment
- when disposing of waste materials

Risks are directly related to the degree of exposure. Most risks occur during application of the chemical and then as it volatilizes, or evaporates, soon after the treatment occurs. A closed system for mixing and delivering preservative and mechanically handling treated wood helps to reduce potential exposure, but does not eliminate the possibility of exposure.

Exposure can be reduced by:

- wearing proper protective clothing
- practicing effective personal hygiene
- observing plant safety precautions

Protective Clothing Blocks Routes of Entry: Unprotected skin can absorb chemicals whenever you come in contact with chemical concentrates or solutions, mists, fumes, vapors or treated wood itself. The skin on certain parts of the body, such as the forearm, the groin and just below the eyes, absorbs chemicals more easily.

Shirts and pants must completely cover the arms and legs. Coveralls are 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. Some situations may require aprons, boots or even a full impermeable material suit. Hot weather can make this type of clothing uncomfortable to wear. But remember, the

Wood preservatives have been classified "restricted-use" based on the potential human risk from chronic exposure (repeated exposure over time.)

Risks are directly related to the degree of exposure.

Exposure can be reduced by:

- **Wearing proper protective clothing**
- **Practicing effective personal hygiene**
- **Observing safety precautions**

Goggles or face masks are needed to protect the eyes from vapors, splashes and spills during handling, maintenance and clean-out of chemicals.

To protect the lungs, a face mask, dust mask or respirator may be needed.

The wood preservative product label lists protective clothing and Personal Protective Equipment (PPE) required for use.

DO NOT WEAR LESS PROTECTIVE CLOTHING THAN THE LABEL INDICATES.

hotter the weather, the more your skin will absorb, so wear PPE!

Permeable materials, such as leather, will not adequately protect your skin. Impermeable clothing materials considered suitable for use with Creosote, Penta, and Inorganic Arsenicals include:

- Neoprene
- Polyvinyl Chloride (PVC)
- Polyvinyl Acetate (PVA)
- Nitrile compounds (NBR)

Goggles or face masks are needed to protect the eyes from vapors, splashes and spills during handling, maintenance and clean-out of chemicals. To protect the lungs, a face mask, dust mask or 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:

- opening or entering pressure treatment cylinders
- cleaning or repairing tanks and vats
- using spray applicators, especially in poorly ventilated areas or when visible mist is present
- working in an arsenic treatment plant, if the level of exposure exceeds permissible limits

Make 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 wood preservative product label lists protective clothing. **DO NOT WEAR LESS PROTECTIVE CLOTHING 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:

- **Don't eat, drink or smoke** in the work area.
- **Wash your hands often**, especially before using the restroom, eating or smoking. Use only a mild soap, not an abrasive one.

- **Remove your gloves to handle paperwork, phones or other equipment**.
- **Be careful when putting your gloves back on.**
- **Leave your work clothes, boots, gloves and other protective gear at the plant.**
- **If you must launder work clothes at home**, do them separately from other household laundry.

Wearing protective clothing and following the general precautions listed above helps decrease your risk of harmful chemical contact, both from accidental and day-to-day exposures.

First 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 the nearest poison control center that is prepared to give advice 24 hours per day. Program the number into your cell phone.

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:

- <u>Skin contact</u>: Remove contaminated clothing and immediately wash affected area with mild soap and cool water. Hot water opens pores and allows deeper chemical penetration. Do not scrub skin, but rinse until there is no “soapy” feeling left. Consult physician if skin irritation persists.
- <u>Eye contact</u>: Flush eyes with running water. Lift upper and lower eyelids for complete irrigation and continue for 15 to 20 minutes. Then, see a physician.
- <u>Inhalation</u>: Move victim to fresh air and apply artificial respiration, if necessary. Get medical help immediately.
- <u>Ingestion</u>: If preservative has been swallowed, immediately call the local poison control center for advice.
  - If the victim is conscious and creosote or pentachlorophenol was swallowed, have the victim 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.
  - 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.

First aid information on the chemical in use must be readily available.

Product labels give basic first aid directions, as do Safety Data Sheets (SDS, formerly MSDS) supplied by the chemical manufacturers.

Know and post the phone number of the nearest poison control center that is prepared to give advice 24 hours per day.

