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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

THIS CHAPTER IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR THE GENERAL EXAM FOR BOTH PRIVATE AND NON-PRIVATE CERTIFIED APPLICATORS.

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 new provisions in NRS Chapter 586.**
- ✓ **Discuss the differences between Authorized Commercial Applicators, Commercial Applicators, Non-Private Certified Applicators and Private Certified Applicators in Nevada.**
- ✓ **Discuss the new NAC 586 requirements for Certified Applicators supervising Non-Certified Applicators.**

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 federal and state laws related to certified applicators.

The 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.

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

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.

FIFRA Section 1: Administration

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

FIFRA Section 2: Definitions:

- Certified Applicator: any individual who is authorized (trained and/or tested for competency in the safe and effective handling and use of pesticides) to use or supervise the use of any pesticides classified for restricted use.
  - Private Applicator: a certified applicator who uses or supervises the use of any restricted-use pesticide for purposes of producing any agricultural commodity on property owned or rented by the applicator or the applicator's employer or, if applied without compensation, on another person's property. (EXAMPLES: farmers, ranchers, nurseries, greenhouse growers, grow facilities, floriculturists, orchardists).
  - Non-Private Applicator: a certified applicator who applies or supervises the application of restricted-used pesticides, except as part of a business of pest control, and does not qualify as a private applicator (EXAMPLES: federal, state, county, city or other municipal employees, school districts, mosquito districts, conservation districts, general improvement districts, churches, airports, HOA employees, private and public golf clubs, hotels/casinos/resorts, restaurants, tribes, mine staff, homeowners)
- "Under the Direct Supervision of a Certified Applicator": 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. The label may require the certified applicator to be physically present during the application; read the label carefully. See the section on requirements for the direct supervision of noncertified applicators by certified applicators at the end of this chapter.
- Person: any individual, partnership, association, corporation, or organized group of persons, whether incorporated or not.
- Pest:
  - 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 humans or other living animals) that is considered a pest.

- Pesticide:
  - 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."
- Label and Labeling:
  - Label: 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 on the label.
  - Use of any equipment or method of application that is not prohibited by the labeling.
  - Mixing 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 (GUP): A pesticide that is less likely to harm humans or the environment when it is used according to label directions. The designation appears immediately below the heading of "Directions for Use".
- Restricted-Use Pesticide (RUP): A pesticide that could cause human injury or environmental damage unless it is applied by competent "certified applicator," which is a person who has shown the ability to use these pesticides safely and effectively. The designation appears in a box on a prominent part of the front panel of the pesticide label.
- Classification of pesticides and their uses by the EPA is based upon "risk

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.

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.

assessment," which includes:
  - potential for poisoning humans
  - type of formulation
  - the way the pesticide is used
  - site of application
  - potential for environmental harm
- 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 (1) acre per pest 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 that it is produced in 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, Reno Extension, conducts training and testing sessions for certification. The Nevada Department of Agriculture provides testing and certification of pesticide applicators.
- Certification requires training and/or testing for competency in the safe and effective handling and use of pesticides. Persons who are not certified pesticide applicators may not use restricted-use pesticides unless they are directly supervised by a certified applicator.

The Nevada Department of Agriculture, in cooperation with the University of Nevada, Reno 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.

FIFRA Section 12: <u>Unlawful Acts</u>

- 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.
  - any pesticide that is "adulterated" or "misbranded" or any device that is misbranded.
- <u>"Adulterated":</u> means 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.
- <u>"Misbranded":</u> 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 human and domestic animal 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 to 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.

Persons who are not certified pesticide applicators may not use Restricted-Use Pesticides unless they are directly supervised by a certified applicator.

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.

FIFRA can issue both Civil and Criminal Penalties for registrants, commercial applicators, wholesalers, dealers, retailers and other distributors who violate any provision of FIFRA

- to add, or take, any substance from any pesticide to defeat the 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 and 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 time period 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 their possession in order to apply the pesticide for that purpose (EXAMPLE: SLN-NV). Registration is only legal in the state or location 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, Reno Extension Pesticide Use & Safety: Transporting Pesticides Safely, https://naes.agnt.unr.edu/PMS/Pubs/2020-3352.pdf.

For more information about The Food Quality Protection Act (FQPA) go to https://www.epa.gov/epcra.

For more information about the FAA, go to https://www.faa.gov

For more information about the EPCCR, go to https://www.epa.gov/epcra

II. Other Laws and Regulations

There are other federal laws that may have impacts on pesticide applications. Below is a short synopsis of several of those laws and a link for more information for the reader.

Food Quality Protection Act of 1996 (FQPA):

EPA regulates pesticides under two major federal statutes: 1) Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), EPA governs the registration, distribution, sale and use of pesticides in the United States; 2) Under the Federal Food, Drug and Cosmetic Act (FFDCA), EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food or feed crops. Tolerances established for meat, poultry, some egg products and other foods are enforced by the Unites States Department Agriculture (USDA). The 1996 FQPA law was 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.

Federal Aviation Administration (FAA)

- 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.

Emergency Planning and the Community Right-to-Know Act (Title III of the Superfund and Reauthorization Act of 1986 (SARA)):

- The Emergency Planning and Community Right-to-Know Act (EPCRA) was passed in 1986 in response to concerns regarding the environmental and safety hazards posed by the storage and handling of toxic chemicals. These concerns were triggered by the 1984 disaster in Bhopal, India, caused by an accidental release of methylisocyanate. The release killed or severely injured more than 2000 people.
- To reduce the likelihood of such a disaster in the United States, Congress imposed requirements for federal, state and local governments, tribes, and industry. These requirements covered emergency planning and "Community Right-to-Know" reporting on hazardous and toxic chemicals. The Community Right-to-Know provisions help increase the public's knowledge and access to information on chemicals at individual facilities,

uses of such chemicals, and their releases into the environment. States and communities, working with facilities, can use the information to improve chemical safety and protect public health and the environment.

- Section 2018 of the America's Water Infrastructure Act, enacted on October 23, 2018, amended the emergency release notification and the hazardous chemical inventory reporting requirements of the Emergency Planning and Community Right-to-Know Act (EPCRA). This new legislation requires state and tribal emergency response commissions to notify the applicable state agency (i.e., the drinking water primacy agency) of any reportable releases and to provide community water systems with hazardous chemical inventory data. These requirements went into effect immediately upon signing the law.

Endangered Species Act (ESA)

- Sets up pesticide restrictions, beginning in 1991, for growers, applicators and dealers and is 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 "Endangered Species Protection Bulletins."
  - 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.
  - Click the "SEARCH" button.
  - 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.

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 "Endangered Species Protection Bulletins."

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.

For more information on OSHA, go to https://www.osha.gov/

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.

An agricultural worker is anyone who is employed doing tasks such as harvesting, weeding, or watering, related to the production of agricultural plants.

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 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.

Worker Protection Program (WPS)

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. A pesticide handler is defined as anyone who is employed by an agricultural establishment to apply, mix, load, or transfer pesticides, handle open containers of pesticide, act as a flagger, or assist in the maintenance of application equipment.

This section provides an overview of who is required to comply with the WPS and a list of compliance requirements.

In general, employers are responsible for WPS compliance. These include:

- Owners/employers on agricultural establishments that grow and harvest for commercial production:
  - Fruits and vegetables on farms.
  - Timber and trees in forests and nurseries.
  - Plants in greenhouses and nurseries.
  - Marijuana grow-rooms/greenhouses
  - Hemp farms
- Employers of researchers who help grow and harvest plants.
- Employers at commercial pesticide handling establishments

Under the WPS, **all employers** are required to do the following:

- Do not retaliate against a worker or handler.
- Provide annual pesticide safety training.
- Provide access to specific information for workers and handlers at a central location during normal work hours, including (agricultural employers only):
  - Pesticide applications on the establishment.
  - Safety Data Sheets for pesticides applied on the establishment.
  - Pesticide safety information that includes emergency information.
- Provide WPS-required safety, pesticide application, and hazard information to workers and handlers or their designated representative, or to treating medical personnel if requested. For additional details, see Chapter 2 of the WPS How to Comply Manual. See full requirements at 40 CFR 170.311(b).
- Provide decontamination supplies.
- Exchange information (between a commercial handler employer and an operator of an agricultural establishment).
- Provide emergency assistance by making transportation available to a medical care facility in case of a pesticide injury or poisoning and provide information to the facility about the pesticide(s) to which the person may have been exposed.

In addition to the duties listed above for all employers, employers of **workers** are required to do the following:

- Implement restrictions during applications by keeping workers and other people out of the treated field and application exclusion zones.
- Implement restricted-entry intervals (REIs).
- Implement protections for early entry by workers, providing:
  - Access to labeling information.
  - Specific information on early entry tasks.
  - Required early entry Personal Protective Equipment.
- Notify workers about applications and pesticide-treated areas and informing them not to enter during the REI by:
  - providing oral warnings or
  - posting warning signs.

In addition to the duties listed above for all employers, employers of **pesticide handlers** are required to do the following:

- Implement restrictions during applications by ensuring that pesticides applied do not contact workers or other people. Handlers must suspend an application if workers or other people are in the application exclusion zone.
- Monitor handlers working with toxic pesticides.

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 Owners and Employers Need to Know" at http://pesticideresources.org/wps/htc/htcmanual.pdf.

A 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.

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

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.

- Provide specific instructions for handlers.
- Provide access to labeling information for handlers.
- Take steps to ensure equipment safety.
- Personal Protective Equipment (PPE):
  - Provide required PPE in clean and good operating condition.
  - Ensure PPE is worn correctly.
  - Provide a clean place for storing personal clothing and removing PPE.
  - Care for, maintain and replace damaged or worn PPE.
  - Replace respirator purifying elements.
  - Dispose of contaminated PPE.
  - Provide instructions for people who clean PPE.
- Provide a medical evaluation, fit test and respirator training to handlers required to wear a respirator by the pesticide label.

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 below.

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 is 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 that of the U.S. Department of Labor.

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

If the label requires protective eyewear, the employer must provide water for emergency eye washing at pesticide mixing/ loading sites.

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.

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

Nevada Revised Statutes (NRS) are laws enacted by the legislature, and Nevada Administrative Code (NAC) are the regulations that outline how laws are administered (detail of the NRS). State laws that pertain to pesticides can be found in Chapters 555 and 586 of the Nevada Revised Statutes (NRS) at https://www.leg.state.nv.us/Division/Legal/LawLibrary/NRS/NRS-555.html and https://www.leg.state.nv.us/Division/Legal/LawLibrary/NRS/NRS-586.html and Chapters 555 and 586 of the Nevada Administrative Code (NAC) at https://www.leg.state.nv.us/Division/Legal/LawLibrary/NAC/NAC-555.html and https://www.leg.state.nv.us/Division/Legal/LawLibrary/NAC/NAC-586.html

The following is an explanation of the Nevada State law, Nevada Revised Statutes (NRS) Chapter 555.

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 humans, animals and crops over wide areas if not applied properly.

B) Licenses and certificates issued fall into two 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 no 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 thereunder.
2) The Department of Agriculture may assess monetary penalties for any violation of the provisions outlined in NRS 555 or the regulation made thereunder.

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

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.

- 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.
  - Registrations require an annual renewal.
  - $125 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 registrant's or manufacturer's 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 RUPs during that previous month) and to 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, or
  - 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/

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

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/.

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

A) Establishes categories for the certification of applicators who apply restricted-use pesticides and general use pesticides.

B) As shown in Table 1, there are two types of certified applicators: Non-Private Certified Applicators and Private Applicators. These two different types of certified applicators have similar required general knowledge but have very different certification categories.

Table 1. 2023 Types of Licenses and Certificates for Pesticide Applicators				
	Authorized Commercial Applicator	**Commercial Applicator**	**Non-Private Certified Applicator**	**Private Certified Applicator**
Definition	Licensed to apply Restricted-Use and General Use Pesticides for hire.	Licensed to apply General Use Pesticides ONLY for hire.	City, County, Federal or other government agency personnel certified to apply both Restricted-Use and General Use Pesticides. All other applicators other than private certified applicators certified to apply Restricted-Use Pesticides.	Applicator who uses or supervises the use of any restricted-use pesticide for purposes of producing any agricultural commodity. See full definition at the bottom of this table.
Previous Designation	Licensed Applicator, Primary Principal, Principal, Agent, Consultant, Demonstration and Research Specialist	No previous designation	Licensed Government Applicator, Non-Primary Principal Commercial	Private
Examples	Pest control business owners and their licensed operators doing custom Restricted-Use and General Use Pesticide applications for hire. Landscapers doing Restricted-Use and General Use Pesticide applications for hire on commercial and residential properties.	Pest control business owners and their licensed operators doing custom General Use Pesticide applications for hire. Landscapers doing General Use Pesticide applications for hire on commercial and residential properties. Exempt from licensure if the landscaper only applies general use pesticides (containing the "caution" signal word) to residential properties without power equipment and does NOT solicit pest control work.	Employees of BLM, USFS, State, County, City or other municipality (including state, county or city owned recreational facilities and golf courses); School district employees; Mosquito, Weed Control and Conservation Districts, Cooperative Weed Management Areas, General Improvement Districts; Landscapers (who do not fall under licensing requirements), hotels, casinos, resorts, private golf clubs, tribes, mine staff	Ranchers, farmers, nurseries, greenhouse growers (including marijuana grow facilities).

Table 1. 2023 Types of Licenses and Certificates for Pesticide Applicators				
	Authorized Commercial Applicator	**Commercial Applicator**	**Non-Private Certified Applicator**	**Private Certified Applicator**
Education/Experience	Principal: 2 years of experience or 6 months experience plus 16 college credits in biological sciences. Operator, Agent, Demonstration and Research Specialist: None	Principal: 2 years of experience or 6 months experience plus 16 college credits in biological sciences. Operator, Agent, Demonstration and Research Specialist: None	None	None
Number of Questions on Exams	Primary Principal will be required to take 100 question Law Exam. Primary Principal, Principal, Operator, Consultant, Demonstration and Research Specialist and Agent will be required to take a Core Exam (General test): 50 questions for Primary Principal; 100 questions for Operator, Principal, Consultant, Demonstration and Research Specialist and Agent. Primary Principal, Principal, Operator, Consultant and Demonstration and Research Specialist will be required to take category exams in all categories they wish to perform pest control activities. Category exams: 50 to 100 questions each.	Primary Principal will be required to take 100 question law exam. Primary Principal, Principal, Operator, Consultant, Demonstration and Research Specialist and Agent will be required to take a Core Examination (General test): 50 questions for Primary Principal; 100 questions for Operator, Principal, Consultant, Demonstration and Research Specialist and Agent. Primary Principal, Principal, Operator, Consultant, Demonstration and Research Specialist will be required to take category exams in all categories they wish to perform pest control activities. Category exams: 50 to 100 questions each.	General test: 50 questions, Category tests: 20 to 50 questions each.	General test: 80 questions, Category tests: 50 questions each.

Table 1. 2023 Types of Licenses and Certificates for Pesticide Applicators

	Authorized Commercial Applicator	Commercial Applicator	Non-Private Certified Applicator	Private Certified Applicator
Passing Grade for Exams	70% is passing grade for Law Exam, Core Exam and all Category Exams.	70% is passing grade for Law Exam, Core Exam and all Category Exams.	70% is passing grade for both general and category exams	70% is passing grade for both general and category exams
Exam Fees	$50 initial exam, $35 each subsequent exam	$50 initial exam, $35 each subsequent exam	$50 per exam session	$50 per exam session
Additional Annual Fees	$250 per Business License, $50 each Primary Principal, Principal, Operator, Consultant, and Demonstration and Research Specialist. $50 per agent. $50 inactive license.	$250 per Business License, $50 each Primary Principal, Principal, Operator, Consultant, and Demonstration and Research Specialist. $50 per agent. $50 inactive license.	$25 for lost card replacement	$25 for lost card replacement
Renewal	Annual (calendar year), by December 31 of each year	Annual (calendar year), by December 31 of each year	Every 4 years	Every 4 years
Retest Period	Principal: 10 days*; Operator, Agent, Consultant, Demonstration and Research Specialist: 7 days* *6 months if caught using an unauthorized testing aid	Principal: 10 days*; Operator, Agent, Consultant, Demonstration and Research Specialist: 7 days* *6 months if caught using an unauthorized testing aid	5 days* *6 months if caught using an unauthorized testing aid	5 days* *6 months if caught using an unauthorized testing aid
Continuing Education Requirements for Renewal	6 total hours each year for Primary Principals, Principals, Operators, Consultants and Demonstration and Research Specialists. At least 1 of the 6 hours must be in Laws and Regulations. Agents have no continuing education requirement; Agents must retest each year.	6 total hours each year for Primary Principals, Principals, Operators, Consultants and Demonstration and Research Specialists. At least 1 of the 6 hours must be in Laws and Regulations. Agents have no continuing education requirement; Agents must retest each year.	12 total hours during the 4-year certification period. At least 2 of the 12 hours must be in Laws and Regulations.	12 total hours during the 4-year certification period. At least 2 of the 12 hours must be in Laws and Regulations.

Table 1. 2023 Types of Licenses and Certificates for Pesticide Applicators

	Authorized Commercial Applicator	Commercial Applicator	Non-Private Certified Applicator	Private Certified Applicator
Report Requirements	A pesticide usage report must be submitted each month for aerial and agricultural licensees for both Restricted-Use and General Use Pesticides. All pest control companies must submit annual pesticide usage report for both Restricted-Use and General Use Pesticides.	A pesticide usage report must be submitted each month for aerial and agricultural licensees for both Restricted-Use and General Use Pesticides. All pest control companies must submit annual pesticide usage report for both Restricted-Use and General Use Pesticides.	None Required	None Required
Records	Keep and maintain records for 2 years of both Restricted-Use (RUP) and General Use (GUP) Pesticide Applications. Wood-destroying Pest Inspection Reports must be kept for 3 years, as per NAC 555.430.2.b	Keep and maintain records for 2 years of both Restricted-Use (RUP) and General Use (GUP) Pesticide Applications. Wood-destroying Pest Inspection Reports must be kept for 3 years, as per NAC 555.430.2.b	Non-Private Certified Applicators must keep records for 2 years for all Restricted-Use Pesticides (RUPs). Non-Private Government Worker Certified Applicators must keep records for 2 years of both Restricted-Use (RUPs) and General Use (GUPs) Pesticides applied on public lands.	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.

Agricultural product: Wheat, cotton, flax, corn, dry beans, oats, barley, rye, tobacco, rice, peanuts, soybeans, sugar beets, sugar cane, tomatoes, grain sorghum, sunflowers, raisins, oranges, sweet corn, dry peas, freezing and canning peas, forage, apples, grapes, potatoes, timber and forests, nursery crops, citrus, and other fruits and vegetables, nuts, tame hay, native grass, hemp, aquacultural species (including, but not limited to, any species of finfish, mollusk, crustacean, or other aquatic invertebrate, amphibian, reptile, or aquatic plant propagated or reared in a controlled or selected environment), or any other agricultural commodity, excluding stored grain, determined by the Board, or any one or more of such commodities, as the context may indicate.

Authorized Commercial Applicator: Licensed to apply Restricted-Use and General Use Pesticides for hire.

Commercial Applicator: Licensed to apply General Use Pesticides ONLY for hire.

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 publicly 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.

GUP: General Use Pesticide

Location Principal: Primary Principal at the business location when the business has more than one location.

Non-Private Certified Applicator: All other certified applicators, other than private certified applicators, certified to apply Restricted-Use Pesticides as part of their job, 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: 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 the certified applicator or the certified applicator's employer or on the property of the certified applicator's neighbors if applied without compensation other than trading of personal services between producers of agricultural commodities.

RUP: Restricted-Use Pesticide

NON-PRIVATE CERTIFIED APPLICATORS: Non-Private Applicators are required to take a general exam and at least one category exam. The General Knowledge Exam is information based on the details provided in the first five chapters of this manual. The category(ies) exam(s) are selected based on the sites and situations the certified applicator plans to apply pesticides. The Category Exams are based on material found in the first five chapters of this manual and the corresponding category chapter in this manual. General (Core) knowledge for Non-Private Certified Applicators includes the following: labeling and label comprehension, safety, environmental concerns, pests, pesticides, equipment, application methods, laws and regulations and the responsibilities of supervisors of non-certified applicators.

Competency for Non-Private Certified applicator categories are:

Category A: Agricultural Plant Pest Control: The control of any pests in the production of agricultural commodities, including but not limited to grains, vegetables, small fruits, fruit trees, peanuts, tree nuts, tobacco, cotton, feed and forage crops, including grasslands and non-crop agricultural lands. This category excludes fumigation. Applicators must demonstrate a practical knowledge of crops, grass lands and non-crop agricultural lands and specific pests of those areas on which they may be using 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. The required knowledge includes pre-harvest intervals, restricted entry intervals, phytotoxicity, potential for environmental contamination such as soil and water problems, non-target injury and other problems resulting from the use of restricted-use pesticides in agricultural areas. The required knowledge also includes the potential for phytotoxicity due to a wide variety of plants to be protected, for drift, for persistence beyond the intended period of pest control and for non-target exposures.

Category B: Agricultural Animal Pest Control: The control of any pest in, on or around agricultural animals, including places on or in which agricultural animals are confined, such as barns and corrals. This category excludes fumigation and predatory animal control. Applicators who apply a pesticide directly to animals must demonstrate practical knowledge of such animals and their associated pests. The required knowledge includes specific pesticide toxicity and residue potential and the hazards associated with such factors as formulation, application techniques, age of animals, stress and extent of treatment.

Category C: Forest Pest Control: The control of any pest in forests, forest nurseries and forest seed-producing areas. This category excludes

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

Category A: Agricultural Plant Pest Control, and Category B: Agricultural Animal Pest Control are considered general knowledge for Private Applicators.

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

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

fumigation. Applicators must demonstrate practical knowledge of the type of forests, forest nurseries, and seed production in the State and the pests involved. The required knowledge includes the cyclic occurrence of certain pests and specific population dynamics as a basis for programming pesticide applications, the relevant organisms causing harm and their vulnerability to the pesticides to be applied, how to determine when pesticide use is proper, selection of application method and proper use of application equipment to minimize non-target exposures, and appropriate responses to meteorological factors and adjacent land use. The required knowledge also includes the potential for phytotoxicity due to a wide variety of plants to be protected, for drift, for persistence beyond the intended period of pest control, and for non-target exposures.

Category D: Ornamental and Turf Pest Control: The control of any pest in the maintenance and production of ornamental plants and turf. Applicators must demonstrate practical knowledge of pesticide problems associated with the production and maintenance of ornamental trees, shrubs, plantings and turf. The required knowledge includes potential of phytotoxicity due to a wide variety of plants to be protected, for drift, for persistence beyond the intended period of pest control, and for non-target exposures. Because of the frequent proximity of human habitation to application activities, applicators in this category must demonstrate practical knowledge of application methods that will minimize or prevent hazards to humans, pets, and other domestic animals.

Category E: Seed Treatment: Treatment of seeds and in seed treatment facilities to control insects, fungi, bacteria and other micro-organisms. This category excludes fumigation pest control. 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 that 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.

Category F: Aquatic Pest Control: The control of any pest in standing or running water, excluding public health pest control and fumigation pest control. Applicators must demonstrate practical knowledge of the characteristics of various aquatic use situations, the potential for adverse effects on non-target effects on non-target plants, fish, birds, beneficial insects, and other organisms which may be present in the immediate aquatic environment and downstream. Applicators must demonstrate practical

knowledge of the principles of limited-area application.

Category G: Right-of-Way Pest Control: The control of pests in the maintenance of rights-of-way, including, but not limited to, public roads, electric power lines, pipelines and railway rights-of-way. This category excludes fumigation. Applicators must demonstrate practical knowledge of the wide variety of environments which rights-of-way may traverse, including waterways. The applicator must demonstrate practical knowledge of pest recognition, techniques to minimize non-target exposure, runoff, drift and excessive foliage destruction. The required knowledge also includes the potential for phytotoxicity due to a wide variety of plants and pests to be controlled and for persistence beyond the intended period of pest control.

The Right-of-Way Pest Control category is for applicators who apply pesticides along roads, railroads or utility rights-of-way.

Category H: Industrial, Institutional, Structural Pest Control: The control of any pest in, on or around the following: food handling establishments, packing houses, food processing facilities, human dwellings, institutions such as schools, hospitals and prisons, industrial establishments including manufacturing facilities, warehouses, grain elevators, and any other structures and adjacent areas, public or private, for the production of stored or manufactured products. This category excludes fumigation. Applicators must demonstrate a practical knowledge of industrial, institutional and structural pests, including recognizing those pests and signs of their presence, their habitats, their life cycles, biology and behavior as it may be relevant to problem identification and control. Applicators must demonstrate practical knowledge of types of formulations appropriate for control of industrial, institutional and structural pests and methods of applications that avoid contamination of food, minimize acute and chronic exposure of people and pets, and minimize environmental impacts of outdoor applications.

Industrial, Institutional and Structural Pest Control have now been combined into one category.

Category K: Public Health Pest Control: Control of any pest having medical and public heath importance by state, federal or other governmental employees. This category excludes fumigation. Applicators must demonstrate practical knowledge of pests that are important vectors of disease, including recognizing the pests and the signs of their presence, their habitats, their life cycles, biology, and behavior as it may be relevant to problem identification and control. The required knowledge also includes how to minimize damage to, and contamination of areas treated, acute and chronic exposures of pesticides to people, and non-target exposures.

Public Health Pest Control now includes Mosquito Pest Control.

Category L2: Non-soil Fumigation Pest Control: The control of any pest by fumigation with poisonous and lethal gases in anything but soil. Applicators must demonstrate practical knowledge of pesticide problems and pest control practices with non-soil fumigant applications pursuant to 40 CFR

Applying fumigants requires certification in a fumigation category.

There are two categories for Fumigation certification: Non-Soil Fumigation and Soil Fumigation.

The M-44 Predatory Pest Control category is available only to employees of the USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services.

171.103.d.14. These pest control practices include, but are not limited to, labeling and labeling comprehension, safety measures specific to the use of fumigants, non-soil fumigant chemical characteristics, selection of appropriate application methods and timing, pest factors that influence activity, personal protective equipment, fumigant management plans and post application summaries, and posting requirements for fumigant applications.

Category L3: Soil Fumigation: The control of any soil pest, when present in the soil, by using fumigants. Applicators in this category must demonstrate practical knowledge of pest problems and pest control in soil fumigation applications pursuant to 40 CFR 171.103.d.13. These pest control practices include, but are not limited to, labeling and labeling comprehension, safety measures specific to the use of fumigants, soil fumigant chemical characteristics, selection of appropriate application methods and timing, soil and pest factors that influence fumigant activity, personal protective equipment, fumigant management plans and post-application summaries, and buffer zones and posting requirements for soil fumigant applications.

Category N: Predatory Pest Control/M-44: The control of any predator using sodium cyanide in any habitat, including, but not limited to, rangelands, forests, and cropland. An Applicator must demonstrate a practical knowledge of pest problems and pest control practices in sodium cyanide applications pursuant to 40 CFR 171.103.d.11 and 40 CFR 171.103.d.12, respectively. Sodium cyanide predator control applicators must demonstrate practical knowledge of mammalian predator pests, including recognizing those pests and signs of their presence, their habitats, their life cycles, biology, and behavior as it may be relevant to pest identification and control. Applicators must demonstrate comprehension of all laws and regulations applicable to the use of mechanical ejection devices for sodium cyanide, including the restrictions on the use of sodium cyanide products ordered by the EPA Administrator. Applicators must also demonstrate practical knowledge and understanding of all of the specific use restrictions for sodium cyanide devices, including safe handling and proper placement of the capsules and device, proper use of the antidote kit, notification to medical personnel before use of the device, conditions of and restrictions on when and where devices can be used, requirements to consult U.S. Fish and Wildlife Service maps before use to avoid affecting endangered species, maximum density of devices, provisions for supervising and monitoring applicators, required information exchange in locations where more than one agency is authorized to place devices, and specific requirements for recordkeeping, monitoring, field posting, proper storage, and disposal of damaged or used sodium cyanide capsules.

PRIVATE CERTIFIED APPLICATORS: Private Applicators are required to take a general exam and have the **option** of taking two category exams (only if the Private applicator plans to perform soil and/or non-soil fumigation). The General Knowledge Exam is information based on the details provided in the first five General Knowledge chapters of this manual and the information in Category A: Agricultural Plant Pest Control and Category B: Agricultural Animal Pest Control. General (Core) knowledge for Private Certified Applicators includes labeling and label comprehension, safety, environmental concerns, pests, pesticides, equipment, application methods, laws and regulations and the responsibilities of supervisors of non-certified applicators, stewardship, and thorough knowledge of agricultural pest control.

Private Certified Applicators can only certify in two categories: Non-Soil Fumigation and Soil Fumigation. Competency for the two private certified applicator categories are:

Category L2: Non-soil Fumigation Pest Control: The control of any pest by fumigation with poisonous and lethal gases in anything but soil. Applicators must demonstrate practical knowledge of pesticide problems and pest control practices with non-soil fumigant applications pursuant to 40 CFR 171.103.d.14. These pest control practices include, but are not limited to, labeling and labeling comprehension, safety measures specific to the use of fumigants, non-soil fumigant chemical characteristics, selection of appropriate application methods and timing, pest factors that influence activity, personal protective equipment, fumigant management plans and post-application summaries, and posting requirements.

Category L3: Soil Fumigation: The control of any soil pest, when present in the soil, by the use of fumigants. Applicators in this category must demonstrate practical knowledge of pest problems and pest control in soil fumigation applications pursuant to 40 CFR 171.103.d.13. These pest control practices include, but are not limited to, labeling and labeling comprehension, safety measures specific to the use of fumigants, soil fumigant chemical characteristics, selection of appropriate application methods and timing, soil and pest factors that influence fumigant activity, personal protective equipment, fumigant management plans and post application summaries, and buffer zones and posting requirements.

Private Certified Applicators must study Category A: Agricultural Plant Pest Control and Category B: Agricultural Animal Pest Control as part of their General Knowledge Exam.

Applying fumigants requires certification in a fumigation category.

Revisions to the EPA Certification of Pesticide Applicators (40 CFR 171) have changed the requirements for persons under the direct supervision of a licensed or certified applicator.

Please read this section very carefully if you supervise non-certified applicators as the requirements have significantly changed

As the supervising certified applicator, YOU must be licensed to perform the type of application being performed

VI. Nevada Administrative Code (NAC) Chapter 586: Requirements for the direct supervision of noncertified applicators by certified applicators

Restricted Use Pesticides may only be applied by an authorized commercial licensed applicator, a non-private certified applicator or a private applicator with the appropriate license or certification to use the restricted use pesticide OR a person under the **direct supervision** of an authorized commercial licensed applicator, a non-private certified applicator or a private applicator with the appropriate license or certification to use the restricted use pesticide. Revisions to the EPA Certification of Pesticide Applicators (40 CFR 171) have changed the requirements for persons under the direct supervision of a licensed or certified applicator. The following information is an excerpt from the 2021 Meeting Competency Standards for Certified Pesticide Applicators publication by the Pesticide Educational Resources Collaborative (PERC). The entire document can be found at https://pesticideresources.org/ct/PERC_Updated_Competency_Guide_2021.pdf

As the supervising certified applicator, you must:

- Be licensed to perform the type of application being performed, including any required categories or endorsements. For example, if you are supervising the use of a restricted-use product to control a pest on turf, you must be certified in 'ornamental and turf' pest control or a similar certification category.
- Be physically present at the site where the restricted use pesticide is applied when required by product labeling.
- Ensure that the non-certified applicator is at least 18 years old. A non-certified applicator can be 16 years old if they are applying restricted use pesticides under the direct supervision of a PRIVATE certified applicator who is an immediate family member and if the restricted use pesticides they are applying are NOT a fumigant or applied aerially.
- Ensure that the non-certified applicator has clean Personal Protective Equipment (PPE) as specified on the label and it is in proper operating condition.
- Ensure that the non-certified applicator uses required PPE properly for its intended purpose.
- Ensure that the non-certified applicator has access to the product's labeling at all times during the application.
- Ensure that all equipment is in proper working condition prior to each day of use. Ensure that the equipment can be used without risk of

reasonably foreseeable harm to either the non-certified applicator, other people, or the environment.

- Ensure that immediate communication is possible between the supervising certified applicator and the non-certified applicator(s). Properly charged cell phones could meet this criterion if signal strength is sufficient and phones are continuously available.
- Ensure that the non-certified applicator has been instructed in the last 12 months of the safe and proper use of any equipment needed for the application. Training on application equipment must take place before the noncertified applicator makes any application of a restricted-use pesticide.
- Ensure that the non-certified applicator received sufficient pesticide safety training, as described in the following section.

Pesticide safety training for non-certified applicators under your supervision

The non-certified applicator must have pesticide safety training at least every 12 months. Alternatively, they may also be a certified applicator who a) isn't certified to perform that particular application or b) isn't certified within the jurisdiction where the application will take place.

The pesticide safety training requirement is met by either:

- taking a non-certified applicator training course such as Pesticide Safety Training for Noncertified Applicators Using Restricted Use Pesticides at Nonagricultural Sites, which is available online at http://pesticideresources.org/ct/rup.html
- taking an agricultural handler training course [as specified by 40 CFR 170.501], such as those listed here: http://pesticideresources.org/wps/jfy/toh/index.html, or
- taking another course approved by a certifying authority [40 CFR 171.201(c)(1)].

The trainer must be qualified and the content must be complete according to the federal regulations. Training can be conducted by someone who is currently certified as an applicator of restricted-use pesticides. It can also be done by someone who is a trainer of certified applicators or pesticide handlers. The trainer may also have completed an EPA-approved train-the-trainer course in pesticide safety for trainers of handlers. Additionally, a certifying authority such as a state, tribe, or territory, may designate a person as a qualified trainer.

The Certified Applicator must ensure that the non-certified applicator has been instructed in the last 12 months of the safe and proper use of any equipment needed for the application.

Training on application equipment must take place before the noncertified applicator makes any application of a restricted-use pesticide.

The non-certified applicator must have pesticide safety training at least every 12 months.

The information required by law for non-certified applicator training is extensive.

The requirements for education of non-certified applicators are very similar to the educational requirements for certified applicators. Certification of all pesticide applicators may be warranted.

The information that must be included in the training is specified by law and must include all of the information the non-certified applicator will need to keep themselves, anyone else, and the environment from harm.

The non-certified applicator training materials must include, at a minimum, the following: (40 CFR 171.201d(3))

i. Potential hazards from toxicity and exposure that pesticides present to non-certified applicators and their families, including acute and chronic effects, delayed effects, and sensitization.
ii. Routes through which pesticides can enter the body.
iii. iii. Signs and symptoms of common types of pesticide poisoning.
iv. Emergency first aid for pesticide injuries or poisonings.
v. v. Routine and emergency decontamination procedures, including emergency eye flushing techniques. Non-certified applicators must be instructed that if pesticides are spilled or sprayed on the body, to immediately wash or to rinse off in the nearest clean water. Non-certified applicators must also be instructed to wash or shower with soap and water, shampoo hair, and change into clean clothes as soon as possible.
vi. How and when to obtain emergency medical care.
vii. After working with pesticides, wash hands before eating, drinking, using chewing gum or tobacco, or using the toilet.
viii. Wash or shower with soap and water, shampoo hair and change into clean clothes as soon as possible after working with pesticides.
ix. Potential hazards from pesticide residues on clothing.
x. Wash work clothes before wearing them again and wash them separately from other clothes.
xi. Do not take pesticides or pesticide containers used at work to your home.
xii. Potential hazards to children and pregnant individuals from pesticide exposure.
xiii. After working with pesticides, remove work boots or shoes before entering your home, and remove work clothes and wash or shower before physical contact with children or family members.
xiv. How to report suspected pesticide use violations to the appropriate State or Tribal agency responsible for pesticide enforcement.
xv. Format and meaning of information contained on pesticide labels and in labeling applicable to the safe use of the pesticide, including the location and meaning of the restricted use product statement, how to identify when the labeling requires the certified applicator to be physically present during the use of the pesticide, and information on personal protective equipment.

xvi. Need for, and appropriate use and removal of, personal protective equipment.

xvii. How to recognize, prevent, and provide first aid treatment for heat-related illness.

xviii. Safety requirements for handling, transporting, storing, and disposing of pesticides, including general procedures for spill cleanup.

xix. Environmental concerns such as drift, runoff, and wildlife hazards.

xx. Restricted use pesticides may be used only by a certified applicator or by a non-certified applicator working under the direct supervision of a certified applicator.

xxi. The certified applicator's responsibility to provide to each non-certified applicator instructions specific to the site and pesticide used. These instructions must include labeling directions, precautions, and requirements applicable to the specific use and site, and how the characteristics of the use site (e.g., surface and groundwater, endangered species, local population, and risks) and the conditions of application (e.g., equipment, method of application, formulation, and risks) might increase or decrease the risk of adverse effects. The certified applicator must provide these instructions in a manner the non-certified applicator can understand.

xxii. The certified applicator's responsibility to ensure that each non-certified applicator has access to the applicable product labeling at all times during its use.

xxiii. The certified applicator's responsibility to ensure that where the labeling of a pesticide product requires that personal protective equipment be worn for mixing, loading, application, or any other use activities, each non- certified applicator has clean, labeling-required personal protective equipment in proper operating condition and that the personal protective equipment is worn and use correctly for its intended purpose.

xxiv. The certified applicator's responsibility to ensure that before each day of use equipment used for mixing, loading, transferring, or applying pesticides is in proper operating condition as intended by the manufacturer, and can be used without risk of reasonably foreseeable adverse effects to the non-certified applicator, other persons, or the environment. The certified applicator's responsibility to ensure that a means to immediately communicate with the certified applicator is available to each non-certified applicator using restricted use pesticides under his or her direct supervision.

You are also responsible for providing use-specific instructions to the non-certified applicator for the restricted-use pesticide, and explaining any federal, state, or tribal regulations relevant for the application.

If you are supervising a noncertified applicator using a restricted-use pesticide, you are required to keep records of safety training for the non-certified applicator.

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

In addition to the training concepts above, you are also responsible for providing **use-specific instructions** to the non-certified applicator for the restricted-use pesticide, and explaining any federal, state, or tribal regulations relevant for the application. For example, provide precautions and requirements applicable to the specific use and site, the conditions of the application, and actions that could increase or decrease the risk of adverse effects.

Recordkeeping

In addition to the other requirements listed above, you will need to ensure that all required records are kept if you are supervising a noncertified applicator using a restricted-use pesticide. This includes detailed documentation of the safety training provided to the noncertified applicator. It is your responsibility to create or verify the existence of the training record before allowing the noncertified applicator to use a restricted-use pesticide under your supervision.

Training records must include: (40 CFR 171.103(e)(1)(i))

- The noncertified applicator's printed name and signature
- The date the training requirement was completed
- The name of the trainer
- The title or description of the training provided

If you used a piece of training material for agricultural handlers under the Worker Protection Standard (WPS), the record must contain all of the information required under that rule, including the trainer's qualification to train, and the EPA approval number for the training material(s).

If you used another piece of training material approved by a local authority, the record must be complete according to the authority's published rules. If the noncertified applicator is certified in another category/type of pesticide application, annual training is not required. However, the supervising certified applicator must keep a record including the noncertified applicator's name, certification number, expiration date, and the name of the certifying authority that issued the certification.

The requirements for education of non-certified applicators are very similar to the educational requirements for certified applicators. Certification of all pesticide applicators may be warranted.

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.
Updated in 2022 by M. Hefner, University of Nevada, Reno Extension and B. Allen, V. Lum and R. Saliga, Nevada Department of Agriculture

General Knowledge: Guidelines for the Safe Use of Pesticides

Guidelines for the Safe Use of Pesticides Learning Objectives

THIS CHAPTER IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR BOTH PRIVATE AND NON-PRIVATE CERTIFIED APPLICATORS GENERAL EXAM.

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 what to do in the event of a poisoning.**
- ✓ **Explain procedures for safely mixing, applying, disposing, storing and transporting pesticides.**
- ✓ **Explain how to clean up a pesticide spill.**
- ✓ **Describe pesticide security measures.**
- ✓ **List record-keeping requirements for pesticide applications.**
- ✓ **Explain pesticide stewardship.**
- ✓ **Describe pesticide application equipment and how to calibrate it.**

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.

Pests not only adversely affect agricultural productivity, but they impair the health of humans, as well as domestic and wild animals, and they 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 the label references but may not be attached to the pesticide container. The law requires that you read, understand and follow all pesticide labeling.

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 they damage the environment.

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.

Section 408 of the Federal Food, Drug and Cosmetic Act authorizes the EPA to set tolerances or maximum residue limits for pesticide residues 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, livestock, 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. Micro-organisms, such as bacteria and viruses, can be pests as well.

What is a Pesticide?

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.

Pesticides are split into two main categories by FIFRA:

- **General Use Pesticides (GUP)** are those pesticides which will not generally cause unreasonable adverse effects on the environment when used in accordance with its labeling. They are available to everyone.
- **Restricted-Use Pesticides (RUP)** are those which may generally cause unreasonable adverse effects on the environment, including injury to the applicator. Applications of these pesticides must be made by a certified applicator or under the direct supervision of a certified applicator.

Pesticide products contain both active and inert ingredients.

Active ingredients are the chemicals in a pesticide product that act to control the pests. Active ingredients must be identified by name on the pesticide product's label, together with its percentage by weight. There are several categories of active ingredients:

- **Conventional**, which are all ingredients other than biological pesticides and antimicrobial pesticides.

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 will not generally cause unreasonable adverse effects on the environment. They are available to everyone.

Restricted-Use Pesticides (RUP) are those that may generally cause unreasonable adverse effects on the environment, including injury to the applicator. Applications of these pesticides must be made by a certified applicator or under the direct supervision of a

certified applicator.

Active ingredients are the chemicals in a pesticide product that act to control the pests.

Inert ingredients are chemicals, compounds and other substances that play key roles in pesticide effectiveness and product performance.

- **Antimicrobial**, which are substances or mixtures of substances used to destroy or suppress the growth of harmful micro-organisms, whether bacteria, viruses or fungi on inanimate objects and surfaces.
- **Biopesticides**, which are types of ingredients derived from certain natural materials.

Pesticide products contain at least one active ingredient and other intentionally added inert ingredients. The inert ingredients are chemicals, compounds and other substances, including common food commodities (e.g., certain edible oils, spices, herbs) and some natural materials (e.g., beeswax, cellulose).

Inert ingredients play key roles in pesticide effectiveness and product performance. These functions include:

- Acting as a solvent to help the active ingredient penetrate a plant's leaf surface.
- Improving the ease of application by preventing caking or foaming.
- Extending the product's shelf-life.
- Improving safety for the applicator.
- Protecting the pesticide from degradation due to exposure to sunlight.

The name “inert” does not mean non-toxic. All inert ingredients must be approved by EPA before they can be included in a pesticide.

Under federal law, the identity of inert ingredients is confidential business information. In general, only the total percentage of all inert ingredients is required to be on the pesticide product label. The law does not require manufacturers to identify inert ingredients by name.

Types of Pesticides

Pesticides can be classified according to their function. A common classification for pesticides is based on the pests they control.

- **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 micro-organisms, 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 type of pesticides derived from natural materials such as animals, plants, bacteria and certain minerals.
- **Biocides:** Kill micro-organisms.
- **Disinfectants and sanitizers:** Kill or inactivate disease-producing micro-organisms 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.
- **Miticides (also called acaricides):** Kill mites that feed on plants and animals.
- **Microbial pesticides:** Micro-organisms that kill, inhibit or outcompete pests, including insects or other microorganisms.
- **Molluscicides:** Kill snails and slugs.
- **Nematicides:** Kill nematodes (microscopic, worm-like organisms that feed on plant roots).
- **Ovicides:** Kill eggs of insects and mites.
- **Pheromones:** Biochemicals used to disrupt the mating behavior of insects.
- **Piscicides:** Control pest fish.
- **Predacides:** Control vertebrate predator pests.
- **Repellants:** Repel pests, including insects, such as mosquitoes, and birds.
- **Rodenticides:** Control mice, rats and other rodents.

Although not usually thought of as pesticides, the following 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.

Pesticides can be categorized by the pests they control.

Defoliants, desiccants and growth regulators are also considered pesticides.

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 humans, non-target animals and the environment, if used in a manner inconsistent with the label directions.

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.

Biopesticides are certain types of pesticides derived from such natural materials, as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations. Biopesticides fall into three major classes:

- Biochemical pesticides 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 that interfere with mating, such as insect sex pheromones, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.
- Microbial pesticides consist of a micro-organism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds and other fungi that kill specific insects.

  The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bt ingredients control moth larvae (caterpillars) found on plants, other Bt ingredients are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.
- Plant-Incorporated-Protectants (PIPs) 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 plant itself, are regulated by EPA.

Conventional pesticides, also referred to as **chemical pesticides**, are all active ingredients other than biological pesticides and antimicrobial pesticides. Conventional active ingredients are generally produced synthetically, and like all pesticides they prevent, mitigate, destroy or repel any pest or act as a growth regulator, desiccant or defoliant.

Pesticide resistance occurs when a population of pests no longer responds to the proper application of a pesticide. Repeated applications of the same pesticide may result in a pest population that is resistant to the active ingredient. Resistance reduces pesticide choices and increases pest management costs. The following tactics are used to manage and prevent pesticide resistance:

- Rotate pesticides with different modes of action.
- Tank-mix pesticides with different modes of action.
- Don't apply pesticides at rates below the recommended label rate.
- Use IPM. Use other management methods when appropriate, including mechanical or physical removal of pests.

Chemical Insecticides: Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors. They are classified based on their structure and mode of action. Many chemical insecticides are derived from a common source or production method. The most common insecticides are:

- **Organophosphate Insecticides:** These pesticides affect the nervous system by disrupting the enzyme that regulates acetylcholine, 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 Insecticides:** These insecticides also affect the nervous system by disrupting the enzyme that regulates acetylcholine, 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

Pesticide resistance occurs when a population of pests no longer responds to the proper application of a pesticide. Repeated applications of the same pesticide may result in a pest population that is resistant to the active ingredient.

Insecticides are chemicals used to control insects by killing them or preventing them from engaging in undesirable or destructive behaviors.

Herbicides are pesticides used to kill or control vegetation.

Synthetic auxins are more effective at controlling broadleaf weeds and trees than grasses.

health and environmental effects and their persistence in the environment (examples are DDT, chlordane).

- **Pyrethroid Insecticides:** 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.

Chemical Herbicides: Herbicides are pesticides used to kill or control vegetation. To be effective, herbicides must reach a living site to disrupt a vital process or structure. Herbicide mode of action is the way the herbicide affects a vital metabolic plant process. There are a number of modes 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. To prevent herbicide resistance, it is important to alternate herbicides with different modes of action when making multiple herbicide applications.

- **Synthetic auxins** interfere with cell division and cell enlargement. The symptoms of these types of herbicides are downward twisting and curving stems and 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, 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.

General metabolic inhibitor symptoms show up slowly in the targeted plants, sometimes taking a week or more to manifest.

Herbicide effectiveness is dependent on both herbicide uptake rate and quantity and herbicide movement in the plant.

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.).

- **Herbicide 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**, 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

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.

Contact herbicides kill only the plant parts they touch, so they will kill the leaves and stems, but not necessarily the roots.

Systemic herbicides are absorbed through the leaves or roots and move freely throughout the plant.

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 surface of the leaves 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 spray drift while maximizing coverage and penetrating the crop canopy.
- The amount of **foliage or shoot growth** 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 **retention time** 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.

- **Selective herbicides:** Herbicides that kill specific types of plants.
- **Nonselective herbicides:** Herbicides that kill all types of plants.
- **Contact herbicides:** Herbicides with little to no movement in plants. 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.

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

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. Toxicity may be acute (immediate) or chronic (manifests over time).

The toxicity of each active ingredient is determined by at least three methods:

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.

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

- 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 when used according to the label directions.

The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Any harmful effects that occur from small doses repeated over time are termed chronic effects. Some of the suspected chronic effects from exposure to certain pesticides include birth defects, production of tumors, blood disorders, and neurotoxic effects (nerve disorders). The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than acute toxicity.

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, 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 for CAUTION signal word pesticides 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 humans, 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*.**

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.

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. These areas absorb pesticides very rapidly. Always wash your hands BEFORE using the restroom if you are applying pesticides. Don't sit on pesticide containers or contaminated seats. A small amount of chemical allowed to remain on the skin can be absorbed into the

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**

Approximately 97 percent of all exposure to pesticides during a spraying operation is dermal.

After applying pesticides, always wash your hands and face before eating, drinking chewing gum, putting on makeup, using tobacco, smoking or vaping.

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.

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, chewing gum, putting on makeup, using tobacco, smoking or vaping.

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.

There are two types of statements on a pesticide label: **mandatory statements** and **advisory statements**. Statements that include the words "**must**, **do** or **do not** are mandatory directions for use. These statements direct the user to a specific action. Other examples of mandatory statements are "apply immediately after mixing" or "wear chemical-resistant gloves." Advisory statements are more descriptive. They describe actions that will keep pesticide application risks low and effectiveness of the application high. For example, "applying the product immediately after preparation will help ensure that it is in suspension. If application is delayed, agitate to remix the product."

The pesticide 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

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.

does not give an indication of what active ingredient the product contains and, therefore, is not a good method for identifying a pesticide in case of a poisoning. Refer to the chemical name or common name in case of poisoning or when using a reference manual to seek additional information about the product, how to apply it or about treatment for poisoning by the active ingredient.

3. PRECAUTIONARY STATEMENTS: Precautionary statements inform the user of the proper precautions to take to protect self, others, domestic animals and the environment from harmful effects of pesticide exposure. Hazard statements help the user apply the pesticide correctly. Precautions must include signal words to reduce hazards to humans, 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. You must verify that the pesticide label does not prohibit the use of the product to control the target pest
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

In the event of pesticide poisoning, call the following for 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.

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.

It is not uncommon to find some active ingredients formulated in several different ways. This is done to make the chemical more stable, suitable for application with modern equipment, or in some cases, more attractive to a pest (i.e., bait).

Baits may be attractive to non-target animals, including children and pets. Follow label directions to place baits in a manner that will limit non-target

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 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 supervisor, pesticide dealer or salesperson, vocational agricultural instructor, or the Nevada Department of Agriculture 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 more stable, suitable for application with modern equipment, 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.

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, or 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.

damages.

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. 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 a problem. Most liquid concentrates of this type can cause rubber hoses, gaskets and pump parts to deteriorate, and some formulations are detrimental to painted surfaces.

Most emulsifiable concentrates are highly flammable, as the active ingredient is mixed with a petroleum solvent.

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 4 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

Fumigants are the most hazardous of all pesticide formulations.

Applications of fumigants require a separate category certification for all pesticide applicators.

Granules and pellets are ready to use as purchased and require no further mixing.

and storing undiluted concentrated materials. The same precautions should be observed with flowables as with emulsifiable concentrates.

Fumigants (LG) are poisonous gases. Applications of fumigants require a separate category certification for all pesticide applicators. Many fumigants are formulated as liquids under pressure and become gases when released. They are used to control pests in soil, ship holds and closed structures, such as buildings, granaries and greenhouses. 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 8 or more pounds of active ingredient per gallon, while low-concentrate formulations usually contain less than 2 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.

Wettable powders are mixed with water to produce suspensions, whereas soluble powders dissolve in water to form solutions.

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

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

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.

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

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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.

is needed. Do not over-protect if heat stress is a concern, but wear whatever is necessary. Generally, the more protective the equipment is, the more it adds to the heat load.

Choose PPE that is designed to be as cool as possible or that provides a cooling effect, such as a powered air-purifying respirator or, when appropriate, back-vented coveralls. Whenever it is practical, choose coveralls that allow air to pass through, such as woven fabrics (cotton, or cotton-polyester blends). Rubber or plastic fabrics and fabric with chemical-resistant barrier layers allow almost no air to pass through. Non-woven polyolefin (TyvekÒ) 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.

Learn the signs and symptoms of heat stress:

- **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.

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**

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, get medical attention immediately.

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. Contact your local hospital, physician, University of Nevada, Reno 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: Get immediate medical attention. Keep the victim calm and contact the local emergency response system, the

Poison Control Center (1-800-222-1222) or take the victim to the nearest medical facility. Also take the product label and any Safety Data Sheets you have about the swallowed pesticide.

Every pesticide is different and reacts differently in the body, so first aid treatment will vary. When helping a person who has swallowed a pesticide, read and follow the first aid information on the pesticide label or the Safety Data Sheets (SDS) for the pesticide. Some labels may recommend that you assist the person by making them vomit. Other labels may contain specific warnings AGAINST inducing vomiting. **Induce vomiting ONLY if emergency personnel on the phone or the product label tells you to do so.**

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. 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.

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.

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 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.

Never induce vomiting if:

- **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.

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.

Wear clean clothing and use protective equipment as needed.

Always keep your head well above the fill hole to avoid inhaling the pesticide. 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. The pesticide label may specifically prohibit mixing certain pesticides; read the label carefully.

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. The Nevada Department of Agriculture 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. For more information on reducing drift, go to the General Knowledge: Pesticide Use and the Environment section of this manual.

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 F or above 85 F. At 40 to 50 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 F or above, many pesticides will volatilize, increasing the potential for drift and decreasing their effectiveness.

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.

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 F, many pesticides show reduced activity. Above 85 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.

Restricted Entry Interval or REI is the time after the end of a pesticide application during which re-entry is restricted without proper PPE to protect against pesticide residues.

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

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

The steps in cleaning spray equipment are generally detailed on the pesticide label.

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 the Restricted Entry Interval or REI. The REI is the time after the end of a pesticide application during which re-entry is restricted without proper PPE to protect against pesticide residues. 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 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. Several 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 excess 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.

The Nevada Department of Agriculture (NDA) has a safe pesticide waste disposal program. They can only accept pesticides; they DO NOT accept batteries, motor oil, antifreeze, paint or other substances. They DO NOT accept pesticide rinsate. They DO accept unusable, expired or unwanted pesticides, including pesticides that have been banned for use in Nevada. The program is free.