<u>Never attempt to give anything by mouth to an unconscious person.</u>

<u>Never induce vomiting in an unconscious person.</u>

Wood preservatives are not selective pesticides. They can harm other animal and plant life.

To reduce the risk of environmental contamination, make protective measures part of your plant design and operation.

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, a characteristic that allows them 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. Pollution has resulted from obvious sources, such as spills or illegal discharges of chemicals into ditches, storm drains or sewers, as well as from less obvious sources, such as unconfined drippings from freshly treated wood. Contaminated runoff can pollute lakes, streams and wetlands, and may damage habitat for fish and wildlife. Specific effects vary, but penta, creosote, and inorganic arsenicals are all <u>toxic</u> 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 from view, 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 can all result in 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 risk of environmental contamination, protective measures must be part of your plant design and operation. Some general common sense precautions include:

- Apply or mix preservatives only in a contained area.
- Allow freshly-treated wood to drip in a roofed and contained enclosure for a reasonable time.
- Recapture contaminated runoff for future recycling or disposal.
- Don't burn treated wood except in an approved incineration facility, as toxic gases may be produced.
- 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 community. Spills are usually caused by negligent actions, such as overfilling tanks or incorrect valve settings, but spills also occur as a result of vandalism or from illegal dumping to avoid the proper disposal.

Response to any spill must be **immediate**. Prompt action can save cleanup time, money, possible legal action and even life. Although most businesses have emergency response procedures, some general steps for effective spill response are:

- Protect life and property. Warn others in the vicinity and evacuate, if necessary. Provide protective equipment to onsite personnel. Keep unauthorized people out of the area.
- 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 mechanical delivery systems can prevent jam-ups and possible injury.
- Contain the spill. Block off drains, culverts and ditches. Surround the spilled chemical with dirt, sand, booms or commercial absorbents.
- 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.
- Clean-up the spill.
- Properly dispose of spill material and all spill clean-up materials.

Response to any spill must be immediate:

- **Protect life and property.**
- **Secure the source of the spill.**
- **Contain the spill.**
- **Contact the authorities immediately.**
- **Clean up the spill**
- **Properly dispose of spill material.**

Conclusion

Preserving wood and wood products from damage by insects or fungi often requires the use of toxic preservatives. In November 1986, use of 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. Follow the information in this chapter carefully to avoid harm to yourself, others or the environment. Specifically:

- Know the symptoms of wood preservative poisoning.

- Observe precautions and use protective clothing to keep chemicals:
    - Off your skin and hair.
    - Out of your eyes.
    - Out of the air you breathe.
- Learn basic first aid.
- Protect the environment.
- Dispose of waste properly.
- Know your spill response procedure, so you can act quickly in an emergency.

The wood preservative section was developed in 1986 by Mediatek, Inc., for the Environmental Protection Agency as a training aid for individuals seeking certification for the use of wood preservatives. This section was updated in 2013.

Originally published in 1987 as Category 12, Wood Preservatives, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson. Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

Category 13: M-44 Predatory Pest Control

NOW ONLY AVAILABLE TO LICENSED GOVERNMENT APPLICATORS AND LIMITED TO EMPLOYEES OF THE USDA WILDLIFE SERVICE

M-44 Predatory Pest Control Learning Objectives

After studying this section, you should be able to:

- ✓ **Describe M-44 predator control device use and restrictions.**
- ✓ **Detail predatory pest control for specific canid pests.**

Category 13 M-44 Predatory Pest Control

Category 13, M-44 Predatory Pest Control, involves the control of predatory pests. Certification in this category is limited to USDA Wildlife Service employees. In 2017, changes were made to Nevada's legislation. As of July 1, 2017, pesticide applications on all Federal (BLM, USFS, etc.), State, County, City or other municipality properties, including County or State owned golf courses and City, County or State Parks, must be made by a Licensed Government Applicator. See Pesticides and the Law chapter in this manual for more information or go to http://agri.nv.gov/Pest-Control/ .The category is no longer available to certified applicators, but the material will remain as a study guide for those who wish to become a licensed government applicator.