While wearing the PPE specified on the pesticide label, inventory the pesticides you want to dispose of and fill out the Disposal Pesticide List sheet at https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Environmental/Disposal%20Pesticide%20List.pdf. Call the NDA at 775-353-3717 to set up a time to drop off your unwanted pesticides and your inventory sheet. Do not drop off the pesticides at the NDA office after hours; this is considered illegal dumping, and you will be subject to a fine or other penalties. For more information about this program, go to https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Media/2014-12-Safe-Waste-Pesticide-Disposal.pdf.

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 empty containers in a sanitary landfill is permissible, but the containers must be punctured to prevent reuse. Recycling is the preferred method of empty container disposal. Plastic from pesticide containers is a valuable resource that can be recycled and used as pesticide containers, pallets, waste drums and other items. Per Nevada Administrative Code (NAC) Chapter 445B.22067, it is illegal to burn pesticide containers in Nevada. The NDA, the Ag Container Recycling Council (ACRC), Interstate Ag Plastics (IAP) and the state's pesticide users came together to implement a convenient and effective container recycling pilot program. Containers with pesticide residues are not accepted. Containers should be triple rinsed. Caps and labels should be removed from the containers, as this interferes with the recycling process. Some containers are not acceptable. For more information, go to https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Media/2014-12-Pesticide%20Container%20Disposal(1).pdf.

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

Recycling is the preferred method of empty container disposal.

Per Nevada Administrative Code (NAC) Chapter 445B.22067, it is illegal to burn pesticide containers in Nevada.

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

You must report a spill that is greater than 1 gallon of liquid or 4 pounds dry weight of unmixed or concentrated pesticides that are detrimental to persons, wildlife, domestic animals, or crops.

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.

Dealing with Pesticide Spills

Despite your best efforts, accidents can happen. Accidental spills of pesticides can have severe consequences to human health, pets, livestock, wildlife and the environment. If a pesticide spill occurs, use these four steps:

1. CAUTION: Keep yourself safe. Make sure you are wearing proper Personal Protective Equipment (PPE) before attempting to clean up a spill. If a spill occurs during a pesticide application, you should already be wearing the proper PPE. Try to exclude entry or access to the spill site.
2. CONTROL: Stop the spill from continuing by stopping the source of the spill. For example, if a spill is from a broken hose on a tank, close the valve to the hose. If a pesticide container is leaking, place the container in a secondary container to limit the spill.
3. CONTAIN: Contain the spill so that it does not spread and get into water sources. Build a dike or levy of absorbent material around the spill to keep it from spreading. You can use containment snakes, pads or absorbent material such as cat litter, wood shavings or corn cob litter.
4. CLEAN UP: Add absorbent material to soak up the spilled pesticide. Start at the outside of the spill, next to the containment material you placed down, and work toward the center of the spill. Once the spill has been absorbed, sweep or shovel up the spill-soaked absorbent material and place it in heavy-duty garbage bags or a waterproof container with a tight-fitting lid. Label the container with the date of the spill and the name of the pesticide. Place the broom or shovel and dustpan in a heavy-duty garbage bag for later decontamination or disposal.

The Nevada Department of Agriculture free Pesticide Waste Disposal Program will also take the waste pesticide from a spill and the pesticide-soaked spill clean-up materials and dispose of it properly. You must call ahead to schedule a drop-off of the material. Call Nevada Department of Agriculture at 775-353-3717. Have the name of the pesticide when you call. Do not drop off the spill material at their office after hours. This is considered illegal dumping and you will be fined.

You must report a spill that is greater than 1 gallon of liquid or 4 pounds dry weight of unmixed or concentrated pesticides that are detrimental to persons, wildlife, domestic animals or crops. Report the spill to the Nevada Department of Agriculture at 775-353-3715. Know the name of the spilled pesticide when you call.

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.

You can see that it is important to have a spill kit on hand when you are applying pesticides. You can build your own spill kit or purchase a spill kit. Most service vehicles are required to have a spill kit. Most service vehicles have a shovel.

A purchased spill kit for a service vehicle usually comes in a 5-gallon bucket with a tight-fitting lid. Inside there should be:

- Telephone numbers for emergency assistance
- Containment snakes
- Absorbent material
- Heavy-duty plastic garbage bags
- Dustpan and broom
- PPE, such as gloves, goggles and disposable coveralls

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.

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

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.

Never store respirators, PPE and other safety equipment in the same room with pesticides because of possible contamination.

Check stored pesticide containers often for leaks or cracks.

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

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 regulation 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.

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.

Pesticide Stewardship

It is the responsibility of every pesticide applicator to insure good pesticide stewardship. To be a good steward of pesticides, applicators should minimize the risks while maximizing the benefits of a pesticides. This includes the following:

- Maintaining pesticide security. All pesticides should be stored in an area that can be locked to keep out unauthorized people. This locked area can be a storage cabinet or an entire building. Post signs on doors and windows to alert people that pesticides are stored there. Post “no smoking” warnings. Whenever possible, transport pesticides in a locked

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

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.

It is the responsibility of every pesticide applicator to insure good pesticide stewardship.

All pesticides should be stored in an area that can be locked to keep out unauthorized people. This locked area can be a storage cabinet or an entire building.

If you are a certified applicator supervising non-certified applicators using restricted-use pesticides, you are responsible for the outcome.

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

Certified applicators that apply pesticides to public lands are required to keep records of both restricted-use and general use pesticides for two years.

compartment. Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are responsible and liable if curious children or careless adults are accidentally poisoned by the pesticides.

- Develop a method to communicate information on pesticide risks and exposures with the non-certified applicators under your supervision. Pesticide safety training must be presented in a manner that the non-certified applicator can understand. Recognize that cultural and language differences may pose substantial barriers to communication. If you are a certified applicator supervising non-certified applicators using restricted-use pesticides, you are responsible for the outcome. Take these communication requirements seriously to reduce the risk of accidents that could cause serious injury or environmental damage.
- Recognize that, as a pesticide applicator, you are the person people see applying pesticides. Communicating information about pesticide risks and exposures includes your customers and the general public, both of whom might be far less knowledgeable about pesticides, the risks they pose and the actions they can take to reduce those risks. Resources such as the National Pesticide Information Center are helpful for learning how to communicate risk and risk reduction to the general public. Plan all pesticide applications with safety of yourself, your coworkers, the general public, pets, livestock, wildlife and the environment in mind.

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. Temperature at the start and finish of the application
11. Wind velocity and wind direction at the start and finish of the application
12. Name of applicator and certification number if the pesticide is a restricted material
13. Miscellaneous comments

Certified applicators that use restricted-use pesticides are required to keep records for two years. Certified applicators that apply pesticides to public lands are required to keep records of both restricted-use and general use pesticides for two years. 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.

Additionally, keeping records helps ensure that different pesticides with different modes of action are used in situations where multiple pesticide applications are required. This helps reduce the potential for developing a resistant pest population.

More detailed information about record-keeping requirements can be obtained from the Nevada Department of Agriculture at https://agri.nv.gov/Resources/Forms/Division_of_Plant_Health_and_Compliance-Environmental_Services/.

Conclusion

Most pesticides are safe when properly used, but the user must **READ, UNDERSTAND, AND FOLLOW THE LABEL DIRECTIONS**.

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

Equipment and Calibration

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. New application equipment is constantly being developed.

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. They are inexpensive, simple to operate and easy to clean and store. 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. These sprayers are not suitable for treating large areas.

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. These systems are not good for small areas or spot treatments.

High-Volume Hydraulic Sprayers:

A type of directed sprayer, these are generally used in greenhouse or enclosed areas. These application systems are inexpensive to own and operate. They can be used to apply many different pesticides and can be used for spot treatments. They require careful calibration to ensure proper droplet size (not too large or too small) and reduce potential runoff. For larger greenhouse structures, this application system maybe very time consuming.

Low Volume Sprayers and Ultra Low Volume Sprayers:

These systems are used in greenhouses and other enclosed areas. They may be handheld and moveable, or they may be fixed within the structure. These include cold foggers, thermal pulse-jet foggers, air-assisted electrostatic sprayers, mechanical aerosol generators and ready to use aerosols. These low-volume and ultra-low volume sprayers take less time to make an application and have less potential for pesticide runoff. They produce small droplets that can move through the enclosed area. These application methods are not effective in open areas.

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, irregular 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. These systems are adaptable or adjustable to many different nozzles and application heights. The potential for drift increases the higher the nozzle height is from the ground surface.

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. These systems provide good coverage and penetration and provide high capacity. They also have high drift potential, are unsuitable in windy conditions and in small areas, and can have a high cost.

Granular applicators:

Equipment used to deliver granular pesticides include 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. Application of the granular pesticide material can be inconsistent. Using this application equipment requires calibration to make sure overlap creates an even application with no overapplication or application gaps.

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. This application method does not contribute to soil compaction. This method can also take advantage of weather windows; ground equipment may not be able to take advantage of these same weather windows. While pesticide drift is possible with any type of application equipment, drift is one of

the main disadvantages of applying pesticides through an aircraft. There is also potential for incomplete or inconsistent coverage.

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 reduces the potential for drift and is safer for non-target species. Applications are not influenced by wind or many other environmental factors. 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.

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. It can be used where soil treatments are not possible, such as wet, sandy, compacted or restricted soils. There is the potential to damage the bark-cambium interface. The application site can create damage that later becomes an entry point for disease or other pests. Applications of these pesticides should only be done to actively transpiring trees. Pesticide labeling may not allow systemic-injected pesticides to be used on many trees that produce fruit or nuts that will be consumed; read the label carefully. It may take some time for the application to move throughout the tree or shrub.

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.

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 fl 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:

Acre-Volume Method:

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

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

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

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

Refill Method Sprayer Calibration:

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:

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

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

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

To Find Acres Per Full Spray Tank:

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

To Determine the Final Spray Mixture:

Liquid Formulation:

From the Label: 4 Quarts/100 Gallons

Sprayer Tank = 175 Gallons

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

Dry Formulation:

From the Label: 2 Pounds per Acre

Sprayer Tank = 100 Gallons

Rate of Application = 22 Gallons/Acre

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

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

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).

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

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:

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

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

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

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:

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

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

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

Weigh the 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 = $2 \times \pi \times r$

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

Circumference = $2 \times 3.1416 \times 1280 = 8042$ 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:

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

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.

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

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

Calibrating a Stationary Sprinkler System

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

An advantage of the stationary system is 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:

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

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

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

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

   Example:
   Irrigation application efficiency = 80% (assumed) = 0.80
   Net irrigation = 1.0 in.
   Gross Irrigation Amount $= \frac{1.0\ inch}{0.80} = 1.25$ inches

   Irrigation Time $= \frac{1.25\ in}{0.24\ in/hr} = 5.2$ 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.
   Example: Injection Rate $= \frac{50\ Gallons}{2\ Hours} = 25$ Gallons per Hour

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

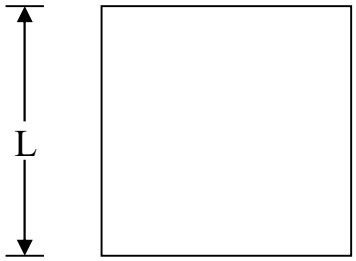
10. If the chemical solution is to be applied throughout or during the last part of the irrigation cycle, allow the irrigation system to operate for sufficient time after the injection to completely flush the chemical from the system. The time required will normally be a minimum of five minutes and may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

Determining Irrigated Acreages

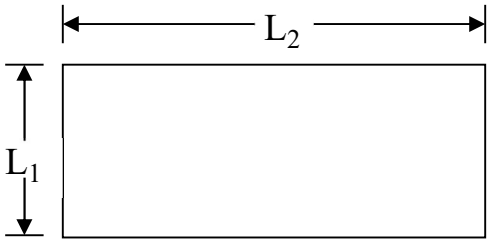
Formulas for calculating acreages in fields and irregular portions of fields are shown below. For irregular fields, sum the areas of the parts of the field using the closest approximations.

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

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

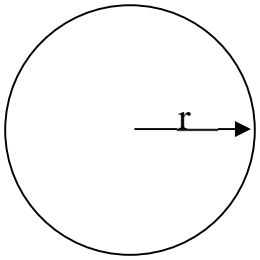


2. Area of a rectangular field.
   Area = L_1 X L_2
   If L_1 = 2640 feet and L_2 = 5280 Feet,
   Area = 2640' X 5280' = 13,939,200 sq. ft
   Acres = $\frac{13{,}939{,}200\ \text{sq. ft}}{43{,}560\ ft^2/\text{acre}}$ = 320 Acres



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

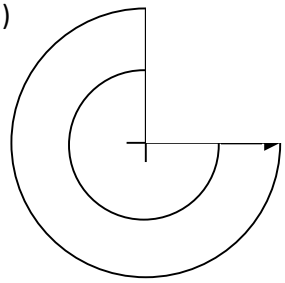
   Acres = $\frac{5{,}309{,}291\ \text{sq. ft}}{43{,}560\ \text{sq. ft}}$ = 121.88 Acres



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*)

360° (this is the total number of degrees in a circle)



If r = 1300 and <° = 270°

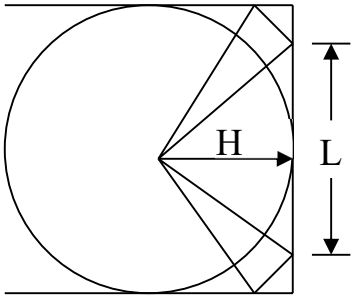
Area = (1300^2 X 3.1416) X $\frac{270°}{360°}$ = 3,981,978 ft^2

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.
Updated in 2022 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, 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?

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.

To answer these questions, you must understand how pesticides move in the environment and the chemical properties that control movement. There are 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 fate in the environment plays an important role in pesticide effectiveness. After application, pesticides 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 for earlier replanting. Other times, rapid degradation is not desirable, as the pesticide 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 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 into the soil, away from direct sunlight.

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

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

Pesticide degradation occurs in three basic ways:

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

How do Pesticides Move in the Environment?

It would be ideal if pesticides always remained on the target site, such as single plants, farm fields, roadsides, soil or structures. However, pesticides can move 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 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 are the product's active ingredient(s) or its breakdown product(s) that remain in the environment after application.

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

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.

- 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 plant parts, feed, seed or other plant-based products.
- Pesticide **residues** on or in animals that have been treated and moved to a new site. The residues can be in the meat, milk or fiber used by people, on animal fur or skin, in animal feces or other waste products, etc.

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

Pesticide 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.

Types of Pesticide Drift

There are two types of pesticide drift: particle drift and vapor drift. Drift may occur outdoors during agricultural and urban landscape 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 application site. 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 applied pesticide will

be converted to the volatile form. Pesticide labeling describes precautions to take 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-sized spray droplets are summarized in Table 1.

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.

Table 1: 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

Most farmers apply pesticides in less than 25 gallons of water per acre to minimize the quantity of water that needs to be hauled to the field. To achieve adequate coverage of the target area with these volumes, especially with post-emergence chemicals, it is necessary to equip the sprayer with

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.

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.

nozzles that produce small droplet sizes. These small droplets increase the potential for drift. 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 5 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 the small particles and can cause drift of some of the 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. Applicators also need to consider 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 pesticide spray increases the number of large droplets and reduces drift. Drift control agents include foam additives, invert emulsions and thickeners. Research with ground sprayers indicated that the addition of a spray thickener reduced spray drift by 66 to 90 percent. However, some post-emergence herbicides require small droplets for optimum performance, so techniques that increase droplet size may reduce weed control. Always follow the label directions regarding the use of any spray 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.

- 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.

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

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

  Keep booms mounted as low as possible to diminish wind effects but allow the recommended spray to 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 drift is usually greater from aerial applications than from ground applications.

- 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, such as stainless steel, are very durable. 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 to obtain uniform coverage.

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.

Don't apply pesticides under windy or gusty conditions.

Avoid spraying at temperatures above 90 F, ideally not over 85 F.

  - 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 specific nozzle type. Operating outside of the suggested range may distort the pattern, resulting in non-uniform coverage and often increasing drift.

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 that 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 to 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 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 honeybee 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.

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 **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.

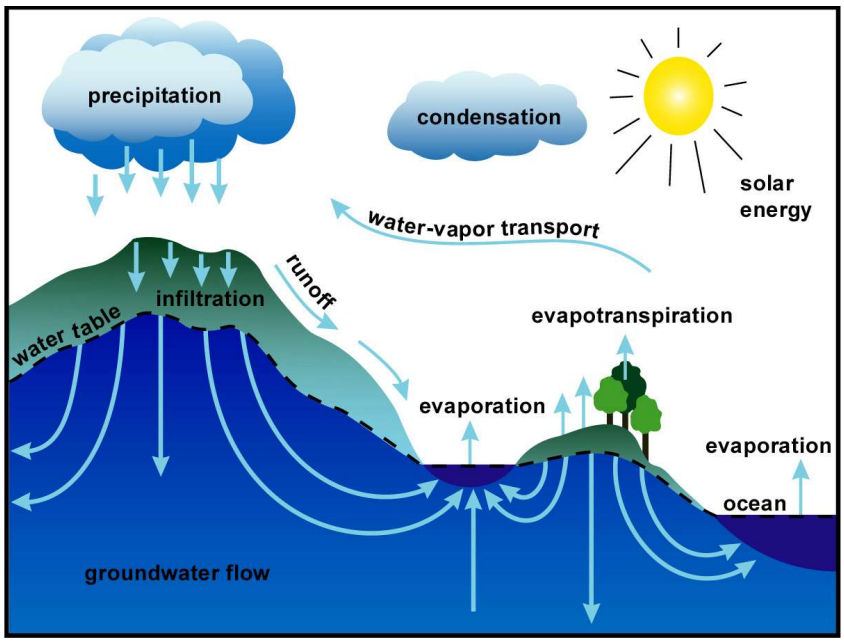
An aquifer is a geologic formation from which groundwater can be drawn. It can be a layer of sand, gravel or other soil materials, or a section of bedrock with fractures through which water can flow.

Groundwater is widely used for household and irrigation water supplies.

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.



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.

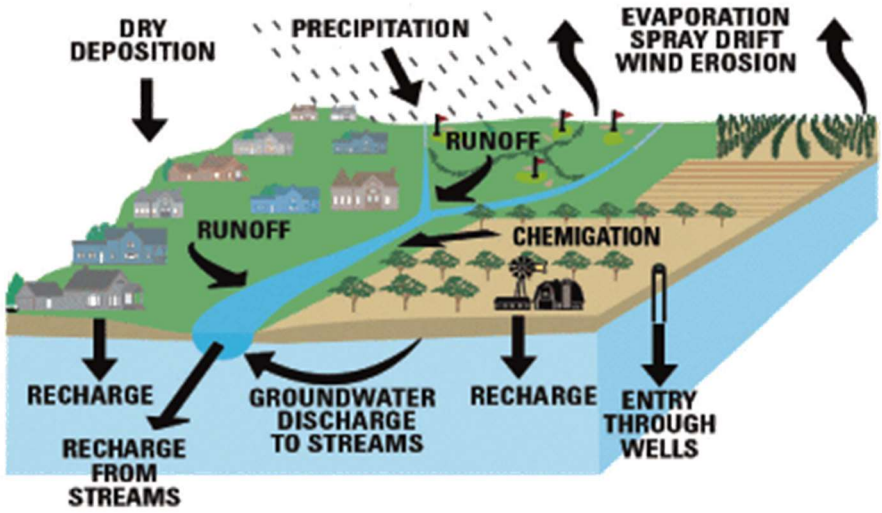
Pesticide Contamination and Water Resources

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 ability of the soil 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. It also illustrates the interaction that occurs between surface water and groundwater. Keep in mind that pesticides that reach surface waters can also contaminate groundwater through these interactions. (Modified from Gilliom and others, 2006.)



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.

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 move pesticides into surface water bodies, such as streams or lakes.

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.

Because of these factors, the risk of groundwater contamination is greater when pesticides are applied to gravelly or sandy soils than to other soil types.

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 and can be increased in terrain with steeper slopes and little vegetative cover. 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 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 directions on the pesticide label. The pesticide label is designed to provide the applicator with useful and important information 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 over spraying 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 pesticide disposal to avoid groundwater contamination. Triple-rinse or pressure-rinse 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.
- **Delay applications if precipitation is expected.** Do not apply pesticides if precipitation is expected. Pesticides can wash off the site in surface water runoff and contaminate both surface water and groundwater.

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.

- **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 and 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.

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.

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

Most phytotoxic injuries are due to herbicides that are persistent at the site of application. Persistent pesticide products may also injure succeeding crops or adjacent, non-target plants as their roots grow.

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 the 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 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 non-hazardous to bees whenever possible.
- Choose the least hazardous pesticide formulations. Emulsifiable concentrates are safer than wettable powders, and granules are the safest and least likely to harm bees.
- Determine if bees are foraging in the target area so that protective measures can be taken.
- Be aware that aerial 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.

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.

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.

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

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 labelled species of animal. For example, do not use pesticide products labeled for dogs on cats, as it could cause an adverse reaction in the cat.

Pesticide effects on livestock

Livestock poisoning by pesticides occurs as a result of contaminated feed or forage or 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 restrictions prevent adverse effects to livestock and livestock products that might occur as a result of pesticides used on pasture and range sites.

Pesticide effects on wildlife

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 may kill important insects that are a vital part of the food chain, beneficial insects that aid in controlling pests, and pollinators. 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.

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**.

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.

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 prohibited 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 several individuals from a “lower level.” For example, birds might eat insects, and then larger birds might eat smaller birds. 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.

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

Sublethal effects do not kill outright, but they interfere with survival and reproduction.

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

Biomagnification is the accumulation of persistent pesticides in animals in increasing concentrations as they move up the food chain.

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

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 https://heritage.nv.gov/

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 the organophosphate insecticide ethyl parathion to sunflower fields adjacent to wetlands in North Dakota led to the death of 96 percent of the mallard ducklings in the wetlands. When the pilot was instructed to avoid these areas, no deaths occurred.

Granular insecticides 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, choose chemicals that are not 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.
- 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 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

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

University of Nevada, Reno Extension
4955 Energy Way
Reno, NV 89502
Phone: 775-784-4848
Fax: 775-784-4881
https://extension.unr.edu

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

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

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.

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 water and groundwater if not applied correctly. Use pesticides carefully and thoughtfully.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

General Knowledge: Integrated Pest Management (IPM)

Integrated Pest Management (IPM) Learning Objectives

THIS CHAPTER IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR BOTH PRIVATE AND NON-PRIVATE CERTIFIED APPLICATORS GENERAL EXAM.

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) 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 presents special challenges. Urban IPM, or pest control programs that incorporate reduced use of

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

Principles of IPM

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

For pest identification help, go to

http://ipm.ucanr.edu

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

pesticides in homes, private and commercial landscapes, golf courses and structural 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, Reno Extension or the Nevada Department of Agriculture for identification. Many university websites have photo galleries to help identify pests. The University of California Statewide Integrated Pest Management website at http://ipm.ucanr.edu has good information. 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 considered 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 four categories: economic, aesthetic, emotional and human health and safety.

   The **economic threshold** is defined as the pest population level that produces damage equal to the cost of treatment. 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 are 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. Each property or situation my have a different aesthetic threshold.

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.

Human health and safety: Point at which the pest infestation causes enough health or safety concerns 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 to 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 saccharinum*) or boxelder tree (*Acer negundo*) will help avoid problems with boxelder bugs. Boxelder bugs do not prey on Norway maples, but both silver maple and boxelder 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 controls: Cultural controls are the practices or strategies we use to grow and maintain healthy plants and animals. Cultural practices, such as proper fertilizer application, 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 that 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 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.

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

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 control 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.

Good sanitation can prevent many pest infestations.

Eliminate food and water sources for pests.

Eliminate shelter sites for pests.

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

Changing the environment is another cultural control 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 controls: 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 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.

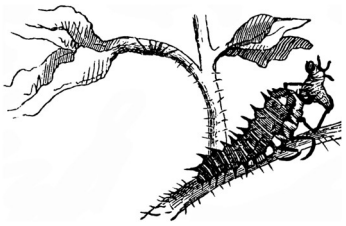
Biological controls: Biological pest control is the use of a living organism to control another living organism. The importance of using biological control agents to control insect and disease pests is often overlooked. Biological agents of landscape pests include:

- **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



Mechanical controls include hoeing.

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



Lady bird beetle larva.



Grazing animals, such as this goat can slow the spread of weeds.

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

coyotes, 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 bacterium that is effective at controlling insects in their larval stage. There are two common commercial varieties: kurstaki (Btk), which controls caterpillars and israelensis (Bti) which controls mosquitoes, black flies, and fungus gnats. Bt products are 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 several 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 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, 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, but 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 consider 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.

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/biological-control-program.

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.

Why Use Integrated Pest Management (IPM)?

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

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

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 can 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 a 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.

For more information, go to A Green Industry Professional's Guide to Integrated Pest Management (IPM), University of Nevada, Reno Extension Special Publication SP-17-14 at https://naes.agnt.unr.edu/PMS/Pubs/2020-2326.pdf. A hard copy of this publication is available at the Washoe County Extension office at 4955 Energy Way, Reno, Nevada.

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.

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Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture

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

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General Knowledge: General Pest Problems

General Pest Problems Learning Objectives

THIS CHAPTER IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR BOTH PRIVATE AND NON-PRIVATE CERTIFIED APPLICATORS GENERAL EXAM.

After studying this section, you should be able to:

- ✓ **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.**
- ✓ **Describe several symptoms common to plant diseases.**
- ✓ **Provide examples of invertebrate pests.**
- ✓ **Describe the two life cycles of insects.**
- ✓ **Describe several plant symptoms of insect infestations.**
- ✓ **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

Four groups of pests:

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

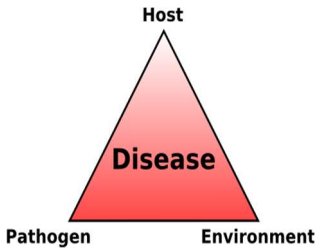
The first step in pest control is proper identification of the pest.

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

individual category chapters, which are more specific to pests encountered in the specific sites.

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, Reno 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 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 and viroids
- 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 peroxyacyl nitrate 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 and viroids:** These are the smallest of the microscopic pathogens and are not visible, even with a regular microscope. Viruses reproduce

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

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

Fungi are the largest group of plant pathogens.

within the plant and may cause strange plant forms, structures or even colors. Viruses can be easily spread from one plant to another by vectors. A vector is a plant or animal that spreads a pathogen but does not cause the 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 in the green areas of leaves or on fruit), ring spots, leaf curling, leaf rolling, 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,

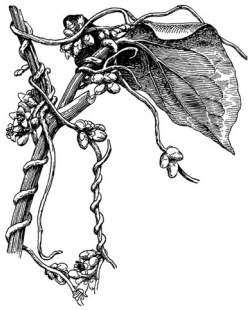
producing toxins and enzymes that disrupt normal plant growth and functions. Individual fungi generally grow as fine, thread-like, microscopic structures called hyphae. The hyphae can form a network, which is called a mycelium. The mycelium can be macroscopic (visible with the naked eye). Fungi also form fruiting structures, of which the most 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 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 decreases 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):** 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 and contaminated soil or seed. The seeds from these plants can remain viable in the soil for several years, awaiting a susceptible host.