Category 13, Predatory Pest Control, involves the control of predatory pests. Certification in this category is limited to USDA Wildlife Service Employees and as of July 2017, will require those individuals to become a Licensed Government Applicator.

The M-44 device is a spring-activated device that delivers a dose of cyanide powder to targeted animals. It uses a cyanide capsule that has been registered as a pesticide with the U.S. EPA. This product is classified as a restricted use pesticide. The device can only be used by trained, certified applicators who are employed by the USDA APHIS Wildlife Services Agency.

The M-44 device consists of four components: a capsule holder wrapped with cloth, wool or other soft material; a cyanide capsule (a small plastic

Each Applicator of the M-44 device shall be trained in:

- **Safe handling of the capsule and device.**
- **Proper use of the antidote kit.**
- **Proper placement of the device.**
- **Necessary recordkeeping.**

container holding sodium cyanide); a spring-activated ejector; and a 5- to 7-inch stake. In the field, the stake is inserted into the soil with the top flush with the ground's surface. With the ejector cocked and set, the capsule is inserted into the holder and screwed onto the ejector. The ejector is secured to the stake. A specially formulated fetid (foul-smelling) bait or other scent material is smeared on the wrapped capsule holder. The bait elicits a "bite and pull" response by the target animal. The M-44 device is triggered when a canid (i.e. coyote or wild dog) tugs on the baited capsule holder, releasing the plunger and ejecting sodium cyanide powder into the animal's mouth. The sodium cyanide quickly reacts with moisture in the animal's mouth, releasing hydrogen cyanide gas. Unconsciousness is quickly followed by death, normally within 1 to 5 minutes after the device is triggered.

M-44 Predatory Pest Control Device Use and Restrictions

I. PURPOSE	To establish guidelines for the use of the M-44 device by Wildlife Service 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 Wildlife Service use only.
III. REFERENCE	The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended.
	M-44 Cyanide Capsules
	M-44 Use Restrictions
	EPA Registration No. 56228-15

Use-Restrictions

In addition to the main product label instructions and directions, EPA mandates 26 use-restrictions, which provide guidance for the application, storage, disposal and training requirements, safety, and necessary recordkeeping. Individual State pesticide regulatory agencies also can require additional restrictions on the use of M-44s in their jurisdiction.

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.

The M-44 device shall only be used to take wild canids.

One person other than the individual applicator shall have knowledge of the exact placement location of all M-44 devices in the field.

The M-44 shall NOT be placed:

- **Within 200 feet of any lake, stream or water body.**
- **Where food crops are planted.**
- **Within 50 feet of a public road or pathway.**

Supervisors of applicators shall check the records, warning signs and M-44 devices of each applicator at least once a year.

Each M-44 device installed in the field shall be inspected at least once a week.

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 10; 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 hole 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

Bilingual warning signs in English and Spanish shall be used in all areas containing M-44 devices.

Each M-44 authorized applicator shall carry an antidote kit when placing or inspecting devices.

Each M-44 authorized applicator shall keep records of the placement of each device and the results of each placement.

Predator Pest Control, Specific Pests

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

Coyotes are the most common predator in Nevada. The M-44 device and trapping are the only controls in Nevada.

No chemical control of mountain lions is registered in Nevada.

Skunks are a serious problem for bee keepers in Nevada. They can also transmit rabies.

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 10 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 (see previous section). The product is registered for use 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 exist when mountain lions remains in the wild, as they are of little danger to man. A mountain lion is a trophy animal and permits from Nevada Department of Wildlife must be obtained prior to harvest.

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 for bee keepers. They also transmit rabies, a generally fatal illness. Skunks normally have one litter per year, but occasionally there is a second litter. Litters usually consist of five to eight kittens.

Skunks can be 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.

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 pelts. A trapping license must be obtained to trap bobcats. Contact the Nevada Fish and Wildlife Department for more information.

Feral dogs: Most feral dogs are descendants of domestic dogs that have gone wild. Their appearance can often be similar to that of many common dog breeds. Feral dogs feed on many things, including carrion and garbage.

They can be efficient predators that prey on small and large animals. A 1974 study found that impacts by feral dogs were primarily to wildlife, and the second most serious damage was to livestock.

Feral dog management may include exclusion, trapping with subsequent euthanization, and shooting (outside of congested areas). The long-term solution to feral dog problems is responsible pet ownership and effective local dog management programs.

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 also be used.

Foxes: Foxes do very little damage, although they will sometimes eat young lambs and chickens.

Weasels: Not common in Nevada, weasels are predators of all kind of fowl. They may be shot or trapped.

NOTE: Most predators are beneficial to some extent, and 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: Rabies is an acute encephalomyelitis (inflammation of the brain) that is caused by the rabies virus. Rabies 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.

Conclusion

Category 13, M-44 Predatory Pest Control, involves the control of predatory pests. Certification in this category is limited to USDA Wildlife Service employees only and as of July 2018 requires those individuals to become a Licensed Government Applicator.

Originally published in 1987 as Category 13, M-44 Predatory Pest Control, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.

Feral dogs cause 70 percent of the predation to farm flocks in Nevada.

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.

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Category 14: Chemigation

Chemigation Learning Objectives

After studying this section, you should be able to:

- ✓ **Explain the Worker Protection Standard (WPS) and how it relates to chemigation.**
- ✓ **Describe three things that may happen if chemigation safety hardware is not installed properly.**
- ✓ **List chemigation safety hardware and its location in the chemigation system.**
- ✓ **Describe the purpose of chemigation hardware.**
- ✓ **List the advantages and disadvantages of chemigation pesticide applications.**

Category 14 Chemigation

Chemigation is the process of applying agricultural fertilizers and pesticides through flood, drip, sprinkler and other types of irrigation systems. This category describes the safe and efficient application of pesticides through sprinkler irrigation systems and focuses on protecting water resources from pesticide contamination related to chemigation. In this chapter, the term “chemigation” will be used for the application of pesticides through irrigation water. For information on calibrating your chemigation equipment, see “Calibration of Chemigation Equipment” under the “General Knowledge: Guidelines for the Safe Use of Pesticides” section of this manual.

Category 14, Chemigation, includes the application of any chemical through irrigation water. This includes insecticides, herbicides, fumigants, nematcides, fertilizers, soil amendments and other compounds.

Advantages of pesticide chemigation: Chemigation offers several distinct advantages in comparison to conventional application methods.

- Soil compaction is avoided, as heavy spray equipment never enters the field.

Chemigation may save time (labor) and money by reducing the need for personnel and equipment.

- 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, as vehicles do not have to traverse the field.
- 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.
- Pesticides can be applied quickly before a disease or insect infestation spreads.
- 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.
- Requires less mixing and loading, reducing applicator exposure.

Disadvantages of pesticide chemigation:

- Specific safety precautions, specialized equipment and training are required for chemigation.
- The initial cost of equipment is high, but with long-term use there may be significant savings in labor and other equipment costs.
- Potential for contamination of water sources is higher with chemigation than with other application methods.
- Some pesticides are not approved for application through chemigation systems.

A major drawback of chemigation is the increased potential for contamination of water sources. Because irrigation water, livestock water and domestic water may come from the same source, it is essential that applicators using chemigation comply with specific rules to protect water sources.

Chemigation and Irrigation

Fertilizers have been applied through many types of irrigation systems for many years. With the introduction of center pivots and linear move (wheel line) irrigation systems, the application of various pesticides has become more widespread. 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. They 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.

The use of drip and micro irrigation has boomed in the last few years. This has stimulated a parallel growth in the use of chemigation. An increasingly wide range of fungicides, herbicides and insecticides are injected through drip and micro irrigation systems in the United States.

Worker Protection Standard

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers the use of pesticides in the production of agricultural plants on farms, forests, nurseries and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use pesticides, or (2) employ workers or pesticide handlers who are exposed to pesticides. If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide the items listed below to your employees and, in some cases, to yourself and to others.

Information about exposure to pesticides: To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training for workers and handlers.
- Display of a pesticide safety poster for workers and handlers.
- Access to pesticide labeling information for pesticide handlers and early-entry workers.
- Access to centrally-located information detailing pesticides applications that have occurred on the establishment.

The Worker Protection Standard (WPS) applies to workers on farms, forests, nurseries and greenhouses.