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

Much of plant disease diagnosis is based upon recognizing the characteristic

Necrosis: the dead or dying portions of a plant.

Hypoplasia: stunting of all or specific plant parts.

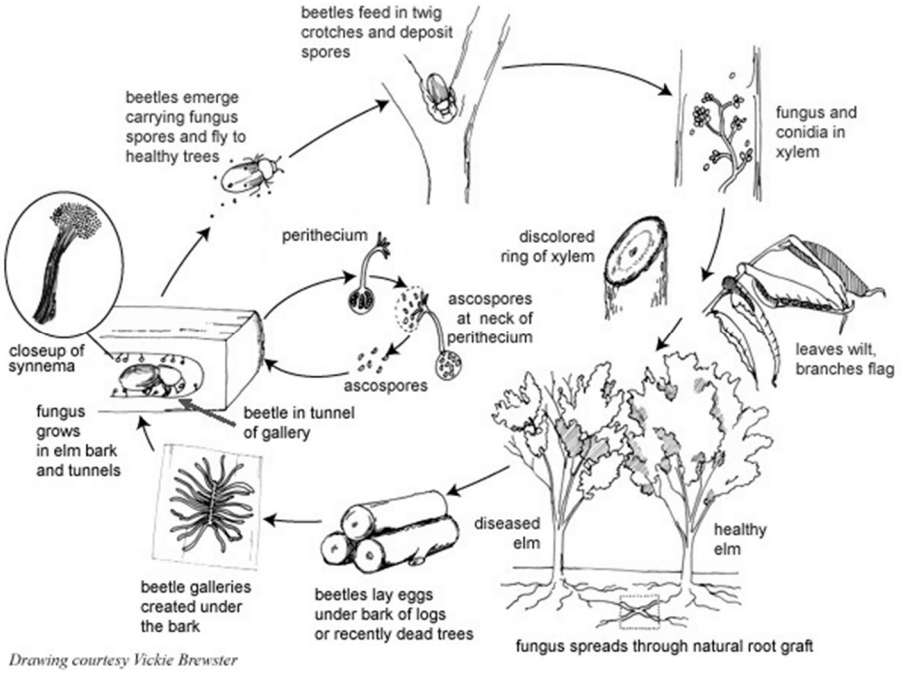
Hyperplasia: over-development of specific plant parts.

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

symptoms that plants express as a result of their abnormal physiology. There are three general types of plant disease symptoms:

- **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 important factors of disease development. In many instances, signs of the pathogen, such as mushrooms, conks, bacterial ooze, etc., are important in disease diagnosis.



Dutch Elm Disease Cycle, APS.net

Plant diseases occur in cyclic fashion depending upon the pathogen type. The

sequence of events that develops in plant disease is called the disease cycle. It is important to understand the disease cycle since effective control is dependent upon interrupting this cycle at some point.

The disease cycle begins with initial infection by the overwintering stage of the biotic agent, known as primary inoculum. In this early stage, the pathogen usually has a small population and often can be controlled. Control measures, however, must be carefully selected, since different pathogens require different methods. Initial infection occurs when inoculum, such as fungus spores, bacterial cells, etc., are spread by wind, water, insects, humans, equipment, etc. onto host surfaces or infection courts. When environmental conditions favor the infection process, a host plant, or a portion of it, may be killed. The pathogen may grow out from killed plant tissue and re-infect other plants, creating many cycles of infection during a growing season. Most air-borne diseases have multiple cycles of infection. In contrast, soil-borne diseases generally have only one cycle of infection. Protective chemicals applied before infection occurs often give good levels of control. If infection occurs, the pathogen proceeds to colonize the host and reproduce itself in large numbers inside plant tissue. At this point, a systemic chemical may be applied to control disease symptoms and reduce the production of secondary inoculum. The environment condition is critical to shift a disease from isolated cases to an epidemic. Obtaining adequate control at this point is usually needed. Eradicative, protective and in some instances, therapeutic chemicals, are used to reverse disease development. As the nutrient 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.

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 by 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.

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.

Rusts are diseases caused by fungi and are named for the yellow to reddish spore masses they form on plant surfaces.

Hail, sunscald, pruning wounds, damage from improper staking and maintenance, as well as infectious agents, may cause cankers.

- **Smuts** are destructive diseases of plants, especially cereal grains, that produce black, powdery masses of spores. Smuts are caused by fungi.

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.

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 can attack healthy plants, while others attack only plants under stress.

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 cytospora canker, cypress canker and fireblight.

Root Rots: Root rots are difficult to diagnose because the affected portion of the plant is underground. Look at the entire root system of container plants and portions of an established system in order to diagnose root rot. When a root system deteriorates as a result of root rot damage, above-ground symptoms may include dieback, wilting, small leaves, dead leaves and increased seed production. These symptoms are similar to the damage caused by several abiotic disorders including over-watering, herbicide damage or mineral toxicity. Most fungi that cause root diseases occur naturally in the soil, and they usually persist for long periods of time. Infected roots may be enlarged, slimy, wet and dark in color. 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 and bedding plant crops and on landscape ornamentals. Selecting virus-free

Root rots are difficult to diagnose because the affected portion of the plant is underground.

Root rots can be avoided by using soil mixes that drain well.

Avoid overwatering which causes soggy soils.

Reduce soil compaction.

Common virus symptoms include stunting, mottling, mosaic patterns, lack of or reduced flowering, chlorosis, or changes in the normal development of leaves and buds.

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.

Plant disease management principles:

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

plants with known resistance to common viral diseases is the best control strategy.

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

Other Diseases: Other diseases include blights, scabs, smuts, galls and storage rots (commonly found on stored bulbs, corms, rhizomes or tubers).

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.

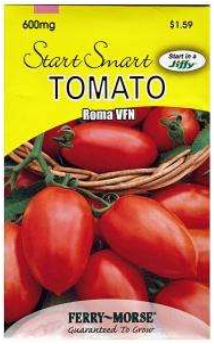
- **Exclusion:** For plant disease management, exclusion consists of practices designed to keep pathogens, vectors and infected plants out of disease-free areas. The goal of this method of management is to prevent the disease from entering the area where the plants are growing. Plant only disease-free 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 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 photo 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 to 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.



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**

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. Prevention
   b. Cultural
   c. Physical/mechanical
   d. Biological
   e. 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 have no backbone and include insects, spiders, snails and slugs.

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.

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

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 people grow or use. 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 human 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 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

Insects are an essential part of any ecosystem.

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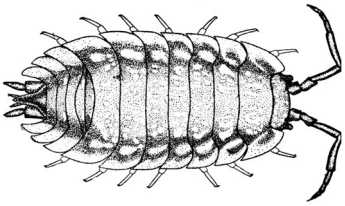
Keeping records of pest observations may aid in predicting and preventing future outbreaks.

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.



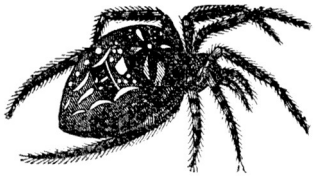
Crustaceans



Millipedes



Centipedes



Arachnids

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, Reno 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

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



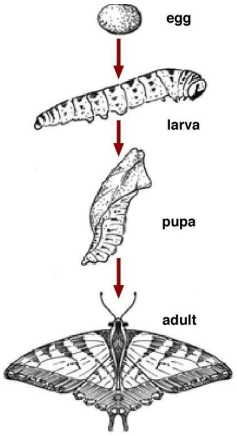
Typical insect

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.

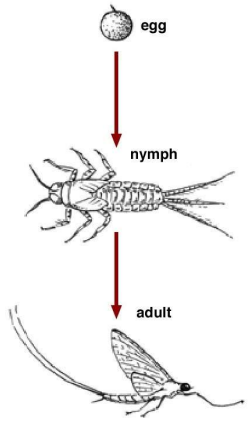
Insect life cycles

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.



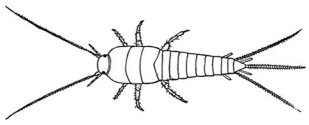
Complete metamorphosis
egg, larva, pupa, adult
UNCE

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.



Incomplete metamorphosis
egg, nymph, adult
UNCE

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.



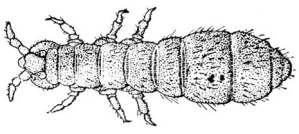




Table 6. Distinguishing characteristics of insects among orders

Order	Mouthparts	Life Cycle	Wings
Zygentoma	chewing	incomplete	none
Collembola	chewing	incomplete	none
Dermaptera	chewing	incomplete	none, 2pr
Isoptera	chewing	incomplete	2 pr
Orthoptera	chewing	incomplete	2pr
Mallophaga	chewing	incomplete	none
Anoplura	sucking	incomplete	none
Thysanoptera	rasping	complete	2pr, none
Hemiptera	sucking	incomplete	2pr
Blattodea (Blattaria)	chewing	incomplete	2 pr
Neuroptera	chewing	complete	2 pr
Lepidoptera	chewing	complete	2 pr
Coleoptera	chewing	complete	2 pr
Siphonaptera	sucking	complete	none
Hymenoptera	chewing/lapping	complete	2 pr
Diptera	lapping-chewing sucking-sponging	complete	1 pr

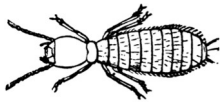
Insect Orders

Zygentoma: 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.

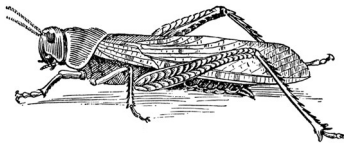
Collembola: Springtails make up this order. Small, wingless insects without compound eyes, these insects go through a simple life cycle. They get around using a tail-like structure that folds beneath their body and propels them. They inhabit moist areas and may be a nuisance in homes. Only one is known to feed on seedlings and mushrooms. Technically, these are not considered insects anymore, but are left in this section for purposes of discussion.

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.

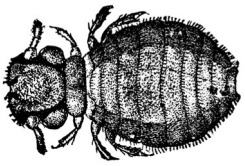
Isoptera: Termites have a broad juncture at the abdomen and thorax, reproductive termites have two pairs of similar-sized and -shaped, membranous wings and moniliform (string of beads) antennae. They are pests of wood and require cellulose from wood or other plant tissue for food. They are social insects.



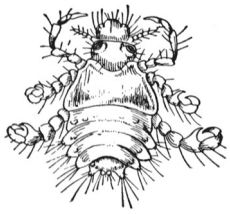
Orthoptera: This order contains the grasshoppers, crickets, praying mantis and walking sticks. Their life cycle is simple. They have strong chewing mouthparts. Their rear wings are membranous and are covered and protected by the front pair. Most are large insects and many are pests.



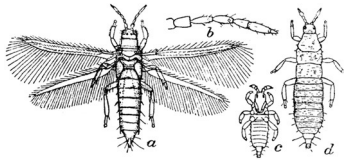
Mallophaga: Chewing lice. Small, wingless, chewing insects, the chewing lice have a simple life cycle spent entirely on the host. The head is wider than the thorax. Most attack birds, domestic fowl and mammals as ectoparasites (external parasites), but not humans.



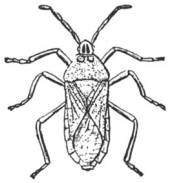
Anoplura: Sucking lice. These small ectoparasites suck blood from mammals, are wingless, and their long, pointed heads are narrower than their thorax. The life cycle of sucking lice is simple. These insects irritate livestock, reducing their vitality. They also transmit diseases to animals and humans.



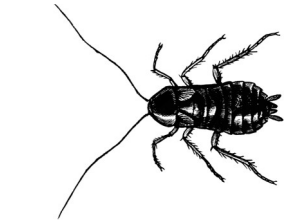
Thysanoptera: Thrips are minute insects and may be winged or wingless. If winged, there are four narrow wings with long hairs. They have a complete life cycle and feed by rasping-sucking plant juices. Most feed on flowers, buds, and leaves. Some are predaceous species to other insects.



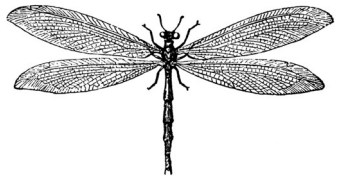
Hemiptera: This order contains the true bugs, including boxelder bugs, leaf-footed bugs, stink bugs, assassin bugs, big-eyed bugs, minute pirate bugs and bed bugs. They can be recognized by the X formed by the wings. This order includes both pests and beneficial insects. This order also now includes the former order **Homoptera,** which includes aphids, leafhoppers, cicadas, scales and mealy bugs; all these insects are plant feeders and may be pests. The insects in this order 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.



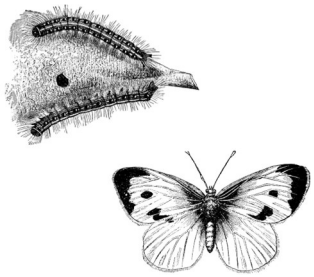




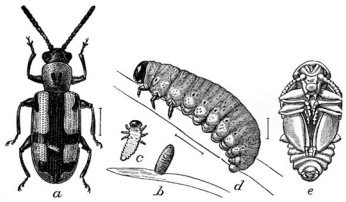
Blattodea: Cockroach family. Cockroaches have an oval, brown to black body, two pairs of membranous wings, if present, and long antennae. Their head is bowed down and covered with a pronotum. They run rapidly and hide from light.



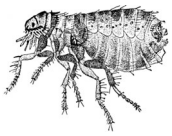
Neuroptera: Antlions and lacewings are in this order. Most of the members of this order are predacious. The adults have wings that have numerous veins, giving them a net-like appearance. Larvae can be destructive. They have chewing mouthparts. They have complete life cycles and many are important aquatic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



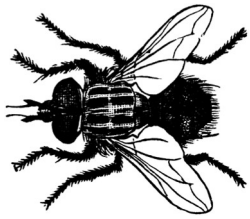
Coleoptera: This is the largest order of insects, with over 300,000 species. Most can be easily identified by the hardened forewings, called elytra. This order contains both beneficial and injurious species of beetles. The larvae are grubs and are economically important. They have a complete life cycle.



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 some 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.

Typical Symptoms of Insect and Other 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.

Leaf spots are most frequently caused by plant pathogens. Sucking insects, such as leafhoppers, may also cause leaf spots.

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.

Many beetle larvae and caterpillars bore into tree trunks or limbs, causing the infested tissues to swell or form cankers.

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.

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.

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.

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.

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 plant 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 infestations of insect pests, 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, 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 a broad range of insects, pest or beneficial.
    - Contact insecticides: chemicals that kill the insect pest only where

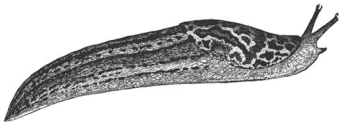
Integrated Pest Management (IPM) control methods:

- **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 site listed on the label?**
- **Is the plant or crop (or animal) to be treated listed on the label?**



Slug



Mussels

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.

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. As of 2021, 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 https://www.ndow.org/wp-content/uploads/2021/11/Fisheries_kt_AIS-Decal-Brochure_current.pdf for more information.

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.

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 detrimental or destructive and difficult to control or eradicate. 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 despite 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

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, https://extension.unr.edu/program.aspx?ID=15 scroll down and select a weed.

Nevada Nuisance Weed Field Guide, https://naes.agnt.unr.edu/PMS/Pubs/1399_2019_01.pdf

Weeds are:

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

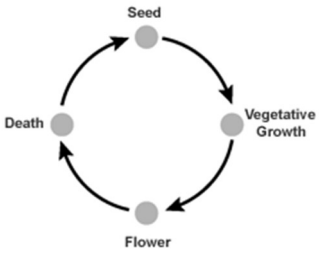


Seedling



Mature plant

Annual growth cycle



Biennial growth cycle

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 to no 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."

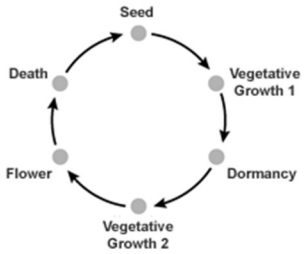
Most plants go through these four stages of development. The time it takes them to do so is another way plants are subdivided.

Plant Life Cycles

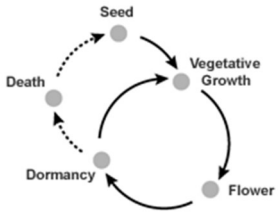
- **Annuals** are those plants that go through all four stages of growth in one year, hence the name annual. That is, they germinate, form a seedling, grow, mature, flower, produce and drop seed and die, all in one growing season or year. Reproduction in annuals is entirely from seed. Annuals are often 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 common 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, produces 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 plants that take two growing seasons to go through all four stages of development.
  - First year, the seed germinates and forms a seedling. The 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 the 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 weeds are perennial plants.
  - Simple perennials are plants that reproduce by seed and pieces of roots. Examples are dandelion, plantain and some 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.



Perennial growth cycle



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.

Classification by Habitat

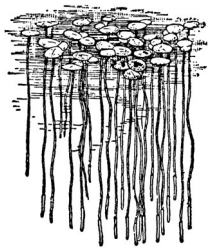
- **Aquatic plants** are those that can survive submersed in water for all or most of the time. These plants have special adaptations that allow them to survive immersed in water. They are divided into two major groups: vascular plants and algae.
  - **Vascular aquatic plants** have roots, stems and 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



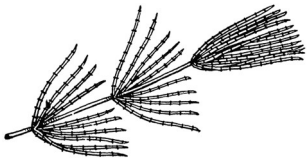
Cattails



Water lily



Duckweed



Chara



Grass 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 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.)

Botanic Classification of Terrestrial Plants

- **Grasses:** These plants are monocots and have one seed leaf. They grow narrow, upright leaves. The leaves (blades) 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:** Also monocots, 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.

Weed control strategies

Most effective weed control management plans include two or more control strategies; this is integrated Pest Management or IPM. Weed IPM 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.
  - Selective herbicides: Chemicals that kill specific types of plants.
  - Nonselective herbicides: Chemicals that kill all types of plants.
  - Contact herbicides: Chemicals that kill the plant only where the chemical touches the plant. They require thorough coverage, are quick-acting and are available for the control of annuals, biennials and seedling perennials.
  - Systemic herbicides: Chemicals that are absorbed through the leaves or roots and move 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



Broadleaf plant

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.**

Chemical weed control:
READ THE LABEL

- **Is the site listed on the label?**
- **Is the plant or crop to be treated listed on the label?**

time to be effective and may be soil or foliage applied.

Factors affecting chemical weed control

Stage of growth

- Seedlings: Very susceptible; all life cycles (annual, biennial and perennial) can be controlled.
- Vegetative: Effective for annuals and biennials, but less so than the seedling stage; chemical control of perennials is poor.
- Flowering: Nearly impossible to control annuals and biennials at this stage of growth; very effective on perennials, particularly at bud or early flowering.
- Post-maturity: Plant is in a dry-down state; annuals and biennials are not affected by chemicals at this stage; 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 weed plants, and this effect may be compounded by lack of winter tolerance due to the action of the herbicide or inability to compete 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 herbicides 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.

Plant factors affecting chemical control:

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

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 they dry before being 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 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 particles are intermediate in size between sand and clay particles. 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.

Soil factors that affect chemical weed control include:

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

Higher humidity reduces evaporation which increases absorption of herbicides into plants.

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 the 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 into plants 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, 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.

Vertebrate Pests

Common vertebrate pest control practices:

- **Exclusion**
- **Sanitation**
- **Trapping**
- **Repellents**
- **Baits**
- **Fumigants**

Vertebrate pests are 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 feed, 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

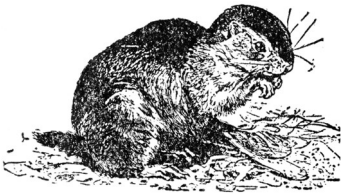
or plague, along with them. Live trapping followed by an approved method of euthanasia is recommended. The American Veterinary Medical Association has specific guidelines for euthanasia.

- **Repellents:** Repellents 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 re-treated, 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:** Aluminum phosphide fumigants are available either as tablets or pellets. Their use is limited to insects which infest stored commodities and for 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 Category 4 Non-soil Fumigation certification category.

Specific Vertebrate Pests

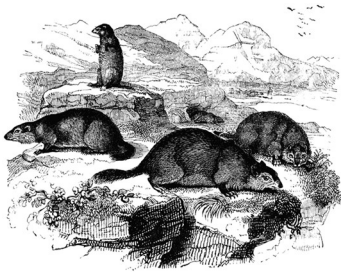
- **Ground Squirrels:** Four species cause problems to crop and ornamental plants in Nevada: Richardson's, Belding's, Townsend's and California ground squirrels. They may also damage irrigation lines by chewing, or they may damage landscape and buildings by burrowing. The best time for control is after 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

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.



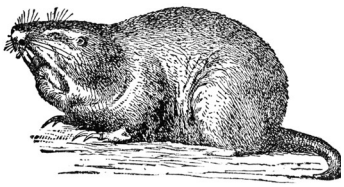
Marmots



Meadow vole



Mole



Pocket gopher

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 only be used underground 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 baits. 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.

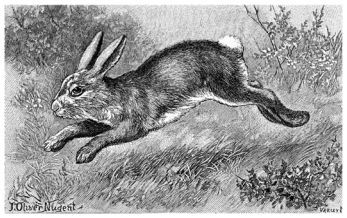
- **Wood rats or pack rats:** Wood or pack rats will set up house in sheds, attics, garages and other structures. They are messy and carry disease. Like all rodents, their teeth continue to grow their whole lives. They must gnaw or chew on things to wear away their teeth. They can cause structural damage 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 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 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 10 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 ¼ 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



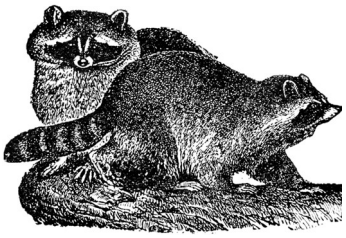
House mouse



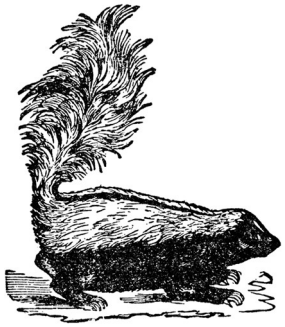
Deer mouse



Jack Rabbit



Raccoons



Skunk

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 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, 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, such as rabies and leptospirosis, that can affect both humans and domestic animals. 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

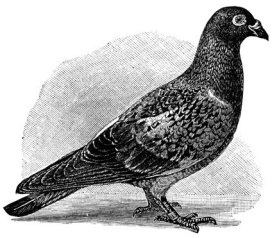
box-style trap to reduce the potential for getting sprayed.

- **Birds:** Droppings, disease potential, and consumption of crops and livestock feeds make pests of certain birds. Bird management includes excluding 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.

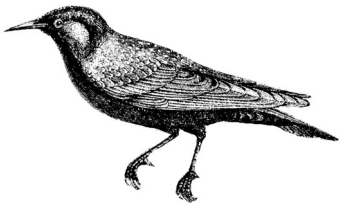
  Caution must be used when dealing with bird pests, as many birds are protected under the Migratory Bird Treaty Act (MBTA). As with all other pests, you must first identify the pest causing your problems. The following common bird pests are <u>not protected</u> by the MBTA.

  - **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.

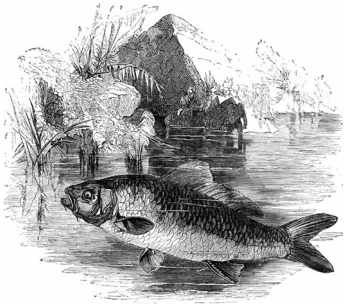
- **Fish Pests**<u>:</u> Fish become pests when they are introduced into waters where they compete with more desirable species. Exotic species such as carp were introduced to North America from Asia. Carp has become one of the most serious fish pests. Also, game fish such as pike, bass or trout, when introduced, can compete for food or prey on native and more desirable species.



Pigeon



Starling



Carp



Pike

The first step in pest control is to properly identify the pest.

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.
Updated 2022 by M. Hefner, University of Nevada, Reno Extension and B. Allen, J. Dick, J. Knight, S. Wang, and R. Saliga, Nevada Department of Agriculture.

Category A: Agricultural Plant Pest Control

Agricultural Plant Pest Control Learning Objectives

THIS CATEGORY IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR THE GENERAL EXAM FOR PRIVATE CERTIFIED APPLICATORS. NON-PRIVATE CERTIFIED APPLICATORS MAY BE CERTIFIED IN THIS CATEGORY BY TAKING A SEPARATE CATEGORY EXAM.

After studying this section, you should be able to:

- ✓ **Describe some of the most common insect pests of agricultural crops.**
- ✓ **Describe the most common diseases found on common Nevada crops.**
- ✓ **Describe chemigation system design and the purpose of the chemigation hardware.**
- ✓ **List the advantages and disadvantages of chemigation pesticide applications.**
- ✓ **Describe special considerations for greenhouse pesticide applications.**

Category A, Agricultural Plant Pest Control

Category A, Agricultural Plant Pest Control, is the category that covers pesticide applications on crops. This includes fruit and vegetable crops, small grain crops, feed crops and forage crops. It also includes the specialized pest control measures that must be considered in nursery and greenhouse settings, including chemigation. Disinfectants used to sterilize plant containers, working surfaces and equipment in the nursery and greenhouse setting are considered pesticides. Plant growth regulators, used to keep potted flowering plants compact, are also considered pesticides.

Agricultural crop production provides the ideal conditions for weeds to grow ground disturbance, irrigation and even nutrients. The growth of a single

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

type of plant, also known as a monoculture, can provide an ideal setting for diseases and insect pests to develop and thrive. Greenhouse and nursery production can provide a habitat for insect pests and diseases to thrive. Vertebrate pests may also be a concern in cropland, nursery, and greenhouse settings.

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 2021 changes to the certification categories require all PRIVATE Certified Applicators to be tested on both Category A, Agricultural Plant Pest Control and Category B, Agricultural Animal Pest Control as part of the general knowledge exam. For NON-PRIVATE Certified Applicators, Category A, Agricultural Plant Pest Control and Category B, Agricultural Animal Pest Control remain certification categories, with each requiring a separate exam.

Principles of IPM:

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

For more information on IPM, please refer to the General Knowledge: Integrated Pest Management chapter of this workbook.

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, in nurseries and in greenhouses.

- **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, Reno 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 ladybird 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 considered 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 or other agricultural product? **What will happen if no action is**

taken? The action threshold in agricultural 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 or reducing damage by controlling the pest. The threshold is the pest density, or population level, at which a pesticide or other control method should be implemented.

- **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.

For further information on Integrated Pest Management, consult the General Knowledge: IPM chapter in this manual.

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:

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.org/wps/htc/htcmanual.pdf

Effective control measures require correct identification and a thorough understanding of the pest's life cycle and biology.

- 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 they 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.

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 the monocultures formed by agricultural crop production and 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.

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 and on field crops. Effective control measures require correct identification and a thorough understanding of the pest's life cycle and biology.

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.