For further information on the WPS, consult the US EPA web publication "How To Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides: What Employers Need to Know" at http://pesticideresources.org/wps/htc/htcmanual.pdf

Protection from exposures to pesticides: To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying pesticides in a way that will expose workers or other persons to them.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI, including providing special instructions related to correct the use of Personal Protective Equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.
- Protect handlers during handling tasks, including monitoring while handling highly toxic pesticides and providing special instructions related to correct use of Personal Protective Equipment (PPE).

Mitigation of pesticide exposures: To mitigate pesticide exposures that employees may receive, the WPS requires that:

- Decontamination supplies are made available to all workers. Employers must provide pesticide handlers and workers an ample supply of water, soap and towels for routine washing and emergency decontamination.
- Emergency assistance information is made available to all workers. Employers must make transportation available to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and must provide information about the pesticide(s) to which the person may have been exposed. Bring the pesticide container to the medical care facility with label intact.

In 2015 the EPA revised the WPS; the new regulations became effective January 1, 2018. These most recent changes are outlined below:

- Mandatory **annual** training to inform employees about the required protections, including instructions on reducing take-home exposure from pesticide work clothing.
- Requirement that only certified applicators or an individual that completes an EPA-approved “train the trainer” program are authorized to conduct the mandatory training.
- Anyone under 18 years of age is prohibited from being a pesticide handler or doing early-entry work during a REI.
- Expanded mandatory posting of no-entry signs for outdoor production if the REI is greater than 48 hours.
- New application exclusion zones of up to 100 feet surrounding pesticide application equipment.

- If the label requires a respirator, the employer must provide a medical evaluation, fit testing and respirator training in compliance with the Occupational Health and Safety Administration (OSHA) respiratory protection standard.
- If the label requires protective eyewear, the employer must provide water for emergency eye washing at pesticide mixing/loading sites.
- Mandatory record-keeping to improve states' ability to follow up on pesticide violations and enforce compliance.
- Anti-retaliation provisions comparable to the U.S. Department of Labor's.

If it is necessary for you to meet the requirements of the WPS, you will need to obtain a copy of the "How to Comply With the 2015 Revised Worker Protection Standard for Agricultural Pesticides" at http://pesticideresources.org/wps/htc/htcmanual.pdf

Protecting Water Resources

Protecting the environment is an essential requirement of all pesticide applications, and chemigation is no different. Water and pesticides are applied through sprinkler systems for most chemigation applications in Nevada. Groundwater is the most frequently used water source in many locations. Water used for chemigation is pumped from a groundwater well and applied directly through a sprinkler system. Groundwater may also be pumped into a ditch or canal and then pumped out of the ditch into a sprinkler system.

Surface water sources, such as rivers or streams, may be diverted into irrigation ditches where water can be pumped into a sprinkler system. All water sources must be protected, regardless of the origin.

After pesticides are applied, they are eventually broken down by sunlight, chemical or microbial activity. If pesticides reach the groundwater, they will be broken down very slowly due to low temperatures, absence of sunlight and lack of microbial activity.

Some pesticide labels do not allow for application by chemigation. For products that do allow application by chemigation, specific instructions will be listed on the label. Many of the instructions are related to backflow hardware that must be installed in the chemigation system. To protect water resources, applicators must read and carefully follow all chemigation requirements on pesticide labels.

Chemigation Safety Hardware

Chemigation requires that two separate hardware systems be joined together: the chemical injection system and the irrigation system. Properly functioning anti-pollution devices must be correctly installed in both systems to effectively prevent groundwater contamination.

The following sketch shows a chemigation layout that includes the United States Environmental Protection Agency's (EPA) required safety devices.