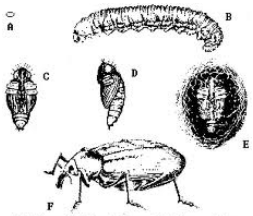
Insect outbreaks often result from one or more of the following factors:

- 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.

Specific Insect Pests in Agricultural Plants

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.



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

Alfalfa weevil
ipm.ncsu.edu

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

Mites are not insects, but arachnids; they have eight legs.

Mites often appear under dry conditions prior to the first irrigation.

Almost every plant has its own type or types of aphid pests.

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.

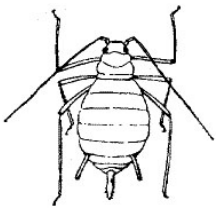
Mites: Mites are not insects, but arachnids. They have two body parts and eight legs. Mites often appear under dry conditions prior to the first irrigation. Often the first irrigation will reduce their populations by knocking them off the plants and interrupting their life cycle. Mites cause damage by 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. Cleaning up field debris is important to reduce overwintering populations and reducing pressure on next season's crop. Bush beans have been shown to be an excellent early indicator of spider mite presence in tomato and pepper crops, showing damage weeks before the crop. A number of predatory mite species have been developed into effective biocontrol's for control of mites on greenhouse crops and in orchards. Some of these predatory mites, such *Amblyseius fallacis*, feed on pollen when pests are not present and are effective when released early in the season before pest pressure is detected. Other species, such as *Phytoseiulus persimilis*, are highly specific to the target pest and can provide good control when released after pests have been detected. It is essential to select biocontrol species based on environmental conditions, as establishment depends on suitable temperature, humidity, and day length. Additionally, proper identification of pest species is necessary; some biocontrol species are generalist predators, while others are highly specific to the target pest. Biocontrol suppliers and crop advisors can aid in selection of biocontrol's appropriate for the environmental conditions and target pest. Mites can be controlled with acaricides (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. Some species are also vectors of plant diseases. 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.

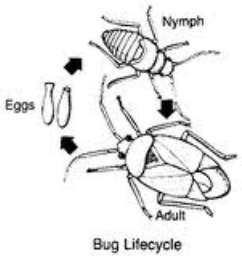
The typical aphid overwinters as either a sexually produced egg or as an adult female. This may occur on a summer host or on an alternate winter host. In the spring, eggs hatch, producing winged adults, or the overwintering adult females move to the summer host. The females mature and begin producing 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 plant growth can help plants tolerate aphid feeding. Resistant cultivars are available. Early harvesting may help to reduce numbers. The effect of naturally occurring pest predators should not be discounted and should be thoughtfully considered when selecting pesticides for controlling aphids. Parasitoid wasps, minute pirate bugs, lacewings, syrphid flies and ladybird beetles can be attracted in large numbers to fields and high tunnels by providing pollen-producing plants interplanted in the crop or along field boarders. Sweet alyssum, buckwheat and marigolds are commonly used in combination to provide season long pollen and habitat for these species. IPM programs for various greenhouse crops have been developed based on parasitoid wasps of the genus *Aphidius* and the predatory midge *Aphidoletes aphidimyza*. Biological control using naturally occurring pest predators can keep aphid numbers below action thresholds. Chemical controls should be applied thoughtfully to minimize injury to these beneficial insects.



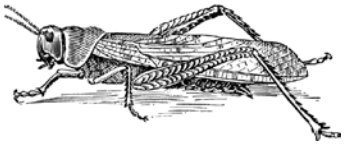
Aphid
extension.missouri.edu

Lygus bugs: These are primarily pests 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 plant maturation, seed set 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.



Lygus bug
www3.telus.net

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/sq. 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



Grasshopper

It is important to report Mormon cricket infestations to the Nevada Department of Agriculture (NDA) using the form found at this link: https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Entomology/mc_gh_form_2013_4.pdf.

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.

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 several 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. It is important to report Mormon cricket infestations to the Nevada Department of Agriculture (NDA) using the form found at this link: https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Entomology/mc_gh_form_2013_4.pdf. Reporting to the NDA helps in controlling the current infestation and in predicting future infestations.

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, with different modes of action, are available. Pesticide baits are also available. Since Mormon crickets cannibalize their dead, the bait that kills one Mormon cricket may kill a second or third with subsequent feeding

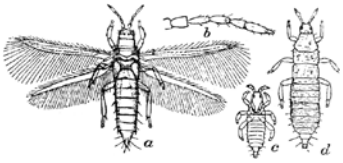
within the band. If you are using chickens as a biological control, you may not want to use these baits or many of the other chemical controls. Other chemical controls include growth regulators. The choice of growth regulator is based on several factors, including the age of the cricket population, forage 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 about 10 insects per leaf. Thrips are vectors for a number of economically important viruses, such as Tomato Spotted Necrotic Wilt Virus (TSNW). Thrips on other crops can cause cupped or silvered leaves, deformed flowers and problems in pollination, resulting from their rasping style of feeding.

Thrips are very difficult to control. Blue sticky cards can be used to monitor for thrips arrival and population numbers in established infestations. Identification of thrips species and survey of damage are important prior to control measures. Beneficial predatory thrips commonly occur in agricultural crops and don't cause damage to plants; they may contribute to suppression of pests. Consider crop rotation and sanitation near crops, such as removing alternate host plants and planting trap crops. Biocontrol programs have been developed for greenhouse cucumbers using a combination of the predatory mites *Amblyseius cucumeris* and *Stratiolaelaps scimitus*. Chemical controls may also be used for control.

There are several varieties of **stink bugs**. They feed on a variety of plants, resulting in 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.

One species of stink bug, **the brown marmorated stink bug (BMSB)**, is causing problems in the eastern United States. It has been found in Nevada and adjacent states. It is 1/2 to 3/4 inch long, marbled brown and shield shaped. Its antennae have white bands, and the edges of its abdomen have alternating light and dark markings. Like most stink bugs, they stink when crushed. BMSB attacks over 170 plant species, including fruit trees. Their piercing/sucking mouth parts cause a variety of damage symptoms, depending on the plant or crop. Additionally, they emit aggregation hormones in the fall and overwinter in homes in attics, crawl spaces, etc. All stink bug controls, including BMSB, include exclusion from homes and debris clean up to prevent overwintering sites. Light and pheromone traps may be



Thrips



BMSB, Dr. Janos Bodor, Calphotos.



BMSB eggs and nymphs, Dr. Janos Bodor, Calphotos.

effective. Biological controls include birds that eat adults and beneficial insects, such as lady bugs and lacewings, that consume the eggs. Stink bugs are difficult to control using pesticides. For more information on BMSB, go to www.stopbmsb.org.



Emerald Ash Borer with paperclip for scale. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org.

Emerald ash borer (EAB) is an exotic beetle that attacks ash trees. Adult beetles are metallic green and about ½ inch long. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Adults leave a D-shaped exit hole in the bark when they emerge in spring. Adults remain active until the end of summer.

Emerald ash borer is thought to have arrived in the United States on solid wood packing material carried in cargo ships or airplanes originating in its native Asia. As of October 2018, it is now found in 35 states, and the Canadian provinces of Ontario, Quebec, New Brunswick, Nova Scotia and Manitoba. Part of the spread of the EAB is through moving firewood.

Prevention measures include a ban on moving firewood from areas with an infestation. Monitor for this pest. New infestations are difficult to detect, as damage to the tree may not be apparent for up to three years. Symptoms of an infestation can include branch dieback in the upper crown, excessive suckers or water sprouts forming on the tree trunk, and vertical bark splits. Woodpeckers like EAB larva, so heavy woodpecker damage on ash trees may be a sign of EAB infestation. There are several different types of chemical controls that may be effective, including systemic insecticides applied as a soil drench and soil or truck injections. New formulations are being tested for effectiveness against EAB; consult with your pesticide dealer for the latest formulations. Read, understand and follow label directions. For more information and to track the spread of EAB, go to the EAB Information Network at http://www.emeraldashborer.info/.



White satin moth. Perry Hampson, Bugwood.org.

A caterpillar pest causing damage in forest and landscape trees in Nevada is the **white satin moth**. The caterpillar of white satin moth causes damage by feeding on poplar, cottonwood, aspen and willow, and sometimes on oak and crabapple trees. The caterpillar will skeletonize leaves by feeding on the leaf tissue between the veins. Extensive infestations can cause defoliation and branch dieback. Severe infestations can cause tree death.

Adult moths are about 1 inch in length and may have a wingspan of up to 2 inches. They have a silvery-white body and satin-like wings. Caterpillars vary in color from pale to medium grayish brown to black. Full sized caterpillars are 1.75 inches long. They have a very distinctive pattern of markings on their backs. A row of yellowish or milky white circular shapes runs down the length of its back, with rows of reddish-brown circles in pairs on either side of the yellowish or milky white circular shapes. Additionally, tufts of reddish-brown hairs stick straight out of its sides and back.

The life cycle of the white satin moth is unusual. It overwinters as a caterpillar, emerging to feed in the spring. In early summer, the caterpillars spin cocoons, and the moths emerge shortly afterwards. The moths lay egg masses until late summer, and young caterpillars feed in late summer to early fall. For this reason, the full-sized caterpillars actually show up in the early spring while the newly hatched caterpillars show up during late summer/early fall.

Scout regularly for these pests. Keep landscape trees healthy by managing water and pruning properly. Biological controls include birds, parasitic wasps, lacewings, predatory mites, and some beetle species. A microbial insecticide, *Bacillus thuringiensis kurstaki* (Btk), can be effective on the caterpillar stage of the white satin moth. This material must be ingested by the caterpillars as they feed on the leaves. Repeated application may be required as the application may wash off. Chemical controls include several foliar-applied insecticides. Some of these insecticides are toxic to beneficial insects and pollinators, so applications should not be made when the trees are blooming. These are foliar applications, not systemic insecticides, so large trees may be difficult to completely treat. Systemic insecticides are not effective. New insecticide formulations are being developed all the time; consult with your pesticide dealer for the latest formulations that may be effective for white satin moth control. For more information go to https://forestry.nv.gov/uploads/missions/20210302_AMT_2019_White_Satin_Moth_Fact_Sheet.pdf.

Gypsy moth (aka spongy moth): There are two varieties: European gypsy moth and Asian gypsy moth. Both have a voracious appetite and will attack more than 300 species of trees and shrubs. Both overwinter as eggs, which are laid in sheltered areas, such as underneath the bark of trees, eaves of homes and other structures or other outdoor objects. Eggs hatch in the spring. Caterpillars are striking, with five pairs of blue dots followed by six pairs of red dots along their backs. The body of the caterpillar is dark colored with light brown hairs. The older caterpillars are 1.5 to 2 inches long. In early summer, the caterpillars pupate, with the moths emerging 10-14 days later. Female moths have a tan-colored body and white to cream-colored wings. Females have a 2-inch wingspan. European gypsy moth females cannot fly; Asian gypsy moth females are capable of flight. Male gypsy moths are smaller than females, with a 1.5-inch wingspan. The males are darker colored and have feathery antennae. Both have distinctive markings on the wing: an inverted V shape that points to a dot on the wings. The gypsy moth has one generation per year.

Early detection and rapid elimination of infestations in Nevada have prevented large infestations of gypsy moth from developing. States with infestations have found the following control measures useful:



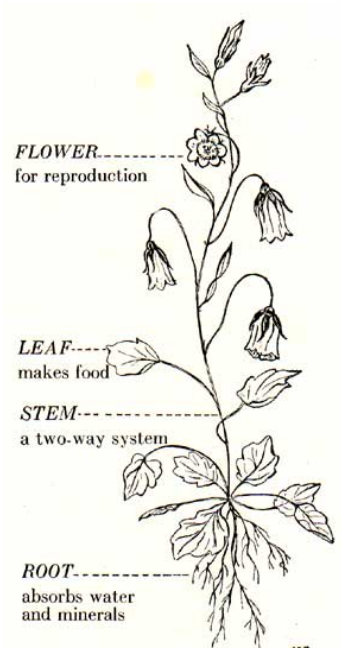
White satin moth caterpillar. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org.



Gypsy or Spongy Moth caterpillar. USDA Forest Service- Region 8 - Southern, USDA Forest Service, Bugwood.org.



Gypsy moth female (white) and male (gray). USDA APHIS PPQ, Bugwood.org.



Typical flowering plant
plant-care.com

- Mass trapping with pheromone-baited traps.
- Release of sterile male gypsy moths.
- Mating disruption with a registered synthetic version of the pheromone disparlure in products such as Disrupt®II, Luretape Gypsy Moth®, and Luretape Plus®.
- Diflubenzuron (Dimilin®), an insect growth regulator.
- *Bacillus thuringiensis kurstaki* (Btk), a microbe that is a natural disease agent of caterpillars. Several registered Btk products are available for use.

For more information on Gypsy or Spongy moth go to:
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187452.pdf

https://www.fs.usda.gov/foresthealth/docs/fidls/FIDL-162-SpongyMoth.pdf

Identification of Common Landscape Pests and Beneficial Organisms in Nevada: https://naes.agnt.unr.edu/PMS/Pubs/2006-4051.pdf

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 honeybee. 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 https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Plant/Entomology/nevada_pollinator_protection_plan_final.pdf.

Weeds Pests in Agricultural Plants

General information on weeds is covered in the General Knowledge: General Pest Problems chapter 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, Reno 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 begins. 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 factors such 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 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.

Successful weed management considers all the potential control methods available:

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

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

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

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 landowners 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, Reno Extension, 775-784-4848. The following publications may help in identifying noxious weeds: Nevada Noxious Weed Field Guide, available by weed name at the University of Nevada, Reno Extension website at https://extension.unr.edu/program.aspx?ID=15 (scroll down and click on the weed you are interested in) and Nevada Nuisance Weed Field Guide, https://naes.agnt.unr.edu/PMS/Pubs/1399_2019_01.pdf. Hard copies of both of these publications are available at most University of Nevada, Reno Extension offices throughout the state.

Plant Diseases in Agricultural Plants

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 the potential control methods; this is called Integrated Pest Management or IPM. The potential control methods are:

- Prevention
- Cultural controls
- Physical or mechanical controls
- Biological controls
- Chemical controls

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

IPM is discussed in detail in the General Knowledge: Integrated Pest Management (IPM) chapter of this manual.

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.

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

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.

Specific Diseases in Agricultural Plants

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



Alfalfa

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:

Phytopthora root rot occurs most often in soils with poor drainage or where water stands for an extended amount of time.

- ***Phytophthora* root rot:** The fungus causing this disease is present in the soil, where the disease can build up. 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. Symptoms include 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.

Damping off is caused by several soil-borne fungi.

- **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, by contaminated equipment, and by 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. Using a soil fumigant requires an additional certification in Category 5: Soil Fumigation.

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, and 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

Nematodes are microscopic roundworms that live in the soil and feed on alfalfa roots.

Common leafspot is favored in cool to moderate temperatures and wet conditions. It can be a problem in the first and second cuttings of alfalfa.

Downy mildew is another fungal disease that favors cool, wet climate conditions.

Dodder is a parasitic plant that attaches to and eventually kills its host plant.



Potato

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 surfaces 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 yield 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 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 bullseye 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 (four to six 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

Destroying all cull piles as the final sanitation practice in the fall will help to control all the potato diseases discussed here.

Calico Virus in potatoes is caused by the same virus that causes alfalfa mosaic disease.

Verticillium Wilt is a fungal disease that plugs the water-conducting tissues, causing premature yellowing and death of the foliage.

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 two to six 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.

Smuts are the major disease problem for small grains.

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

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.

The major disease problems of onions and garlic are 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.
- **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-planting soil fumigation is effective for control. Soil fumigation requires and additional certification in Category L3: Soil Fumigation.

- **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 many fruits and vegetables in Nevada. Symptoms are a powdery mycelium and spores on all foliage. Control: This fungal disease is best controlled with various copper and/or sulfur formulations.
- **Fireblight** 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 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.



Pear, Apple



Melon



Tomatoes

Chemigation is the application of agricultural chemicals, both pesticides and fertilizers, through an irrigation system.

Chemigation may save time (labor) and money by reducing the need for personnel and equipment.

- **Curly Top Virus** is a disease that affects tomatoes in Nevada. This disease is transmitted by leafhoppers, which carry the disease for life. Leafhoppers 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. Leafhoppers 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 leafhoppers. Talc, diatomaceous earth, or finely ground pumice are equally effective. There are no curly top resistant varieties of tomato to date.

Chemigation

Chemigation is the process of applying agricultural pesticides through floods, drips, sprinklers, and other types of irrigation systems. Applications of pesticides through an irrigation system requires thoughtful planning, specialized equipment, and additional safety measures to protect applicators and co-workers and also protect water resources. 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.

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.
- 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 pesticide 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.

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 and 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.

Specific safety precautions, specialized equipment and training are required for chemigation.

Potential for contamination of water sources is higher with chemigation than with other pesticide application methods.

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.

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.

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 micro-irrigation, including drip 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 micro-irrigation systems in the United States.

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 devices listed in table A.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 A.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 discussed above, 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

Check Valves and Vacuum Relief Valves: Check valves 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. If 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,

Check valves and vacuum relief valves (anti-siphon devices) keep water and/or pesticide and water from backflowing or siphoning back into the irrigation water source should the irrigation pump shut down.

The following sketch shows a chemigation layout that includes the United States Environmental Protection Agency's (EPA) required safety devices.

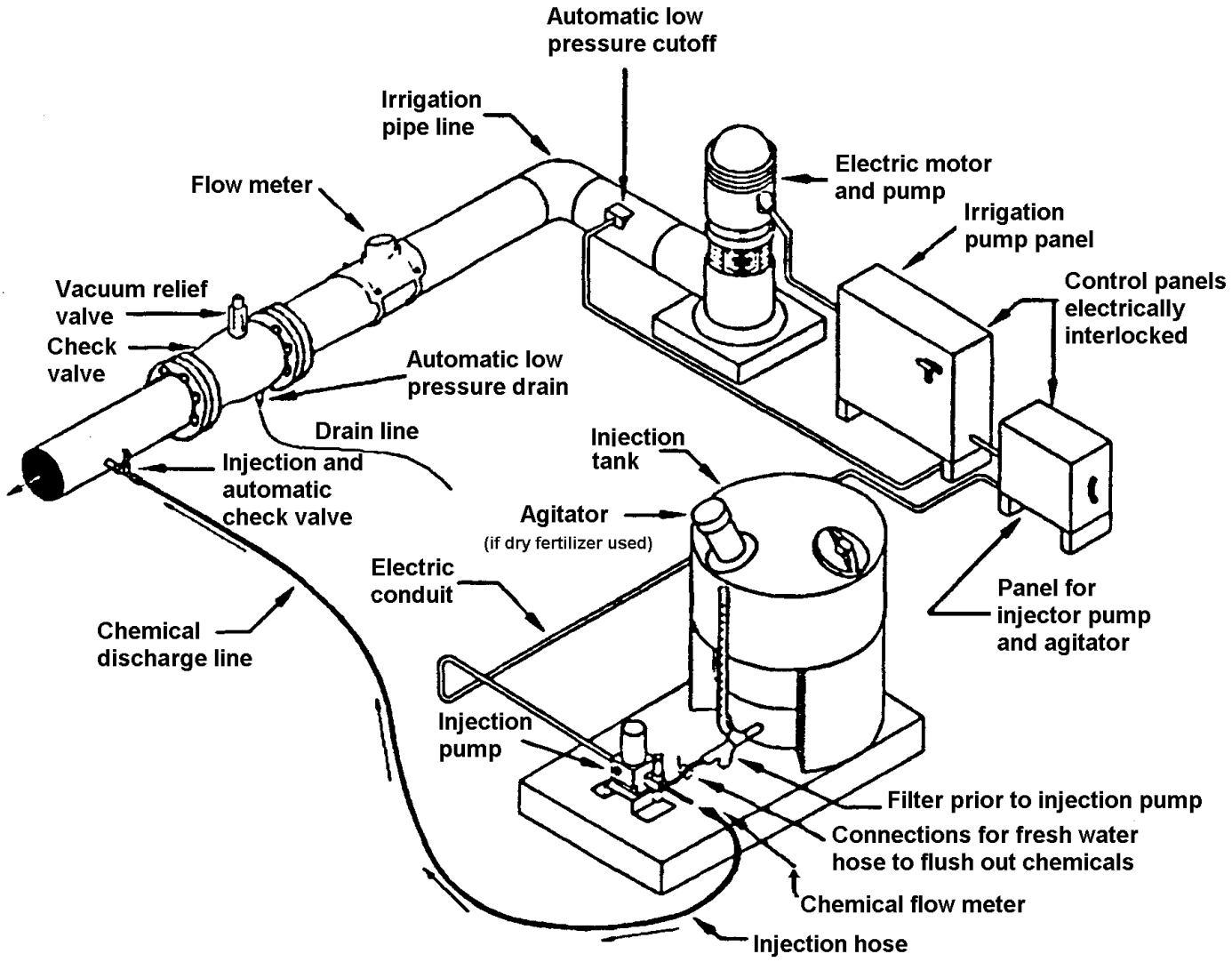


Table A.1. Description of required safety devices

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 1A.2.*

Table A.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 dis placement 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

Chemigation safety devices must ensure that if the irrigation pump stops, the pesticide injection also stops.

Each pesticide label must state that the pesticide product can be chemigated. Applicators must adhere to the instructions provided on the pesticide container labels.

Inspect hoses regularly for leaks and cracks.

Low-Pressure Drain continued: 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.

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

Hoses: In most cases, hoses should be constructed of reinforced braided Ethyl Vinyl Acetate (EVA). EVA is:

- Flexible at a wide range of temperatures.
- Capable of working at pressures up to 200 psi.
- 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.

Fittings: 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.

Tanks: **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.

Containment Structures: 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.

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

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 corrosion.

For safety reasons, it is important to maintain a clean chemigation area.

Always follow label instructions for safety.

There are many types of injectors on the market. Some require power, and others do not.

(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.

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.

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

Special Considerations for Greenhouse Pesticide 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

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.

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.

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.

Vertebrate Pests in Agricultural Plants

Vertebrate pests are those pest animals that have backbones. Specific control measures vary for different species and are discussed individually in the General Pest Problems chapter of this manual.

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:** Repellents 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:** To purchase, apply or supervise the use of this pesticide, applicators must successfully pass the Category L2, Non-Soil Fumigation category exam.

Common vertebrate pest control practices:

- **Exclusion**
- **Sanitation**
- **Trapping**
- **Repellents**
- **Rodenticide baits**
- **Fumigation**

Fumigation requires certification in Category L2 Non-soil Fumigation.

Specific Vertebrate Pests: Please refer to the vertebrate pest section of the General Knowledge: General Pest Problems chapter in this manual.

Conclusion

Category A, Agricultural Plant Pest Control, is the category that covers pesticide applications on crops. This includes fruit and vegetable crops, small grain crops, feed crops, forage crops, nurseries, and greenhouses.

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 your management efforts and their success.

The first step in pest control is to correctly identify the pest. It is imperative to determine that the damage you see was caused by a 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 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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

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Category B: Agricultural Animal Pest Control

Agricultural Animal Pest Control Learning Objectives

THIS CATEGORY IS PART OF THE GENERAL KNOWLEDGE REQUIRED FOR THE GENERAL EXAM FOR PRIVATE CERTIFIED APPLICATORS. NON-PRIVATE CERTIFIED APPLICATORS MAY BE CERTIFIED IN THIS CATEGORY BY TAKING A SEPARATE CATEGORY EXAM.

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.**
- ✓ **Describe the use of contraceptives in wild and feral horses and burros.**

Category B, Agricultural Animal Pest Control

Category B, Agricultural Animal Pest Control, 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.

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

Category B, Agricultural Animal Pest Control covers the pest control of both internal and external parasites in livestock.

produce, such as milk, eggs and fiber, will be used or consumed by humans, as will the animals themselves. Thoughtful planning and implementation are required to minimize unintended damage, reduce costs and maximize profit.

Additionally, this category provides the certification required for those wishing to use contraceptives on wild and feral horses and burros. The exam for this category will include reading a contraceptive label and answering questions on the label.

2021 changes to the certification categories require all PRIVATE Certified Applicators to be tested on both Category A, Agricultural Plant Pest Control and Category B, Agricultural Animal Pest Control as part of the general knowledge exam. For NON-PRIVATE Certified Applicators, Category A, Agricultural Plant Pest Control and Category B, Agricultural Animal Pest Control remain certification categories, with each requiring a separate category exam.

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 modes of action to reduce the risk of developing pesticide resistance.

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, Reno 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 considered 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 modes of action to reduce the risk of developing pesticide resistance.
- **Monitor, evaluate and document the results.** This allows you to make adjustments to your pest control plan to improve the effectiveness of future pest control strategies.

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

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.

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 are the biggest pest problem affecting livestock production.

Insect pests of livestock can be divided into two basic categories: endoparasites and ectoparasites.

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.

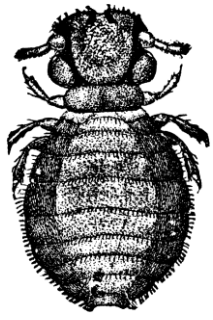
Endoparasites are those that spend their entire lives inside the animals.

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.

Ectoparasites spend all or a portion of their lives living on the outside of the animal.

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



Chewing Lice

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 several 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.

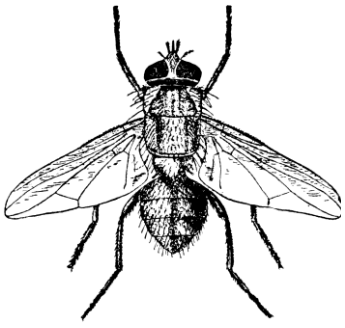
Horn Fly: Horn flies are small (3-4 mm) gray-black flies. When feeding on livestock, they are usually in a head-down position. Horn flies have piercing sucking-type mouth parts and they feed on livestock blood. They are the number one pest of cattle in the world. The fly spends all its adult life on 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 two 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

Lice are about the size of a flea and will be observed moving around.

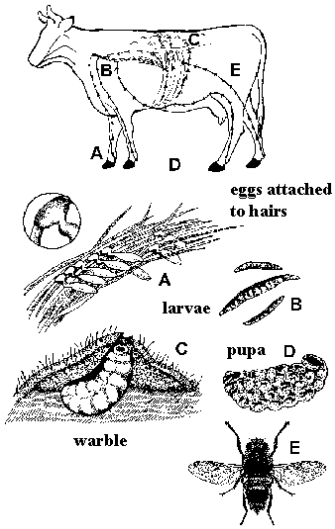
Lice are the most common ectoparasite of swine.

Two of the most common ectoparasite pests of beef cattle are the horn fly and lice.



Horn Fly

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.



Life cycle of Heel or Grub Fly
http://edis.ifas.ufl.edu/in146

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 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 humans. 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.

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 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 are 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 flies are about 6 mm in length and dull gray in color, with four 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

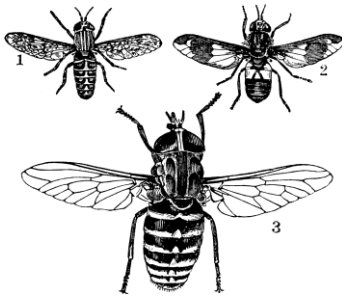
Since adult heel or grub (bomb) flies do not feed, treatment and control are focused on the larvae.