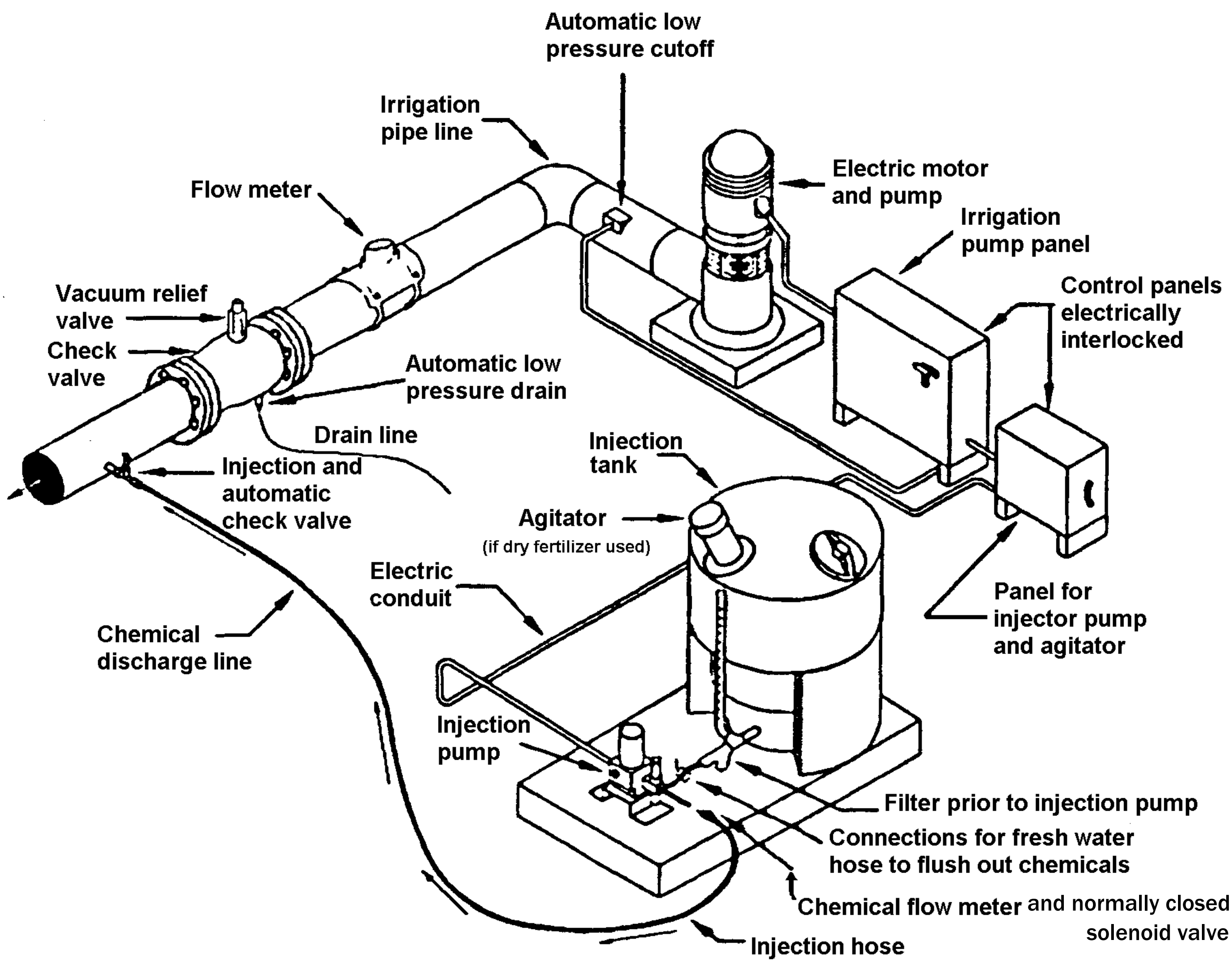

Table 14.1 Description of required safety devices

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. A one-way valve with a 10 psi spring that closes when not under pressure	Prevents water from flowing backwards into the chemical tank, causing the tank to overflow
Vacuum relief valve	Between the check valve and the well	Prevents a 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

**These devices may be replaced with an alternative device listed in Table 14-2.*

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

Each pesticide label must state that the pesticide product can be chemigated. Applicators must adhere to the instructions provided on the pesticide container labels.

The devices listed in table 14.1 are intended to protect water sources from pesticide contamination. They are listed on labels of pesticides that are approved for chemigation and must be installed on systems that are used to chemigate those products.

The U.S. EPA has approved a list of alternative chemigation safety equipment that can be used in the place of specific equipment as required by pesticide labeling (Table 14.2). Any chemigation equipment that is required on pesticide product labeling but has no listed alternative(s) is still required as a component of the chemigation system.