House Fly



Stable Fly



Horse Flies

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 mm 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 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.

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 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 mm 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 can 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 mm 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 five 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.

Ticks: Ticks are small arthropods with eight legs and no antennae. Ticks can be subdivided into hard, or ixodid, 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 hard 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.

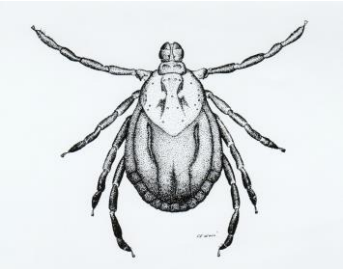
Hard ticks include the American dog tick, the brown dog tick, Rocky Mountain wood tick, the deer tick, also known as the black-legged tick, and the winter tick, also known as the moose tick. Ticks acquire their host animals by a behavior called "questing." The tick climbs onto vegetation, such as a grass 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. 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 (*Ricksettsia rickettsia*), Lyme disease (*Borrelia burgdorferi* and *Borrelia mayonii*), Colorado tick fever (CTF virus) and tularemia (*Francisella tularensis*). It is important to identify the type of tick to determine if further testing for disease is warranted. The following websites have pictures of the individual ticks mentioned at several life stages:

The Centers for Disease Control and Prevention, Tick Website, https://www.cdc.gov/ticks/index.html

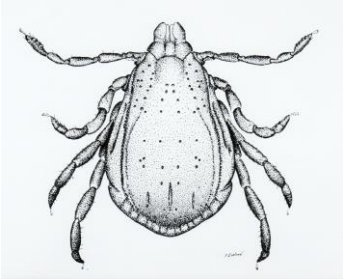
The University of Rhode Island Tick Encounter website, https://web.uri.edu/tickencounter/fieldguide/

The American dog tick (*Dermacantor similis*) is found west of the Rocky Mountains. These ticks most commonly feed on dogs but will also feed on

Face flies can be a vector of *Moraxella bovis*, more commonly known as pink eye.



American dog tick. Drawing by F. E. Wood, umd.edu.



Brown dog tick. Drawing by F. E. Wood, umd.edu.



Western black legged tick. by F. E. Wood, umd.edu.

rodents, livestock and humans. Adult females are most likely to bite humans. American dog ticks can transmit tulameria and, Rocky Mountain spotted fever.

The brown dog tick (*Rhipicephalus sanguineus*) feed mainly on dogs, but will feed on livestock, wildlife and humans. It can transmit Rocky Mountain spotted fever and is considered the primary vector of the disease in the southwestern United States. It also transmits other diseases to dogs only. Unlike other ticks, the brown dog tick can complete its entire life cycle indoors. Severe infestations will require good sanitation and several treatments over several months to eradicate.

The Rocky Mountain wood tick (*Dermacentor andersoni*) feeds on small rodents in the larval and nymph stages and on large mammals, including humans, as adults. These ticks transmit Rocky Mountain spotted fever and tularemia to humans, cats and dogs. They can transmit Colorado tick fever virus to humans. They also can transmit *Anaplasma marginale* to cattle.

The deer tick, also known as the western black legged tick (*Ixodes pacificus*), feeds on lizards, birds and rodents in the larval and nymph stages. As adults, they feed on deer and other large mammals, including livestock. The nymphs and adult females have been reported to feed on humans. These ticks transmit Lyme disease and very likely *Borrelia miyamotoi* disease, a form of relapsing fever.

The winter tick, also known as the moose tick (*Dermacentor albipictus*), feeds on large-hooved mammals, both wildlife and livestock. These ticks do not feed on humans. Deer and most other mammals can remove the ticks during grooming, but moose cannot remove them during grooming and can die from a severe infestation.

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 modes of action. Rotating ear tags with different modes 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 living and nesting areas.

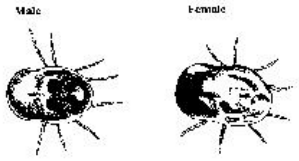
Spinose Ear Ticks: These pests are soft ticks that infest cattle, horses, dogs and humans. They spend their larval and nymph stages feeding in the ear canal. Affected animals will shake their heads and rub their ears, trying to dislodge the pests. Animals with severe infestations will appear dull and 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 four 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.

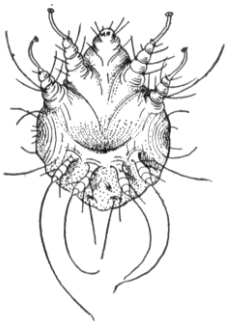
Psoroptic Mange Mites: Psoroptic mange mites are non-burrowing mites that live on the skin surface of infected animals. These mites puncture the skin and feed on lymph fluids (clear body fluids, not blood) or feed on skin scales. Feeding causes intense itching and scabs. These mites tend to affect the 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 that they develop weeping sore



Spinose Ear Ticks
ianrpubs.unl.edu



Sarcoptic Mange Mite

Incidence of sarcoptic mange should be reported to the Nevada State Veterinarian.

ZonaStat-H is a porcine zona pellucida (PZP) immuno-contraceptive vaccine for use in limiting the populations of wild and feral horses and burros.

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.

Wild and Feral Horse and Burro Contraception

Wild and feral horses and burros may become pests in some situations. Wild horse and burro herd populations have significantly increased in some areas, exceeding the appropriate population levels on those public lands. Uncontrolled populations may lead to adverse environmental effects, such as degradation of wildlife and native vegetation habitat. Additionally, these populations may lead to conflicts with other rangeland uses, such as cattle grazing and recreation. To help control these populations, wild and feral horses and burros may be removed and transferred to private ownership. They may be maintained in holding facilities, which can be very expensive. Another option being tested in several areas of the United States is ZonaStat-H, a porcine zona pellucida (PZP) immunocontraceptive vaccine for use in limiting the populations of wild and feral horses and burros. This product is a restricted-use pesticide in Nevada. The product may only be used on wild and feral horses and burros. Individuals must be certified pesticide applicators and must follow label instructions for application of this product. **Reading a label from this product and answering a few questions based on the label will be part of the general test for PRIVATE certified applicators and part of the category exam for NON-PRIVATE certified applicators.**

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 are 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.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen, D. Farris and R. Saliga, Nevada Department of Agriculture.

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Category C: Forest Pest Control

Forest Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLIICATORS BY TAKING A SEPARATE CATEGORY EXAM.

After studying this section, you should be able to:

- ✓ **Define the major forest 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 forests.**
- ✓ **Identify the different control methods available for IWM.**
- ✓ **Describe the most common vertebrate pests that impact forests in Nevada and control strategies for each.**

Category C, Forest Pest Control

Category C, Forest Pest Control, covers insects, plant pathogens, weeds and vertebrate pests that cause damage on or interfere with land use on forest sites. Nevada's forests provide valuable forage and habitat for wildlife and, to a lesser extent, livestock. 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. 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.

Category C, Forest Pest Control, is the category that covers pests of forest trees, both evergreen and deciduous.

Forest Uses:

- **Watershed protection**
- **Wildlife habitat**
- **Timber management**
- **Recreation**
- **Forage for livestock**
- **Tree nurseries**
- **Suburban and urban forest**

Only 6percent of the approximately 8.3 million acres of unreserved forest land in Nevada is classified as timberland; the other 94 percent is classified as unproductive forest land.

Pinyon/juniper forest-type group makes up 80 percent of Nevada's forests.

Types of Forests in Nevada

The information presented in this section is from the USDA Forest Service Rocky Mountain Research Station website at https://www.fs.usda.gov/rmrs/interior-west-forest-inventory-analysis-nevada. This information is based on a 2015 forest survey.

Nevada's forests cover 10.6 million acres, or about 16 percent, of the land in the state. The forests cover a wide variety of environments and forest types that are valued for scenic beauty, wood and non-timber forest products, wildlife habitat and ecosystems services.

The Bureau of Land Management (BLM) manages 6.6 million acres, or 63 percent, of the state's forested lands. 6.1 million acres of this land is unreserved; 0.5 million acres consists of reserved areas, such as wilderness areas. Of the 6.1 million acres of forest unreserved, only 73,000 acres is classified as productive timberland.

The USDA Forest Service manages about 3.2 million acres of forested land in Nevada. 2.2 million acres of this land is classified as unreserved, with the remaining 1.0 million acres classified as reserved areas, such as wilderness areas. Of the 2.2 million acres of unreserved in Nevada, only 144,000 acres are classified as productive timberland.

Private owners, such as Native American tribes, individuals, families and corporations, manage 411,000 acres of forest land in Nevada. There are other public agencies that manage very small portions of Nevada Forested land, including Department of Defense, Department of Energy, U. S. Fish and Wildlife Services, the National Park Service and the state of Nevada.

Only 6 percent of the approximately 8.3 million acres of unreserved forest land is classified as timberland; the other 94 percent is classified as unproductive forest land.

Nevada's forests span a wide range of environments, from pinyon/juniper woodlands to timber forests in the high mountain ranges.

Pinyon/juniper forest-type group makes up 80 percent of Nevada's forests. The most common species are Utah juniper or singleleaf pinyon, but curlleaf mountain mahogany, western juniper, white fir, ponderosa pine, quaking aspen, subalpine fir, whitebark pine and Great Basin bristlecone pine are also found in different areas around the state.

In the Sierra Nevada, the forest land is heavily populated by Jeffrey pine, with California red fir, lodgepole pine, white fir and quaking aspen also common.

Other Forest Related Resources in Nevada

The following is information from the Nevada Division of Forestry website at http://forestry.nv.gov/natural-resource-management/state-conservation-nurseries.

The Nevada Division of Forestry has two state nurseries that offer plants for sale: the Las Vegas State Tree Nursery, located at Floyd P. Lamb City Park at Tule Springs, which offers plants adapted to the Mojave Desert, and the Washoe State Tree Nursery, located in Washoe Valley between Carson City and Reno, which offers plant materials adapted to the Great Basin Desert and the Sierra Nevada Region.

Both NDF nurseries provide custom growing services to state and federal agencies, municipalities, tribes, conservation groups, contractors and individuals for restoration and conservation projects across Nevada and neighboring states.

Rural tree sales are offered for sale in Elko twice a year, generally in May and October.

The Nevada Division of Forestry also has the Nevada Seedbank program, which provides seed, equipment and other materials to rehabilitate wildland fire and fire suppression related damages. It also assists private landowners and public agencies with conservation treatments on their land to reduce soil erosion, increase plant diversity, improve wildlife habitat and reduce the threat of wildland fire.

Nevada Division of Forestry has several forest related resources available; visit their website at http://forestry.nv.gov/natural-resource-management/state-conservation-nurseries

Forest Insect Pests

Native and exotic pest species present unique threats to forests in Nevada. 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. 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 are chewing insects that attack foliage.



Douglas-fir tussock moth caterpillar. William M. Ciesla, Forest Health Management International, Bugwood.org.



Douglas-fir tussock moth. William M. Ciesla, Forest Health Management International, Bugwood.org.



Western tent caterpillars. Whitney Cranshaw, CSU, Bugwood.org.



Gypsy or Spongy Moth caterpillar. USDA Forest Service- Region 8 - Southern, Bugwood.org.

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.

Douglas-fir tussock moth: Feeds on Douglas-fir, all true firs, spruce and occasionally on other pines. Caterpillar larvae feed in the spring and early summer, starting with buds and old needles and moving on to new foliage as it grows. Mature caterpillar larvae are 1 inch long and brown with prominent ivory spots. Adult moths are mottled rust-brown and have a wingspan of slightly less than 1 inch. Female moths lay eggs on needles in late summer. Larvae hatch and overwinter in sheltered sites. This moth is a native insect but is capable of significant defoliation, sometimes causing top kill and mortality of trees.

Tent caterpillar: Feeds on aspen, birch, oak, some maples and other deciduous tree species. This is a native insect that can cause significant damage of both urban and native forests. This pest overwinters as an egg. Eggs hatch in the spring and tend to migrate high in the tree, feeding on foliage. There are several different species of tent caterpillar, but all form the distinctive "tent" of webbing that protects them from predators. The adult moths are variable in color from dark reddish-brown to tan, yellow or gray. Pruning out the infested branches is a viable control method for small infestations in urban forests, but not viable for forest scale infestations. Many insect predators and parasites feed on tent caterpillars, along with birds.

In North America, the primary introduced defoliator of forests is the **gypsy moth (aka spongy 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.

There are two varieties: European gypsy moth and Asian gypsy moth. They both have a voracious appetite and will attack more than 300 species of trees and shrubs. They both overwinter as eggs, which are laid in sheltered areas, such as underneath the bark of trees, eaves of homes and other structures or outdoor objects. Eggs hatch in the spring. Caterpillars are striking, with five pairs of blue dots followed by six pairs of red dots along their backs. The body of the caterpillar is dark colored with light brown hairs. The older caterpillars are 1.5 to 2 inches long. In early summer, the caterpillars pupate, with the moths emerging 10-14 days later. Female moths

have a tan-colored body and white- to cream-colored wings. Females have a 2-inch wingspan. European gypsy moth females cannot fly; Asian gypsy moth females are capable of flight. Male gypsy moths are smaller than females, with a 1.5-inch wingspan. The males are darker colored and have feathery antennae. Both have distinctive markings on the wing: an inverted V shape that points to a dot on the wings. The gypsy moth has one generation per year.

Ealy detection and rapid elimination of infestations in Nevada have prevented large infestations of gypsy moth from developing. States with infestations have found the following control measures useful:

- Mass trapping with pheromone-baited traps.
- Release of sterile male gypsy moths.
- Mating disruption with a registered synthetic version of the pheromone disparlure.
- Diflubenzuron (Dimilin®), an insect growth regulator.
- Bacillus thuringiensis kurstaki (Btk), a microbe that is a natural disease agent of caterpillars. Several registered Btk products are available for use.

A caterpillar pest causing damage in forest and landscape trees in Nevada is the **white satin moth**. The caterpillar of white satin moth causes damage by feeding on poplar, cottonwood, aspen and willow, and sometimes oak and crabapple trees. The caterpillar will skeletonize leaves by feeding on the leaf tissue between leaf veins. Extensive infestations can cause defoliation and branch dieback. Severe infestations can cause tree death.

Adult moths are about 1 inch in length and may have a wingspan of up to 2 inches. They have a silvery-white body and satin-like wings. Caterpillars vary in color from pale to medium grayish brown to black. Full sized caterpillars are 1.75 inches long. They have a very distinctive pattern on markings on their back. A row of yellowish or milky white circular shapes runs down the length of its back, with rows of reddish-brown circles in pairs on either side of the yellowish or milky white circular shapes. Additionally, tufts of reddish-brown hairs stick straight out of its sides and back.

The life cycle of the white satin moth is unusual. It overwinters as a caterpillar, emerging to feed in the spring. Early summer, it spins a cocoon and the moth emerges shortly afterwards. The moths lay egg masses until late summer, and young caterpillars feed in late summer to early fall. For this reason, the full-sized caterpillars actually show up in the early spring, while the newly hatched caterpillars show up during late summer/early fall.

Scout regularly for these pests. Keep landscape trees healthy by managing water and pruning properly. Biological controls include birds, parasitic wasps, lacewings, predatory mites and some beetle species. A microbial insecticide,



Gypsy moth female (white) and male (gray). USDA APHIS PPQ, Bugwood.org.



White satin moth caterpillar. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org.



White satin moth. Perry Hampson, Bugwood.org.

Control of defoliators can be difficult. Outbreaks may cover wide expanses of up to 1 million acres or more and may be recurrent and progressive.

Cambium and phloem feeders are insects that feed on the water- and food-conducting tissues in trees.



Emerald Ash Borer with paperclip for scale. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org.

Bacillus thuringiensis kurstaki (Btk), can be effective on the caterpillar stage of the white satin moth. This material must be ingested by the caterpillars as they feed on the leaves. Repeated application may be required as the application may wash off. Chemical controls include several foliar-applied insecticides. Some of these insecticides are toxic to beneficial insects and pollinators, so applications should not be made when the trees are blooming. These are foliar applications, not systemics insecticides, so large trees may be difficult to completely treat. Systemic insecticides are not effective. New insecticide formulations are being developed all the time; consult with your pesticide dealer for the latest formulations that may be effective for white satin moth control. For more information go to https://forestry.nv.gov/uploads/missions/20210302_AMT_2019_White_Satin_Moth_Fact_Sheet.pdf.

Control of defoliators can be difficult. Outbreaks may cover wide expanses of up to 1 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.

Emerald Ash Borer (EAB) is an exotic beetle that attacks ash trees. Adult beetles are metallic green and about ½ inch long. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Adults leave a D-shaped exit hole in the bark when they emerge in spring. Adults remain active until the end of summer.

Emerald ash borer is thought to have arrived in the United States on solid wood packing material carried in cargo ships or airplanes originating in its native Asia. As of October 2018, it is now found in 35 states, and the Canadian provinces of Ontario, Quebec, New Brunswick, Nova Scotia and Manitoba. Part of the spread of the EAB is through moving firewood.

Prevention measures include a ban on moving firewood from areas with an infestation. Monitor for this pest. New infestations are difficult to detect, as damage to the tree may not be apparent for up to three years. Symptoms of an infestation can include branch dieback in the upper crown, excessive

suckers or water sprouts forming on the tree trunk, and vertical bark splits. Woodpeckers like EAB larva, so heavy woodpecker damage on ash trees may be a sign of infestation. There are several different types of chemical controls that may be effective, including systemic insecticides applied as a soil drench, soil injections, or truck injections. New formulations are being tested for effectiveness against EAB; consult with your pesticide dealer for the latest formulations. Read, understand and follow label directions. For more information and to track the spread of EAB, go to the EAB Information Network at http://www.emeraldashborer.info/.

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.

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 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, 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

Part of the spread of the EAB is through moving firewood.

Prevention measures include a ban on moving firewood from areas with an infestation.

Shoot- and root-feeding insects are serious pests in the nursery and Christmas tree industries.

Sap-sucking pests include mites, aphids, scales, mealy bugs, spittle bugs and plant bugs.

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 human activities in the infested area. Biological control agents offer some control, but more detailed studies are required to develop improved methods in this area.

For more information on these pests in an urban forest setting, consult Identification of Common Landscape Pests and Beneficial Organisms in Nevada at https://naes.agnt.unr.edu/PMS/Pubs/2006-4051.pdf.

For more information on common forest pests infestations in Nevada, consult 2019 Forest Pest Conditions in Nevada at https://forestry.nv.gov/uploads/missions/20190101_AMT_2019_Nevada_Forest_Pest_Conditions_Report.pdf.

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 mistletoes are host-specific parasitic plants.

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 feet 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 common in Nevada. Pruning out infected branches and destroying them will help control this disease. It is important that trees not be water-stressed 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 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

Nevada has a smaller amount of forest lands, as compared with rangelands, but weed management is equally important on these sites.

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

Chemical formulations change all the time. Consult your local dealer for recommendations for your particular pest and site.

For the latest noxious weed list, see http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/

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

Successful weed management considers all the potential control methods available:

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

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, https://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 rangelands 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 animals.

The objectives of weed management on forest lands are to:

- Improve carrying capacity and productivity of forest lands.
- Reduce competition from weeds, thus improving growth of desirable vegetation and overall health of the 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 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 lands by preventing the spread of invasive weeds.
- Enhance species diversity and the beauty of Nevada's forest 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 forest weed management programs. When planting in forests, 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 for 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 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 reduce weed establishment and can be followed up with tree thinning as the trees grow to reduce tree-to-tree competition and to 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 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.

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 a new area.**

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

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.

Intensive grazing can reduce or remove some weedy species in young forests. Unfortunately, grazing is not entirely selective, and trees or other forest 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 Department of Agriculture for information and permits for insect biocontrols.

Chemical: There are many herbicides registered for use on 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 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.

Foliar Applications: Spraying foliage is effective in controlling many forest species and is recommended when controlling hard-to-kill noxious weeds. Aerial and ground equipment is used in spraying. Backpack sprayers apply 3 to 10 gallons per acre, while aerial spraying requires 5 to 10 gallons per acre of mixed product.

Because many forest 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. The General Knowledge: Pesticide Use and the Environment chapter of this manual covers minimizing pesticide drift.

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 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 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.

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.

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 weed control, go to http://npirspublic.ceris.purdue.edu/state/state_menu.aspx?state=NV

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 preemergence and post-emergence effect and are used in conifer forests 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 preemergence herbicides are the most common pesticide contaminants found in Nevada's groundwater. Some pesticide labels advise the applicator to not 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 groundwater).

Applicators must consider 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.

Forest and Range Vertebrate Pests

Animals play an important role in forest ecosystems. Several species of rodent, including pocket gophers and ground squirrels, occur naturally in forest sites. Other native species, such as deer and rabbits, also inhabit these areas. Harm to 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.

For more information on vertebrate pests, consult the General Knowledge: General Pest Problems chapter of this manual.

Conclusion

Nevada's forests provide valuable forage and habitat for 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. To accomplish effective pest control, applicators should consider all land uses, consider all control methods available and apply pesticides according to label instructions.

Originally published in 1987 as Category 2 Pest Control on Forest and Rangelands, 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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

Using toxic baits to control deer or rabbits is strictly prohibited.

Applicators must consider various land-use practices and resources associated with these lands when developing pest management strategies.

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Category D: Ornamental and Turf Pest Control

Ornamental and Turf Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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 ornamental plantings and turf areas.**
- ✓ **Describe the most common vertebrate pests that impact ornamentals and turf and control strategies for each.**

Category D: Ornamental and Turf Pest Control

Ornamental and turf pests occur in landscaping found around commercial establishments (hotels, casinos, resorts, restaurants), industrial parks, private and public golf courses, city and county parks and recreational areas, 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 public. Thoughtful planning and implementation of pest

Category D, Ornamental and Turf Pest Control, is the category concerned with pests in landscape or turf areas.

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.

Landscapers must become licensed if they are doing any of the following:

- Advertising pest control or soliciting for pesticide applications, including bidding for maintenance contracts that involve pesticide applications.
- Operating as a commercial (for hire) pest control company.
- Conducting any pesticide applications on commercial, public or residential properties.

For further information or clarification, go to Nevada Department of Agriculture Pest Control website, https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Plant/PEST/landscaper_licensing_flier_r3_Final.pdf.

Principles of IPM:

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

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, Reno 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 considered 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 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 the most effective and economical and have the 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 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 adjust 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

Factors Affecting Pesticide Application Effectiveness

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

Use the correct pesticide, one that is labeled for use on the plant and/or site and that will be effective on the identified pest.

Consider the weather, including temperature, wind speed and the potential for precipitation.

Most pesticides are not effective below 50 F, and many tend to volatilize above 85-90 F.

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. Consider the weather, including temperature, wind speed and the potential for precipitation. Most pesticides are not effective below 50 F and many tend to volatilize above 85-90 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.

Ornamental and turf applications are near human habitation, so applicators need to plan pesticide applications to minimize hazards to humans, pets and other domestic animals, surface and groundwater, and the environment. In landscape situations, the risk of phytotoxicity to non-target plants is greater due to the proximity of individual plants to one another. Phytotoxicity is damage to plants caused by chemicals, fertilizers or pesticides. Another concern in landscapes is the persistence of pesticides beyond the intended period of pest control, which may interfere with subsequent landscape plans. Careful planning is required prior to a pesticide application to ensure long-term plans for the site are considered. Review the Guidelines for the Safe Use of Pesticides chapter and the Pesticide Use and the Environment chapter of this manual for further information.

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 each 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 eggshells, 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 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.

Knowing the life cycle of the insect pest helps you to identify when it is most susceptible to a pesticide.

Indications you may have an insect pest:

- **Webbing or silk**
- **Insect remains**
- **Waxy protective coverings**
- **Honeydew**
- **Sawdust, wood chips or pitch balls**

Spider mites are very small and are usually identified by the presence of fine, delicate webbing on the plant leaves, stems and trunk.

Most aphids are plant-family specific.



Aphid



Scale

Common Invertebrate Pests

Mites: Mites are not insects. They are 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. Cleaning up garden debris is important to reduce overwintering populations, reducing pressure on next season's crop. 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.

Aphids: These small, soft-bodied insects are common problems. There are many species of aphid, 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. The effect of naturally occurring pest predators should not be discounted and thoughtfully considered when selecting pesticides for controlling aphids. Parasitoid wasps, minute pirate bugs, lacewings, syrphid flies and ladybird beetles all prey on aphids. Large infestations can be controlled with insecticidal soaps, horticultural or "dormant" oils, and many other insecticides. Read and follow label instructions.

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.

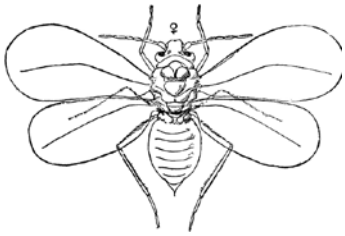
Whiteflies: These small white insects look like tiny moths. The larval stages of whiteflies are similar in appearance to scale insects. When an infested plant is disturbed, the adult insects will fly up and then settle back down. Both larval and adult whiteflies suck sap from leaves. Infested plants 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. Thrips are also vectors of a number of plant viruses. 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, many insecticides and biocontrols. Read and follow label instructions.

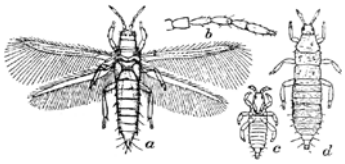
Beetles: Beetles belong to the order Coleoptera, which is the largest order of insects. Beetles have two pairs of wings. The front pair is generally hard or leathery, and the wings meet in a straight line down the center of the back. Beetles may attack any part of a plant, and they may do damage at any 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 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 ornamentals 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 borers target all species of birch. The adult beetles are ½-inch long, hard-shelled and slender. They are brown with a greenish tint. The



Whitefly



Thrips

Because there is such a wide variety of beetles, it is very important to identify the beetle and its life stage.



Japanese beetle

ag.purdue.edu



Bronze birch borer
oardc.osu.edu



Emerald ash borer on paperclip for scale. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org.

larvae are creamy white, slender and flattened. The larvae are responsible for damage to trees. They bore through 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.

Emerald ash borers (EAB) are exotic beetles that attack ash trees. Adult beetles are metallic green and about ½ inch long. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Adults leave a D-shaped exit hole in the bark when they emerge in spring. Adults remain active until the end of summer.

Emerald ash borer is thought to have arrived in the United States on solid wood packing material carried in cargo ships or airplanes originating in its native Asia. As of October 2018, it is now found in 35 states, and the Canadian provinces of Ontario, Quebec, New Brunswick, Nova Scotia and Manitoba. Part of the spread of the EAB is through moving firewood.

Prevention measures include a ban on moving firewood from areas with an infestation. Monitor for this pest. New infestations are difficult to detect, as damage to the tree may not be apparent for up to three years. Symptoms of an infestation can include branch dieback in the upper crown, excessive suckers or water sprouts forming on the tree trunk, and vertical bark splits. Woodpeckers like EAB larva, so heavy woodpecker damage on ash trees may be a sign of infestation. There are several different types of chemical controls that may be effective, including systemic insecticides applied as a soil drench, soil injections and truck injections. New formulations are being tested for effectiveness against EAB; consult with your pesticide dealer for the latest formulations. Read, understand and follow label directions. For more information and to track the spread of EAB, go to the EAB Information Network at http://www.emeraldashborer.info/.

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 boxelder bugs, elm seed bugs and stink bugs.

Boxelder 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 boxelder 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 boxelder bugs during the following year.



Box elder bug
extension.umn.edu

Elm seed bugs attack elm trees, as their name implies. Elm seed bugs use their piercing-sucking mouth parts on elm seeds and to suck sap from the veins of elm leaves. The threat to landscape plants is minimal. Elm seed bugs become pests when they congregate on homes and landscape plants in great numbers. They also become pests when they move into homes, especially in mid-summer during hot, dry weather. Elm seed bugs do not bite or sting. They do not feed on houseplants, stored foods, furniture or clothing. They do emit an odor when crushed that is described as over-ripe cantaloupe mixed with turpentine; needless to say, many homeowners find this unpleasant.

Elm seed bugs go through three life stages: egg, wingless nymphs and winged adults. The newly hatched nymphs are bright red and 1/20th of an inch long. Elm seed bug nymphs go through five increasingly large instars. The adults are 1/3-inch long and dark brown with reddish highlights. A very distinctive feature is a dark, backwards-facing triangle located on the abdomen, near the thorax. Additionally, adults have small white bands on the outer edges of the abdomen. They have a single generation per year.



Elm seed bug. Emilie Bess, USDA APHIS PPQ, Bugwood.org.

Control measures include bug-proofing homes and other structures to keep the elm seed bugs out: Weather-strip around loose-fitting doors, caulk around windows and repair torn window screens. Bugs in landscapes or those that make it inside can be vacuumed up and disposed of in sealed containers to prevent reinfestation. Raking and disposing of elm seeds can discourage infestations, as it will reduce their food source. Inspect firewood before bringing it inside. Broad-spectrum outdoor barrier insecticide treatments on foundations may aid in preventing infestations in the home. Follow label instructions for application methods and limitations. These products cannot be used in the home. Do not spray an entire landscape to control these insects, as that would cause numerous non-target insect deaths, including beneficial insects and pollinators, and may be harmful to humans, pets, livestock and wildlife in the area.

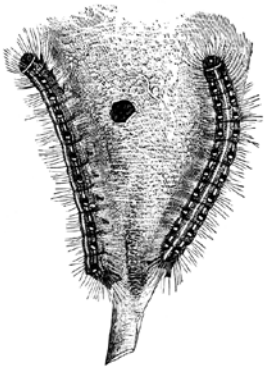
Stink bugs: There are several varieties of **stink bugs**. They feed on a variety of plants, resulting in seedling death and stunting of plants. As they feed on



Adult brown marmorated stink bug. Dr. Janos Bodor, Calphotos.



Brown marmorated stink bug eggs and nymphs. Dr. Janos Bodor, Calphotos.



Caterpillars

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.

One species of stink bug, the **brown marmorated stink bug (BMSB)**, is causing problems in the eastern United States. It has been found in Nevada and adjacent states. It is 1/2 to 3/4 inches long, marbled brown, and shield shaped. Its antennae have white bands, and the edges of its abdomen have alternating light and dark markings. Like most stink bugs, they stink when crushed. BMSB attacks over 170 species of plants, including fruit trees. Their piercing-sucking mouth parts cause a variety of damage symptoms, depending on the plant or crop. Additionally, they emit aggregation hormones in the fall and overwinter in homes: attics, crawl spaces, etc. BMSB controls, and basically all stink bug controls, include exclusion from homes and debris clean-up to prevent overwintering sites. There are light and pheromone traps that may be effective. Biological controls include birds that eat adults and beneficial insects, such as ladybird beetles and lacewings that will consume the eggs. Stink bugs are difficult to control using pesticides. For more information on BMSB, go to www.stopbmsb.org.

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.

A caterpillar pest causing damage in forest and landscape trees in Nevada is the **white satin moth**. The caterpillar of white satin moth causes damage by feeding on poplar, cottonwood, aspen, willow, and sometimes oak and crabapple trees. The caterpillar will skeletonize leaves by feeding on the leaf tissue between leaf veins. Extensive infestations can cause defoliation and branch dieback. Severe infestations can cause tree death.

Adult moths are about 1 inch in length and may have a wingspan of up to 2 inches. They have a silvery-white body and satin-like wings. Caterpillars vary in color from pale to medium grayish-brown to black. Full sized caterpillars are 1.75 inches long. They have a very distinctive pattern of markings on

their back. A row of yellowish or milky white circular shapes runs down the length of its back, with rows of reddish-brown circles in pairs on either side of the yellowish or milky-white circular shapes. Additionally, tufts of reddish-brown hairs stick straight out of its sides and back.

The life cycle of the white satin moth is unusual. It overwinters as a caterpillar, emerging to feed in the spring. Early summer, they spin cocoons and the moths emerge shortly afterwards. The moths lay egg masses until late summer, and young caterpillars feed in late summer to early fall. For this reason, the full-sized caterpillars are detectable in the early spring, while the newly hatched caterpillars are detectable during late summer/early fall.

Scout regularly for these pests. Keep landscape trees healthy by managing water and pruning properly. Biological controls include birds, parasitic wasps, lacewings, predatory mites and some beetle species. A microbial insecticide, *Bacillus thuringiensis kurstaki* (Btk), can be effective on the caterpillar stage of the white satin moth. This material must be ingested by the caterpillars as they feed on the leaves. Repeated application may be required as the application may wash off. Chemical controls include several foliar-applied insecticides. Some of these insecticides are toxic to beneficial insects and pollinators, so applications should not be made when the trees are blooming. These are foliar applications, not systemics insecticides, so large trees may be difficult to completely treat. Systemic insecticides are not effective. New insecticide formulations are being developed all the time; consult with your pesticide dealer for the latest formulations that may be effective for white satin moth control. For more information go to https://forestry.nv.gov/uploads/missions/20210302_AMT_2019_White_Satin_Moth_Fact_Sheet.pdf.

Gypsy moth (aka spongy moth): There are two varieties, European gypsy moth and Asian gypsy moth. They both have a voracious appetite and will attack more than 300 species of trees and shrubs. They both overwinter as eggs, which are laid in sheltered areas, such as underneath the bark of trees, eaves of homes and other structures or outdoor objects. Eggs hatch in the spring. Caterpillars are striking, with five pairs of blue dots followed by six pairs of red dots along their backs. The body of the caterpillar is dark-colored with light brown hairs. The older caterpillars are 1.5 to 2 inches long. In early summer, the caterpillars pupate, with the moths emerging 10-14 days later. Female moths have a tan-colored body and white to cream-colored wings. Females have a 2-inch wingspan. European gypsy moth females cannot fly; Asian gypsy moth females are capable of flight. Male gypsy moths are smaller than females, with a 1.5-inch wingspan. The males are darker-colored and have feathery antennae. Both have distinctive markings on the wing: an inverted V shape that points to a dot on the wings. The gypsy moth has one generation per year.



White satin moth. Perry Hampson, Bugwood.org.



White satin moth caterpillar. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org.



Gypsy or spongy moth caterpillar. USDA Forest Service- Region 8 - Southern, Bugwood.org.



Gypsy moth female (white) and male (gray). USDA APHIS PPQ, Bugwood.org.



Sawfly larva

Early detection and rapid elimination of infestations in Nevada have prevented large infestations of gypsy moth from developing. States with infestations have found the following control measures useful:

- Mass trapping with pheromone-baited traps
- Release of sterile male gypsy moths
- Mating disruption with a registered synthetic version of the pheromone disparlure in products such as Disrupt®II, Luretape Gypsy Moth®, and Luretape Plus®
- Diflubenzuron (Dimilin®), an insect growth regulator
- Bacillus thuringiensis kurstaki (Btk), a microbe that is a natural disease agent of caterpillars. Several registered Btk products are available for use

For more information on Gypsy or Spongy moth go to:
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187452.pdf

https://www.fs.usda.gov/foresthealth/docs/fidls/FIDL-162-SpongyMoth.pdf

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 a nuisance if they set up housekeeping too close to human habitation.

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 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.

Ornamental plant diseases

- **Root rot:** This is a common problem in ornamental plants. Root rot is caused by several different fungal species or single-celled fungus-like organisms called *Phytophthora* or *Pythium*. Although root rot is caused

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

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.



Fire blight
extension.usu.edu

by microbial infection, 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 and managing plants to reduce stress. Chemical controls are also available.
- **Fire blight** occurs in several 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 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 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 F and nighttime lows are in the mid-60s F. High humidity and large amounts of nitrogen also favor the disease. Plant resistant turf varieties, control fertilizer applications and maintain a healthy 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



Powdery mildew
www.ipm.iastate.edu

Chemical formulations change all the time. Consult your local dealer for recommendations for the specific pest and site.

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.

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 and 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 lawn. 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 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 F to 65 F), but temperatures above 70 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



Pink snow mold
William M. Brown, Jr., Bugwood.org

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.



Fairy ring
Wendy Hanson Mazet, UNCE

Weeds

General information on weeds is covered in the General Knowledge: General Pest Problems chapter 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, Reno Extension can help identify weeds. Many books contain photoss 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 peer-reviewed for accuracy.

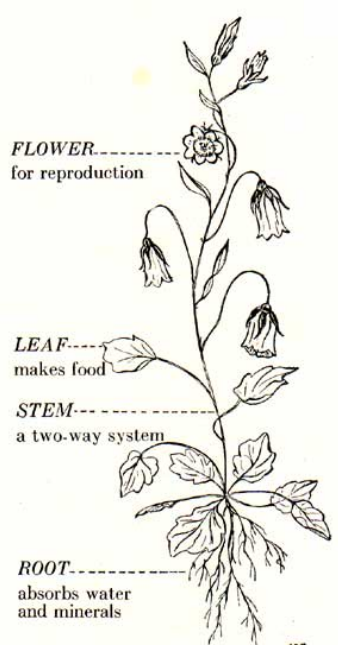
It is important to understand some of the living dynamics of plant growth to understand how herbicides work and the different ways they may affect plants. Plants consist of roots, stems or trunks, and leaves. Water movement in most plants is from the roots upward through the trunk or stem and into the 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.

Proper identification is essential when managing weeds. Contact the University of Nevada, Reno Extension or the Nevada Department of Agriculture for help in identifying weeds.

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,



www.plant-care.com

Successful weed management considers all the control methods available:

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

A noxious weed is a plant that has been defined as a pest by law or regulation.

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 landowners 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, Reno Extension, 775-784-4848. The following publications may help in identifying

noxious weeds: Nevada Noxious Weed Field Guide, available by weed name at the University of Nevada, Reno Extension website at https://extension.unr.edu/publications.aspx and Nevada Nuisance Weed Field Guide, https://naes.agnt.unr.edu/PMS/Pubs/1399_2019_01.pdf. Hard copies of both publications are available at most University of Nevada, Reno Extension offices throughout the state.

Vertebrate Pests

Vertebrate pests are those pest animals that have backbones. Specific control measures vary for different species and are discussed individually in the General Pest Problems chapter of this manual.

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:** To purchase, apply or supervise the use of this pesticide,

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**

applicators must successfully pass the Category L2: Non-Soil Fumigation exam.

Specific Vertebrate Pests: Please refer to the vertebrate pest section of the General Knowledge: General Pest Problems chapter in this manual.

Conclusion

Pest mangers should identify the pest, understand its life cycle and identify other host plants before they try to control a pest.

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 or site. Pest managers 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.

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 Category 3 Ornamental and Turf 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.
Updated 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen, J. Knight, R. Saliga and S. Wang, Nevada Department of Agriculture.

Category E: Seed Treatment Pest Control

Seed Treatment Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE TO ONLY NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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 E, Seed Treatment Pest Control

Seed treatment 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:

Category E, Seed Treatment 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.

- **Disinfestation** is the application of a chemical that kills or inactivates organisms present on the surface of the 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. Dispose of empty pesticide containers according to label directions. Never reuse pesticide containers.

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. Follow pesticide label and equipment manufacturer instructions.

- **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 treatment should be done in a well-ventilated area. Those treating the seed or nearby the seed treatment area should follow label directions regarding personal protective equipment (PPE). Avoid skin contact or breathing in dusts.

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.

Common seed insect pests are wireworms and the seed corn maggot.

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.

Seed treatment generally controls insect pests and fungal diseases. Most seed treatments do not control bacterial pathogens, and none control seed-borne viruses.

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 A: Agricultural Plant Pest Control 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, aka cereal grains (wheat, barley):** Seed treatment is for

Read, understand and follow label directions. Dispose of any unused treated seed as you would a chemical pesticide.

control of smuts, rots and damping off. Smut diseases are readily spread by infected seed.

- **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.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen, Nevada Department of Agriculture.

Category F: Aquatic Pest Control

Aquatic Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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 F, Aquatic Pest Control

Category F, 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 9, Public Health Pest Control. Aquatic pests are found in and beside 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.

All Certified Applicators must keep records of all Restricted Use Pesticides that they apply for two years. Non-Private Certified Applicators that apply pesticides to **public lands** must keep records of both General Use and Restricted Use Pesticides that they apply for two years. For more information on record-keeping requirements, see the General Knowledge: Pesticides and the Law chapter of this manual.

Category F, 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.

Review drift prevention strategies in General Knowledge: Pesticides and the Environment chapter of this manual.

Review minimizing non-target organism effects in the General Knowledge: Pesticides and the Environment chapter of this manual.

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

As discussed in the General Knowledge: Pesticides and the Environment chapter of this manual, it is important to prevent pesticide drift. Drift prevention is vitally important when applying pesticides to or near surface waters. Drift can affect not only the application site but also downstream environments. Review drift prevention strategies in the General Knowledge: Pesticides and the Environment chapter of this manual.

As discussed in the General Knowledge: Pesticides and the Environment chapter of this manual, pesticides can affect non-target organisms. This 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. Review the General Knowledge: Pesticides and the Environment chapter of this manual for important information on minimizing any non-target damage when applying pesticides to aquatic environments.

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 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:** These algae are often confused with flowering plants because they attach 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 flowering 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, curlyleaf 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.

Algae are nonvascular plants that do not have roots, stems, leaves or flowers. They reproduce by spores, division or by breaking apart (fragmentation).

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 flowering plants are divided into four distinct groups:

- **Submersed**
- **Rooted floating**
- **Free-floating**
- **Emergent**

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**

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. 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 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 Affecting 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 10 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 riprap, 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 waters' 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.

Weed prevention methods:

- **Reduce nutrient inflows.**
- **Place riprap around pond edges.**
- **Eliminate shallow areas.**
- **Clean watercraft.**
- **Line ponds or ditches.**
- **Construct nutrient settling ponds.**

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.

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/. Click on the Forms and Resources button.

Cultural Control: 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.

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 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 10 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.

Biological Control: 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 introduced into a closed aquatic system. A closed aquatic system is a water body where fish are prevented from ingress (entering) or egress

(leaving) by erecting a natural or manmade barrier. Contact the Nevada Department of Wildlife for information on the process for permitting grass carp release.

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, practice limited area application of pesticides. Apply pesticides to no more than one-quarter to one-third of the surface area at a time. Wait two weeks before the next application to allow time for plants to adequately decompose and the oxygen levels in the water to stabilize. These steps are also listed on pesticide labels. Read the label!

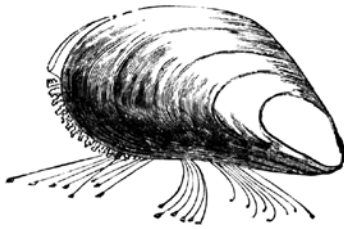
Chemical Control of Flowering Plants: Herbicides labeled for aquatic use are formulated as granules and liquids. Liquid formulations are applied as sprays and are used for rooted-floating, free-floating, and emergent weeds. Granular formulations are preferred when controlling submersed plants, because 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.

Limited Area Application is the practice of treating only part of an aquatic infestation at a time to allow oxygen levels in the water to stabilize.

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.



Weeds growing on the bank and emergent weeds present the most serious aquatic weed problems in Nevada. Weed species vary depending on 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.

Chemical Control of 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 2021, 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 https://www.ndow.org/wp-content/uploads/2021/11/Fisheries_kt_AIS-Decal-Brochure_current.pdf for more information.

Both quagga and zebra mussels 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.

Many water bodies now have either voluntary or mandatory "clean, drain and dry" orders for watercraft to prevent the spread of Quagga and zebra mussels.

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 compete 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.

Pest fish are often non-indigenous (exotic) species that were intentionally transported and introduced to a body of water.

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 and 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.

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 and 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, Reno Extension or the Nevada Department of Agriculture. Once the pest has been identified, take the integrated pest management (IPM) approach for its control by considering multiple control methods. Consult the General Knowledge: IPM chapter of this manual for more information on IPM.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

Category G: Right-of-Way Pest Control

Right-of-Way Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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 methods to protect land adjacent to rights-of-way.**
- ✓ **Describe factors to consider when selecting pesticides.**

Category G: Right-of-Way 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

Rights-of-way are distinct areas involved in the transport of people, goods and services.

Aquatic sites are not included in this category; aquatic sites are covered by Category F, Aquatic Pest Control.

There are many goals when managing rights-of-way. Safe access is important, as are fire prevention, visibility, erosion control and safety for

A "noxious weed" is a plant designated by law as requiring control.

Rights-of-way are generally long and narrow and pass-through areas with different soil types, vegetative communities, topographies and sensitive sites.

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.

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-way 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.

Preventing pesticide drift, non-target pesticide exposure, and protecting surface water and groundwater can be challenging during rights-of-way pesticide applications due to the linear nature of many rights-of-way and varied adjacent land uses. Careful planning is required prior to a pesticide application to consider all these factors. Review the General Knowledge: Guidelines for the Safe Use of Pesticides chapter and the General Knowledge: Pesticide Use and the Environment chapter of this manual for further information.

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 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

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.

Construction site right-of-way goals include:

- **Preventing weed movement and controlling weeds onsite**
- **Preventing weed spread to adjacent lands**
- **Reducing potential fire hazards**

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/NV_Certified_Weed_Free_Producer_Links/ 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 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 nearby non-target 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

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.

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.

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 Category F: Aquatic Pest Control chapter of this manual 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, cultural, physical or mechanical, 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

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.

Cultural Control: These are practices that prevent or reduce weed infestations by making the conditions favorable for desirable competitive

Methods of control:

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

Preventing weed introduction and spread is the most cost-effective method of managing weeds.

Cultural controls make conditions favorable for desirable vegetation that can compete with weeds.

Using mechanical controls on perennial weeds that spread by the roots can make infestations worse.

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.

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.

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 many 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.

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 products, ready-to-use products and 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 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.

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

Be sure to read, understand and follow the pesticide label directions.

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 and roadsides. Prevent rodent damage by using traps and/or rodenticides. Rodent management options are outlined in the General Knowledge: General Pest Problems chapter 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

Occasionally, burrowing rodents can cause damage to right-of-way sites, such as roads and roadsides.

It is important to report Mormon cricket infestations to the Nevada Department of Agriculture (NDA) using the form found at this link: https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Entomology/mc_gh_form_2013_4.pdf.

Rights-of-ways are generally long and narrow and pass through areas with different soil types, vegetative communities, topographies and sensitive sites.

The differences in use and in physical attributes make a "one-size-fits-all" solution to right-of-way pest control impossible.

squashed by vehicles. It is important to report Mormon cricket infestations to the Nevada Department of Agriculture (NDA) using the form found at this link: https://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Entomology/mc_gh_form_2013_4.pdf. Reporting to the NDA helps in controlling the current infestation and in predicting future infestations. 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-way 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.

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Revised in 2018, by M. Hefner, University of Nevada Cooperative Extension, and B. Allen and C. Moses, Nevada Department of Agriculture.
Revised in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture.

Category H: Industrial, Institutional and Structural Pest Control

Industrial, Institutional and Structural Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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.**
- ✓ **Describe the most common wood-destroying pest microorganisms and strategies to control or prevent infestations of these pests.**
- ✓ **List the most common invertebrate pests encountered in industrial and institutional pest control and methods to control them.**
- ✓ **Identify the most common invertebrate wood-destroying pests and methods to control them.**
- ✓ **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 vertebrate pests encountered in industrial and institutional pest control and methods to control them.**

Category H, Industrial, Institutional and Structural Pest Control describes management practices for pests found in industrial and institutional sites and structural (wood-destroying) pests.

Industrial sites include grain elevators, warehouses, hotels, casinos, food establishments, stores, offices and operational sites.

Institutional sites include schools, rest homes and hospitals.

Category H, Industrial, Institutional and Structural Pest Control

Category H, Industrial, Institutional and Structural Pest Control describes management practices for pests found in industrial and institutional sites and structural (wood-destroying) pests. The primary pests found in industrial and institutional sites are insects, rodents and, less commonly, bats. Birds can also be pests; refer to the General Knowledge: General Pest Problems chapter of this manual for information on bird pests. Structural pests are generally wood-destroying pests. The most common wood-destroying pests are termites. Wood-destroying powderpost beetles, carpenter ants and wood-damaging fungi are also pests of concern in this category.

This category **does not** cover pests in ornamental and turf sites. For ornamental and turf pest control information, see the Category D: Ornamental and Turf Pest Control chapter in this manual. This category **does not** cover public health pests, such as bed bugs; for information on bed bugs and other public health pests, see Category K: Public Health Pest Control in this manual.

Industrial and Institutional Pest Control

Both industrial and institutional settings have similar sites. 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.

Industrial and Institutional Pest Control Strategies

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 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.

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.

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.

Traps can be used both as inspection and monitoring tools and as mechanical controls.

Trapping is the most common means of mechanical control for both insects and rodents in industrial and institutional sites.

Remember that all pesticides are considered toxic and should be used with caution around food, food storage and food preparation areas.

- **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 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. Many industrial, institutional and structural sites are also living areas for people and animals. It is important to consider the formulations, application methods and pre-application site preparation methods to avoid contamination of food, minimize damage to and contamination of areas treated, minimize acute and chronic exposures of people and pets and minimize environmental impacts of outdoor applications.

  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 can be used in industrial sites to control commodity pests**.** Use of fumigants requires additional certification in Category L2, Non-soil Fumigation. Refer to the Category L2: Non-soil Fumigation chapter in this manual for more information.

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 ant control are picked up 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.

Use of fumigants requires additional certification in Category L2, Non-soil Fumigation. Refer to the Category L2: Non-soil Fumigation chapter in this manual for more information.

Industrial and Institutional 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.

Structural (Wood-damaging) Microorganism Pests

Microorganisms that damage wood are generally fungi. Fungi lack chlorophyll. They cannot make their own food like plants can. Fungi feed off organic matter, in this case wood. Fungi damage wood when their mycelia, a mass of thread-like filaments, enter wood and release enzymes that breakdown cell walls and membranes and then absorb the released cell contents. The damp wood is the fungus food, and the fungus causes breakdown 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 site.

The best control is prevention by monitoring and correcting excess moisture problems in the structure.

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

Fungi require favorable temperatures of 50 F to 90 F and a moisture content of about 30%.

Brown rot fungi are probably the most important cause of decay of softwood species used in above-ground construction in the United States.

moist wood during storage, processing and use. The fungi that grow on wood have the following basic requirements:

- Favorable temperature: between 50 F and 90 F
- Adequate moisture: a wood moisture content of about 30%

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 softwood 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 and 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.

Stored Product Insect Pests

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 eat 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 mealworm. 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.

Stored product insect pests require very definite temperature ranges (40 F to 70 F) and humidity ranges (40% to 70%) to survive.

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 Industrial and Institutional Invertebrate Pests

Invertebrate pests include insects and arachnids, such as spiders and mites. The following are those insects or arachnids most encountered in industrial or institutional settings. Bed Bugs are not included in this category. Please see Category 9: Public Health, in this manual for more information on Bed Bugs and other public health pests.

Cockroaches: There are four species of importance.

The **German cockroach** is the most common cockroach in Nevada. Usually found outdoors, these cockroaches enter the premises in search of moisture.

The German cockroach is the most common cockroach in Nevada.



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

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 can 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 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, Reno 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.

Structural (Wood Destroying) Invertebrate Pests

The most common wood-destroying insect pests in Nevada are termites, carpenter ants and wood-destroying beetles. Pesticide applications for the control of wood-destroying pests can be extremely complex and hazardous; it is recommended that they only be performed by licensed pest control operators.

It is easy to confuse ants with termites. Both are insects, with three body parts, six legs and one pair of 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).



Wasp
Whitney Cranshaw, CSU, Bugwood.org



Black widow spider
James Solomon, USFS, Bugwood.org;

Wood destroying insects fall into three groups:

- **Termites**
- **Carpenter ants**
- **Beetles**

Pesticide applications for the control of wood-destroying pests can be extremely complex and hazardous; it is recommended that they only be performed by licensed pest control operators.

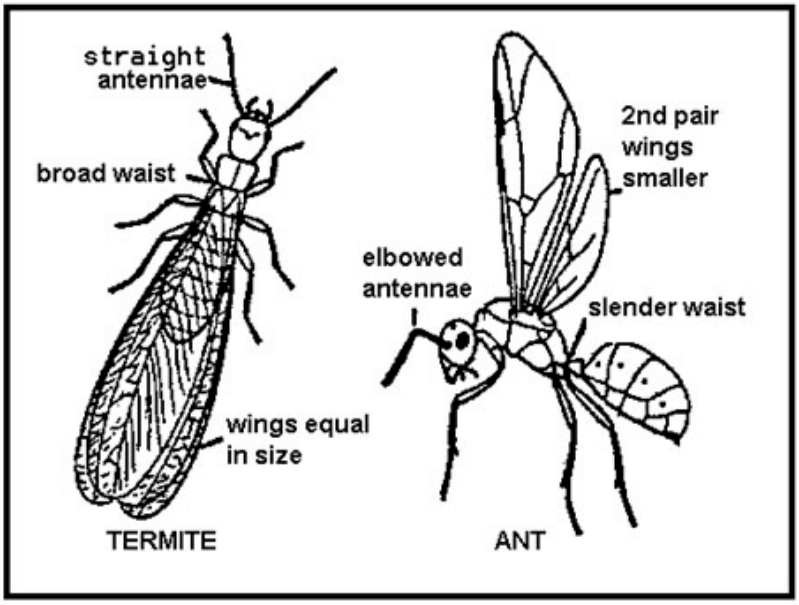
Termites use wood for food and shelter. They are the most destructive of all the wood-damaging insects.

There are three types of termites:

- **Subterranean**
- **Dry wood**
- **Damp wood**

Subterranean termites require a constant source of moisture that is usually obtained from the soil.

- **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.



How to tell winged ants from termites.

U ARK EXTENSION

Termites use wood for food and shelter. They are the most destructive of all the wood-damaging insects. 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 require a constant source of moisture that is usually obtained from the soil. 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. 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.

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 information on pesticide products available for your site and situation. Oils or other adjuvants may be required to achieve penetration of the chemical into the soil.

Good sanitation reduces food sources for termites.