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 or approved alternate devices in Table 14.2), any of the following scenarios may occur:

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.

Description of Chemigation Safety Devices

<u>Check Valves and Vacuum Relief Valves</u>: Check and vacuum relief valves (anti-siphon devices) are required on the irrigation pipeline. They keep water and/or pesticide and water from backflowing or siphoning back into the irrigation water source should the irrigation pump shut down. Both of these valves must 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 the 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. The 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 manufacturers 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, which 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 used for monitoring check valve performance. This device should be placed on the bottom side of the irrigation pipeline. In the event that the main line 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, between the irrigation pump and the main line check valve. In some cases placement of the valve may be more feasible downstream of the main line 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. 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 prevents the pesticide from being pumped 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 engine pulley. Other possibilities include operating the injection pump from 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 shutoff 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.

Chemigation safety devices must ensure that if the irrigation pump stops, the pesticide injection also stops.

Inspect hoses regularly for leaks and cracks.

Flush hoses and injection equipment with clear water at the end of every chemical injection.

Construct tanks of poly or fiberglass, *not* mild steel. Mild steel has a greater potential for erosion.

Pesticide Labels

Labels for pesticides that are chemigated 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.

Appropriate Materials for Hardware

<u>Hoses</u>: 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.
- Stable under UV radiation. It does not deteriorate after prolonged exposure to sunlight.
- Chemically compatible with pesticides.
- Available in thicknesses that work under suction without collapsing.

Inspect hoses regularly for leaks and cracks. Flush hoses and injection equipment at the end of every injection with clear water. When hoses and chemigation equipment are not in use, cover them with a tarp or similar material.

<u>Fittings</u>: When injecting pesticides into an irrigation system, the material of choice is generally 316 stainless steel, as some pesticides can destroy PVC fittings. To be safe, contact the manufacturers of both the pesticide and the injection equipment to determine compatibility of the pesticide being injected with the equipment being used and the potential for corrodibility or other adverse chemical reaction.

<u>Tanks</u>: **Avoid mild steel tanks!** Construct tanks of poly or fiberglass, as mild steel can corrode. 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.

<u>Containment Structures</u>: If a pesticide could potentially be hazardous in the event of a spill, it is recommended the chemical tank be located within a containment structure. A containment structure may simply be a larger poly tank that essentially acts as a "double-hulled" unit (a 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.

For safety reasons, it is important to maintain a clean chemigation area.

Chemical Safety: Always follow label instructions for safety. It is essential that the manufacturer's guidelines be followed when mixing fertilizers and pesticides together. Many fertilizers and pesticides cannot 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 depends on the individual operator’s skills and preferences as well as initial and maintenance costs.

The following may need to be considered when choosing the way to inject pesticides:

- Differences between injecting liquids, such as flowable (F) products, suspended concentrates (SC), or emulsifiable concentrates (EC) versus injecting non-liquids, such as wettable powder (WP) or soluble powder (SP) pesticides. Liquid pesticides may not need agitation or mixing in the field, whereas non-liquid pesticides require 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 for worker safety.
- Availability of power.
- Portability versus permanent installations.

There are many types of injectors on the market. Some require power and others do not.

Injector types: There are many injectors on the market. Some require power and others do not. Below are examples of different types of injectors that are available. Some injectors are specific to an irrigation method, such as 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 tanks
- Nitrogen gas powered pumps
- Nitrogen pressurized tanks
- Water powered pumps
- Diaphragm and piston 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 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 when used for chemigation:

- Piston pumps are subject to accelerated wear of the piston seals.
- Calibration of piston pumps is relatively time-consuming.

Conclusion

Chemigation is the application of any chemical through irrigation water. This includes insecticides, herbicides, fumigants, nematicides, fertilizers, soil amendments and other compounds. Read, understand and follow all label directions. Make sure the pesticide you choose is labeled for chemigation use.

Originally published in 1987 as Category 14, Chemigation, Nevada Pesticide Applicator's Certification Workbook, SP-87-07, by W. Johnson, J. Knight, C. Moses, J. Carpenter, and R. Wilson.
Updated in 2018 by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.