Dry wood termites: Dry wood termites have soldier, nymph 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. 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. Dry wood 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. 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.

Dry wood termites are most prevalent in hardwoods.

Dry wood termites do not require as much moisture to establish a colony as subterranean or damp wood termites.

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. 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. **Use of fumigants requires additional certification in Category L2, Non-soil Fumigation. Refer to the Category L2: Non-soil Fumigation chapter in this manual for more information.**

Damp wood termites are the largest sized termite in Nevada.

Damp wood termites are most often associated with rotting wood, often near the soil.

Damp wood termites, like the subterranean termites, require contact with the soil.

Damp wood termites: These are the largest sized termites 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. Like the subterranean termites, they 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. Contact your local pesticide distributor for the latest information on pesticide products available for your site and situation. Oils or other adjuvants may be required to achieve penetration of the chemical into the soil.

Carpenter ants: Carpenter ants may be black or red. They 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, a 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.

Carpenter ants use wood for shelter, not for food. They do not actually feed on the wood.

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.

Carpenter ants generally attack only soft or decaying wood.

You must also correct whatever problem is causing the excess moisture that 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.

Remember that if you are planning to apply pesticides to the carpenter ant parent nest that is probably outside the structure in the landscape, you will need to have ornamental and turf certification also.

Wood-destroying beetles: There are four species of importance:

Powder Post or Lyctus Beetles 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 (two to 12 months or longer) and a much shorter pupal stage, newly formed

Powder post beetles attack both freshly cut and seasoned wood.

Roundhead borers damage seasoned wood in buildings.

Flathead borers infest live trees as well as recently felled and dead standing softwood trees.

adults chew round, 1/16-inch holes through the wood surface and emerge to lay eggs. 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.

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.

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 six hours at 120 F to 140 F. Small items can also be frozen at 0 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. Contact your local pesticide 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. **Use of fumigants requires additional certification in Category L2, Non-soil Fumigation. Refer to the Category L2: Non-soil Fumigation chapter in this manual for more information.**

Selected Industrial and Institutional 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. Line garbage cans with plastic bags, and put garbage cans up on racks. Make entranceways rodent-proof. All of these practices will discourage both rats and mice.

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 or other candy, sardines, nutmeats, dried fruit or anything oily.

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 control measures 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 feet to 15 feet apart. The life span of a mouse in the wild is usually less than one year.

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 5% to 10% bleach solution. Do not sweep, vacuum or atomize these wastes.



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.



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

Exclusion is the best method of control for all industrial and institutional pests.

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 Category K: Public Health Pest Control chapter in this manual for further information on deer mice and hantavirus.

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 openings 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.

Summary

If a pesticide application is warranted, use extreme caution when applying the pesticide. Pesticide formulations change all the time. Consult your local pesticide dealer for the correct product to use in your situation.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension, and B. Allen and R. Saliga, Nevada Department of Agriculture.

Category K: Public Health Pest Control

Public Health Pest Control Learning Objectives

THIS CATEGORY IS AVAILABLE ONLY TO NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

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 K, Public Health Pest Control

Public health pest control involves the management of insects and other animals that transmit diseases to humans. It also includes arthropod pests such as bed bugs and cockroaches. It is important to understand a few terms and concepts.

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).

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.

Category K, Public Health Pest Control, involves the management of insects and other animals that transmit diseases to humans.

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.

Vectors are living creatures that transmit disease or pathogens from one animal to another animal.

Just like all other pests, it is important to understand the life cycle of these public health pests in order to control them.

Host: A living animal that provides sustenance to a parasite. For example, California ground squirrels are hosts for rodent fleas.

Pathogen: A microscopic organism that causes disease in living things. Examples of pathogens in humans include bacteria, viruses, fungi, protozoa and rickettsiae.

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.

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.

Specific Diseases Transmitted by Vertebrates

Hantavirus is a zoonotic disease that was first identified in the Southwest in 1993. The 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%. 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.

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 United States. 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

Hantavirus is a zoonotic disease that can cause illness and death in humans. The reservoir of hantavirus is the deer mouse.

Deer mice have white bellies and feet. Their tails are furred, and the underside of the tail is white also.

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.

Deer mice have white hair on their belly, legs and feet. The tail has short hair that is bicolored: dark on the top and white on the sides and bottom

Deer mice have larger ears and eyes than house mice.

The oral history of the Navajo Indians suggests that deer mice and people should not be together because deer mice cause sickness.

white hair on their belly, legs and feet. The tail has short hair that is bicolored: dark on the top and white on the sides and bottom. The house mouse has a tail that is scaly, with few hairs. The belly of a house mouse is lighter than its back and sides, but a house mouse does not 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 inch 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, midwestern and western 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.

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 one to three weeks. Occasionally symptoms may take up to six 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.

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.

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

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

The greatest risk of hantavirus 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.

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

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, pine nuts 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.

Rodent Control Strategies

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). Baits for trapping include peanut butter plus oatmeal, bacon, gumdrops or other candy, sardines, nutmeats, dried fruit or anything oily. 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.

If 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 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.

Rabies is a zoonotic disease of public health concern in Nevada, primarily associated with bats and wild carnivores, such as skunks, foxes, coyotes and feral dogs. 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 one to three months after exposure. However, the time to develop symptoms can vary

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.

Rabies is a zoonotic disease that passes from mammal to mammal, including humans. It is most commonly found in bats in Nevada, but has also been identified in skunks, raccoons and foxes.

from less than one week to over one 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 bat 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 1/4 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 United States. However, wild animal rabies remains a threat and is spreading in some areas.

Specific Diseases Transmitted by Arthropods

Plaque is a bacterial infection vectored to humans by rodent fleas.

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% 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 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). For further information on controlling ground squirrels and other rodents, consult the General Knowledge: General Pest Problems chapter of this manual.

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.

Hard tick control: 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

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**

Removal of leaf litter and clearing tall grass and brush around houses and at the edge of gardens may reduce the numbers of ticks.

warm-blooded animals, including humans. Soft ticks feed for only about 20 minutes while the unsuspecting host is sleeping.

Soft tick control: 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.

Mosquitos: Mosquitoes are flies, members of the order Diptera. They are pests to humans and other animals. They act as vectors of several diseases worldwide, 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-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.

Mosquitoes undergo complete metamorphosis: egg to larva to pupa to adult.

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 among 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 are called "wrigglers."

Mosquito pupae are called "tumblers."

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 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.

Controlling mosquitoes is most effective in the early life stages.

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 exoskeleton hardens and its wings dry. At this point it can 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 can 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 Mosquito in Nevada: There are 37 species of mosquito 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 the principal hosts, but they do attack humans and readily invades homes; breeds in artificial pools and ponds, catch basins, waste treatment ponds and roadside ditches.

There are 37 species of mosquito found in Nevada.

The primary goal of mosquito control is the elimination or treatment of the water source or breeding area.

Chemical controls that target adult mosquitoes are called adulticides.

Chemical controls that target mosquito larvae are called larvicides.

- *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.

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 using 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 (UltraLow 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 species of mosquito on the specific site. Given the history of pesticide resistance developing in mosquitoes, alternating chemicals throughout the season is always advisable.

To reduce the mosquito population around homes and other structures:

- Repair window screens if needed, and make sure window and door screens remain closed.
- Change water every few days in bird baths, pet water bowls and water troughs for large animals.
- Mosquito fish or goldfish 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.

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 most people who are bitten by a mosquito with WNV never develop symptoms.

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),

West Nile virus (WNV) infection is a mosquito-borne virus and is closely related to St. Louis encephalitis (SLE) virus.

WNV is passed by mosquitos from infected birds to other birds, animals and humans.

There is no human vaccine for WNV, nor is there a vaccine for dogs or cats. There is a vaccine for horses.

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.

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% DEET for adults and no more than 10% for children are effective. Do not use repellant containing DEET on children under 3 years of age. 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, or 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.

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.

Additional Pest Arthropods

Bed bugs, members of the Hemiptera (true bugs) order, are not associated with disease transmission in the United States. These insects are considered a public health concern because they can be a terrible nuisance and are difficult to eradicate.

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 several 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.

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 20 to 400 days without feeding, depending on the temperature and humidity. The ease with which they spread and their ability to live without food for long periods of time 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. Commercial heating services are available for bed bug infestations. The current recommendation for effective commercial heating services calls for a temperature of at least 140 F for two hours or 130 F for three hours (the minimum lethal temperature is 113 F), which will kill most bed bugs and eggs. Chilling to a temperature of 32 F or lower and maintaining this temperature for several days will also kill bed bugs. 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. For the most up-to-date information on bed bugs, go to the Western IPM Center bed bug working group website at https://westernbedbugipm.ucanr.edu/.

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

Bed bugs are not associated with disease, but they are an insect of concern throughout the United States.

Bed bugs spread easily and are difficult to eradicate once an infestation has occurred.

For the most up-to-date information on bed bugs, go to the Western IPM Center bed bug working group website at https://westernbedbugipm.ucanr.edu/.

Cockroach control depends on maintaining strict cleanliness. Remove any crumbs, dirty dishes and food and drink spills to eliminate food sources for cockroaches.



Clockwise from top left: German, brown banded, American, and Oriental cockroaches.

Art Cushman, USDA, Smithsonian Institution, Department of Entomology, Bugwood.org

German, American and Oriental cockroaches will enter premises in search of moisture.

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 in Nevada. It is a small cockroach, generally about ½ inch long, tan to almost black. While this species has wings, it can't fly well. 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 (1.5 inches long) 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, shiny and up to 1 inch long. 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. Brown banded cockroaches are tan to light brown and ½ inch or less in length. 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.

Conclusion

Category K, 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 public health pests.

For more information go to the following websites:

- American Mosquito Control Association: https://www.mosquito.org/Nevada
- Centers for Disease Control and Prevention, http://www.cdc.gov
- Nevada Department of Agriculture, Division of Animal Industry: https://agri.nv.gov/Animals/Animal_Home/
- Nevada Department of Health and Human Services: https://dhhs.nv.gov/
- Southern Nevada Health District Vector Borne and Zoonotic Diseases, http://www.southernnevadahealthdistrict.org/stats-reports/zoonotic-diseases.php
- Washoe County Health District Vector Borne Disease Prevention Program, https://www.washoecounty.us/health/programs-and-services/vector-borne-diseases/index.php

Prevention and exclusion are the best methods of control for many of these public health pests.

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, J. 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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and B. Allen and R. Saliga, Nevada Department of Agriculture

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Category L2: Non-soil Fumigation

Non-soil Fumigation for Pest Control Learning Objectives

NON-SOIL FUMIGATION IS A HIGHLY SPECIALIZED FORM OF PEST CONTROL. THIS CATEGORY IS AVAILABLE TO BOTH PRIVATE AND NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

Study materials for this category are found in the Non-soil Fumigation Manual, developed by Pesticide Educational Resources Collaborative (PERC) in 2021. This manual is NOT available online. A copy of this manual can be obtained from the Nevada Department of Agriculture by calling 775-353-3712.

After studying the manual, you should be able to:

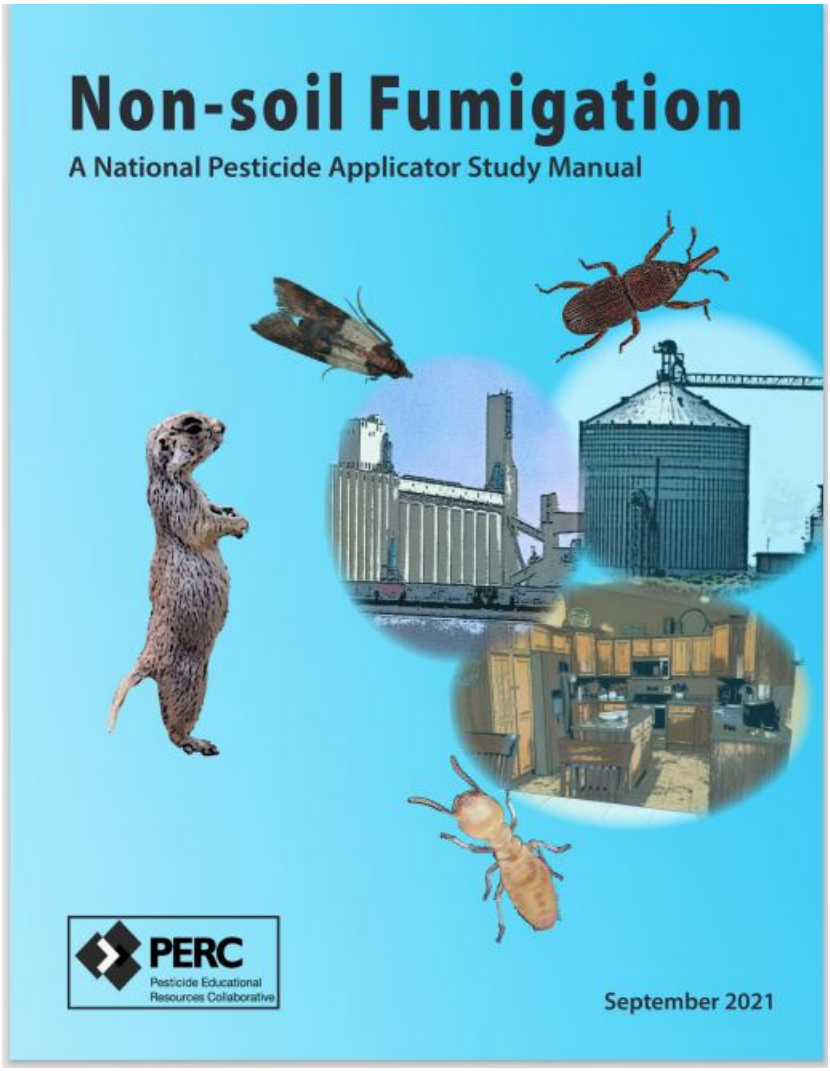
- ✓ **Understand labeling requirements specific to fumigants, including requirements for transportation and storage.**
- ✓ **Describe specialized safety measures used during fumigant applications to protect yourself, non-certified applicators under your direct supervision and any other nearby people or animals.**
- ✓ **Describe the chemical characteristics of non-soil fumigants.**
- ✓ **Design a fumigant application plan that includes appropriate application methods, proper sealing of the application area and application posting requirements.**
- ✓ **Describe the Personal Protective Equipment commonly used during fumigation applications.**
- ✓ **Describe fumigation record keeping requirements, including fumigant management plans and post-application summaries.**

Chemical formulations change regularly. Consult your local dealer for product recommendations for specific pests.

Read, understand and follow label directions.

It is the law.

Category L2: Non-soil Fumigation Pest Control



A picture of the manual cover is shown above

Conclusion

All fumigants are restricted-use pesticides. 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.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and Bret Allen and R. Saliga, Nevada Department of Agriculture.

Category L3: Soil Fumigation

Soil Fumigation for Pest Control Learning Objectives

SOIL FUMIGATION IS A HIGHLY SPECIALIZED FORM OF PEST CONTROL. THIS CATEGORY IS AVAILABLE TO BOTH PRIVATE AND NON-PRIVATE APPLICATORS BY TAKING A SEPARATE CATEGORY EXAM.

Study materials for this category are found in the Soil Fumigation Manual, A National Pesticide Applicator Certification Study Guide published by National Association of State Departments of Agriculture (NASDA) in 2012. It is available for download at https://www.epa.gov/system/files/documents/2023-11/soil-fumigation-manual-2012.pdf; there is also a link to the manual on the University of Nevada, Reno Extension Pesticide Safety page at https://extension.unr.edu/program.aspx?ID=24

After studying the manual, you should be able to:

- ✓ **Understand labeling requirements specific to soil fumigants, including requirements for transportation and storage.**
- ✓ **Describe specialized safety measures used during soil fumigant applications to protect yourself, non-certified applicators under your direct supervision, and any other nearby people or animals.**
- ✓ **Design a soil fumigant application that includes appropriate application methods, buffer zones and application posting requirements.**
- ✓ **Discuss soil and pest factors that can affect a soil fumigant application.**
- ✓ **Describe the Personal Protective Equipment commonly used during soil fumigation applications.**
- ✓ **Describe soil fumigation record keeping requirements, including fumigant management plans and post application summaries.**

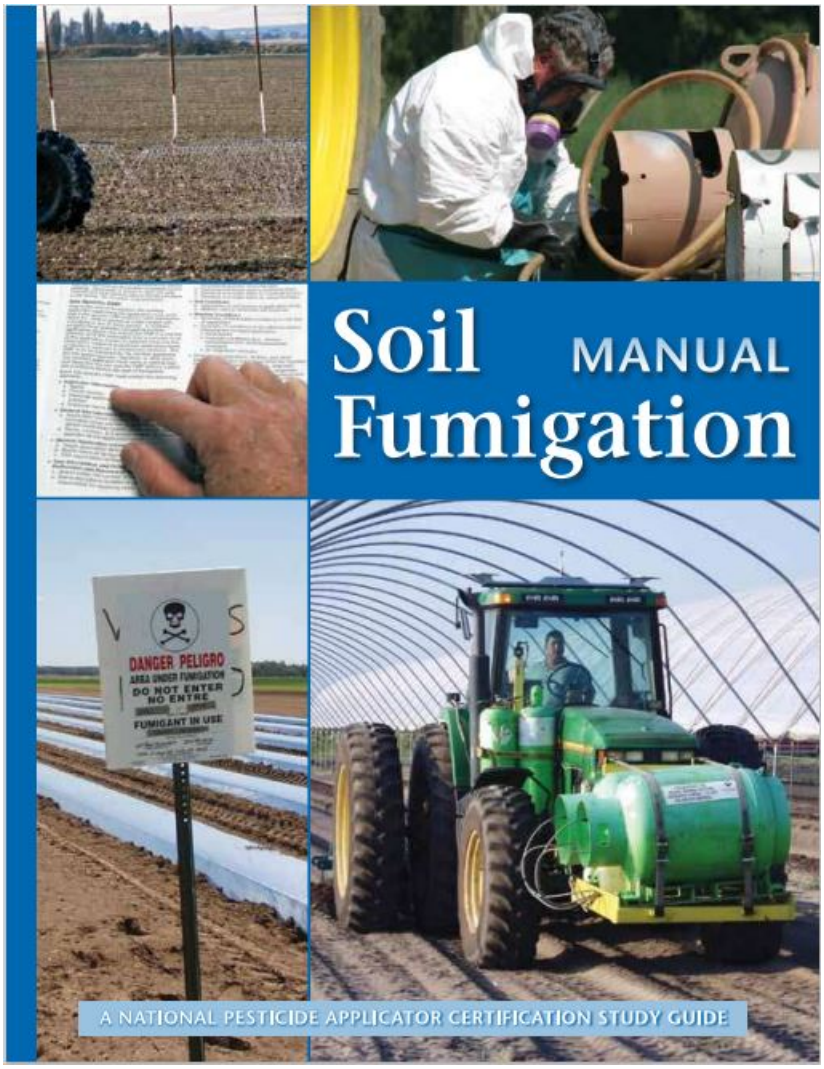
Chemical formulations change regularly. Consult your local dealer for product recommendations for specific pests.

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.

Read, understand and follow label directions.

It is the law.

Category L3: Soil Fumigation Pest Control



A picture of the manual cover is shown above.

Conclusion

All fumigants are restricted-use pesticides. 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.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and Bret Allen and R. Saliga, Nevada Department of Agriculture.

Category N: M-44 Predatory Pest Control

M-44 Predatory Pest Control Learning Objectives

THIS CATEGORY IS LIMITED TO USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE (APHIS) WILDLIFE SERVICE EMPLOYEES ONLY. IT IS FOR THE CONTROL OF COYOTES, RED AND GRAY FOXES, AND WILD OR FERAL DOGS ONLY.

After studying this category, you should be able to:

- ✓ **Describe M-44 predator control device use.**
- ✓ **Describe M-44 use restrictions.**
- ✓ **Describe M-44 recordkeeping requirements.**

Category N: M-44 Predatory Pest Control

Category N, M-44 Predatory Pest Control, involves the control of coyotes, red and gray foxes and wild or feral dogs that are vectors of communicable diseases or suspected of preying on livestock, poultry or federally designated threatened and endangered (T/E) species. Certification in this category is limited to USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Service employees.

The M-44 device is a spring-activated device that delivers a dose of cyanide powder to targeted animals. It uses a sodium 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

Category N, Predatory Pest Control, involves the control of coyotes, red and gray foxes and wild or feral dogs ONLY.

Certification in this category is limited to USDA APHIS Wildlife Service Employees ONLY.

In addition to the main product label instructions and directions, EPA mandates 27 use-restrictions, which provide guidance for the application, storage, disposal and training requirements, safety, and necessary recordkeeping.

Each Applicator of the M-44 device must be trained in:

- **Safe handling of the capsule and device.**
- **Proper placement of the device.**
- **Necessary record keeping.**

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, fox 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 one to five 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 USDA APHIS Wildlife Service use only.
III. REFERENCE	The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended. M-44 Cyanide Capsules, EPA Registration No. 56228-15

M-44 Use Restrictions, as of May 14, 2020

In addition to the main product label instructions and directions, EPA mandates 27 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 must conform to all applicable federal, state and local laws and regulations.
2. Applicators must 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 placement of the device, and (3) necessary recordkeeping.

4. M-44 devices and sodium cyanide capsules must 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 must 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 must not be used solely to take animals for the value of their fur.
7. The M-44 device must only be used on or within 7 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 must not be used: (1) on 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) in national or state parks, national or state monuments, federally designated wilderness areas and wildlife refuge areas, except that the M-44 device may be used in the areas listed above in (4) only for the protection of federal designated threatened or endangered species.

   To determine whether the applicable land management agency has set aside any area on federal Lands for recreational use, either on a permanent or temporary basis, the APHIS State Director or his/her designated representative, who are considering authorizing or are responsible for ongoing use of M-44 capsules on public lands, must contact each applicable land management agency quarterly to determine whether any portions of the projected or current M-44 use areas are, or are to be, set aside for recreational use. Within 30-days of that contact, the APHIS State Director, or his/her designated representative, must provide the applicable land management agency with written documentation specifying the applicable land management agency's determinations of what projected or current M-44 use areas

The M-44 device must only be used to control coyotes, red and gray foxes and wild or feral dogs.

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.

The M-44 device must not be used in areas where federally listed threatened or endangered animal species might be adversely affected.

One person in APHIS other than the individual applicator must have knowledge of the exact placement location of all M-44 devices in the field.

are to be set aside for recreational use. For purposes of this Use Restriction, areas set aside for recreational use include areas where and when there are scheduled recreational events, areas identified on maps with "recreation" in the title, areas where developed or known camping occurs, areas near designated or known recreational trail heads and designated or known vehicle access sites.

9. The M-44 device must not be used in areas where federally listed threatened or endangered animal species might be adversely affected. Each applicator must be issued a map, prepared by or in consultation with the U.S. Fish and Wildlife Service, which clearly indicates such areas.

   (1) Except as provided in paragraph (2) below, the M-44 device must not be used in areas occupied by any federally listed threatened or endangered species or any federally listed experimental populations as set forth in the most current versions of maps that have been prepared or approved by the U.S. Fish and Wildlife Service (FWS). At the time of application, the applicator must be in possession of the most current map, if such map exists, that covers the application site. If maps covering the application site do not exist, then the M-44 applicator must, prior to application, consult with FWS to determine whether the application site is in an area occupied by listed animal species. Any use of the M-44 thereafter shall be consistent with any conditions or limitations provided by FWS through such consultation.

   (2) Notwithstanding paragraph (1), the M-44 device may be used in areas occupied by endangered, threatened or experimental populations if use in such areas a) has been addressed by FWS in special regulations pursuant to section 4(d) of the ESA, in requirements imposed through incidental take statements or incidental take permits, or in other applicable agreements with the FWS, and b) the applicator's use of the M- 44 is consistent with any conditions or limitations provided by FWS for such use.

10. At least one person within APHIS, in addition to the individual applicator, must have knowledge of the exact placement of all M-44 devices in the field. This includes initial placement and any subsequent changes of M-44 GPS locations as soon as possible, but no later than 14 days. In the case of applications to privately owned land, the applicator must also have written permission from the landowner or lessee who has requested the M-44 device use prior to their placement. When devices are placed on private land, all residences on the property must be notified of the M-44 device use.

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 must not be placed within 200 feet of any non-frozen 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. M-44 devices may be set within 200 feet of frozen bodies of water only if (i) they are removed before the water body is no longer completely frozen, and (ii) are set at such elevation to prevent inundation in the event of an untimely thaw.
13. The M-44 device must not be placed in areas where food crops are planted.
14. The M-44 device must not be placed within 300 feet of any designated public road or public pathway.
15. The maximum density of M-44s placed in any 100-acre pasture land areas must 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 must 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 must be visually be inspected by an applicator or cooperator at least once every week, weather permitting access, to check for interference or unusual conditions, and must be serviced as required by the applicator.
19. Damaged or nonfunctional M-44 devices must be removed from the field.
20. An M-44 device must 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, including when in transit.

The M-44 shall NOT be placed:

- **Within 200 feet of any lake, stream or water body.**
- **Where food crops are planted.**
- **Within 300 feet of a designated public road or public pathway.**

Supervisors of applicators must 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 must be inspected at least once a week.

After 30 days, a M-44 device must be removed if here is no sign a target predator has visited the site.

Bilingual warning signs in English and Spanish must be used in all areas containing M-44 devices.

In all areas where the use of the M-44 device is anticipated, local medical people must be notified of the intended use.

Each M-44 authorized applicator must keep records of the placement of each device and the results of each placement.

22. Used sodium cyanide capsules must 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 must be used in all areas containing M-44 devices. All such signs must 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. Install freestanding warning signs at access points or on property boundaries where no fence lines exist, as appropriate. Signs must be inspected weekly to ensure their continued presence and ensure that they are conspicuous and legible.
    b. Two elevated signs, placed in the most likely directions of approach, must be placed within 15 feet of each individual M-44 device warning persons not to handle the device.
24. In all areas where the use of the M-44 device is anticipated, local medical people must 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. It must be the responsibility of the supervisor to perform this function. Notifications must be made at least annually.
25. Each authorized M-44 applicator must keep records dealing with the placement of the device and the results of each placement. Such records must 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 and removal.
    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.
26. The M-44 device must not be used within 600 feet of occupied residences, except those of any cooperating entity who have given APHIS written permission for M-44 placement on their property.

27. Prior to device placement, APHIS must notify any occupied residence within 0.5 miles of an M-44 device of the presence of M-44s by one or more of the following methods: face-to-face communication, person-to-person telephone conversations (voice message is NOT acceptable), door hanger notice, certified mail.

Conclusion

Category N, M-44 Predatory Pest Control, involves the control of coyotes, red and gray foxes, and wild or feral dogs that that are vectors of communicable diseases or suspected of preying on livestock, poultry or federally designated threatened and endangered (T/E) species. Certification in this category is limited to USDA APHIS Wildlife Service employees only.

The M-44 device must not be used within 600 feet of occupied residences, except those of any cooperating entity who has given APHIS written permission for M-44 placement on their property.

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.
Updated in 2023 by M. Hefner, University of Nevada, Reno Extension and Bret Allen and R. Saliga, Nevada Department of Agriculture.

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