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**

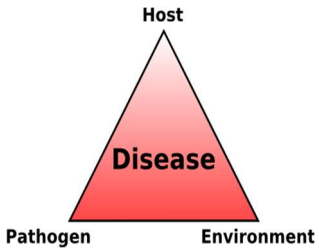
The first step in pest control is proper identification of the pest.

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,

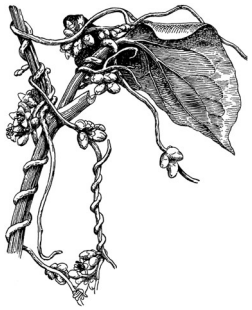
producing toxins and enzymes that disrupt normal plant growth and functions. Individual fungi generally grow as fine, thread-like, microscopic structures called hyphae. The hyphae can form a network, which is called a mycelium. The mycelium can be macroscopic (visible with the naked eye). Fungi also 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.

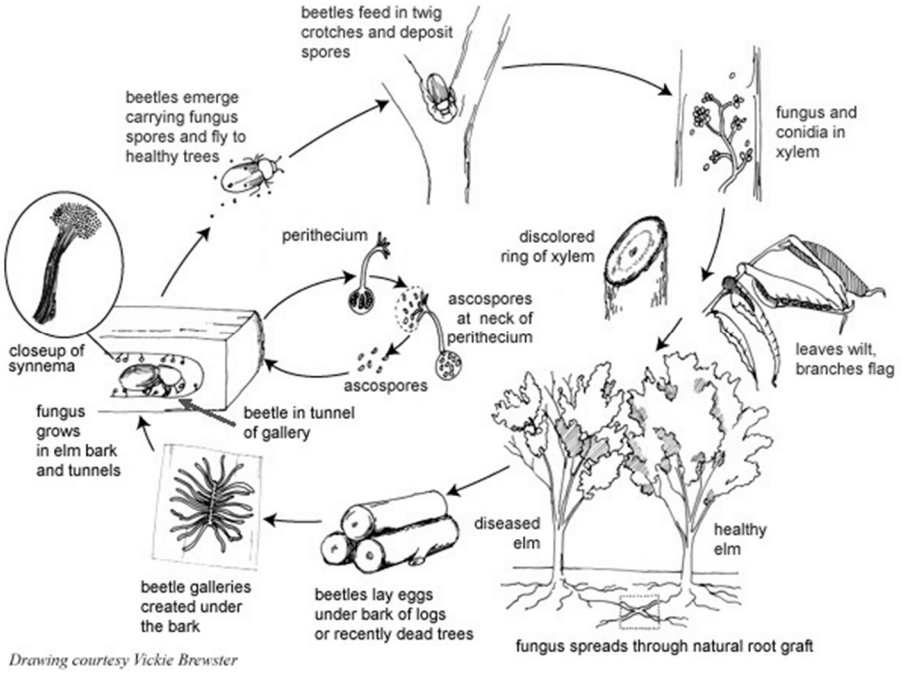
Hyperplasia: over-development of specific plant parts.

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.

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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).

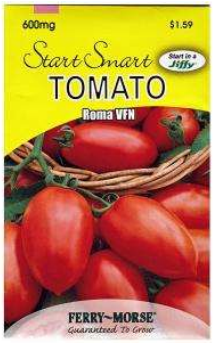
Plant disease management, like most pest management, is based on several important principles. A basic understanding of control principals is necessary in managing plant diseases. The following principals were first described in 1929 and are still used today. Disease control is often not practical or 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.

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

Pest populations must be regularly monitored.

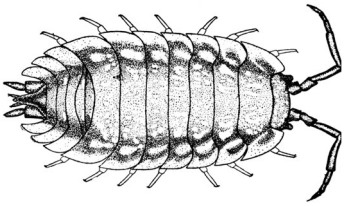
Keeping records of pest observations may aid in predicting and preventing future outbreaks.

Pest Thresholds:

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

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

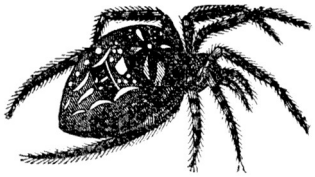
Emotional: Point at which the pest infestation causes enough emotional trauma to justify treatment.



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

Class Insecta (all insects)

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

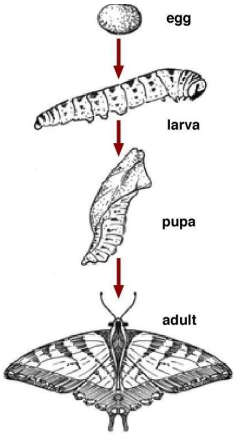
Insect life cycles

It is important to know the life cycle of an insect so that control mechanisms, when necessary, may be incorporated at the most susceptible stage of the life cycle. Insects can be divided into two basic groups, based on their life cycle: complete metamorphosis and incomplete or simple metamorphosis. Complete metamorphosis consists of a life cycle of egg-larva-pupa-adult. These insects look very different from the larval to adult stages. Common insects exhibiting complete metamorphosis include butterflies, moths, flies, bees, wasps, ants and mosquitoes.

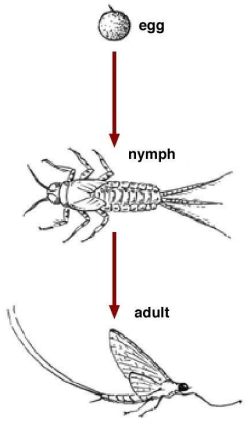
Incomplete metamorphosis is also referred to as gradual or simple metamorphosis and consists of a life cycle of egg-nymph-adult. The nymph stage looks similar to the adult stage but is generally smaller and without wings. Many insects with an incomplete metamorphosis life cycle grow through several nymph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

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

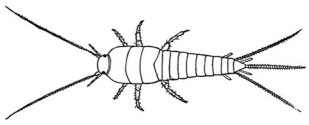
Typical insect



Complete metamorphosis
egg, larva, pupa, adult
UNCE



Incomplete metamorphosis
egg, nymph, adult
UNCE



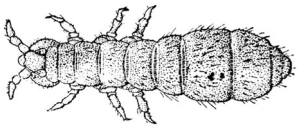


Table 6. Distinguishing characteristics of insects among orders

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

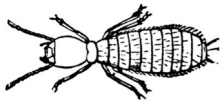
Insect Orders

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.

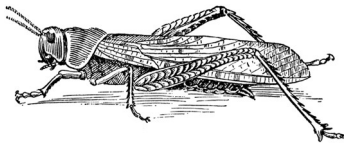
Collembola: Springtails make up this order. Small, wingless insects without compound eyes, these insects go through a simple life cycle. They get around using a tail-like structure that folds beneath their body and propels them. They inhabit moist areas and may be a nuisance in homes. Only one is known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

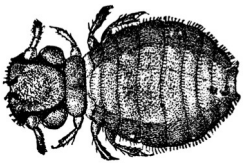
Isoptera: Termites have a broad juncture at the abdomen and thorax, reproductive termites have two pairs of similar-sized and -shaped, membranous wings and moniliform (string of beads) antennae. They are pests of wood and require cellulose from wood or other plant tissue for food. They are social insects.



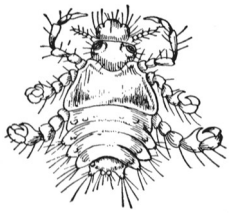
Orthoptera: This order contains the grasshoppers, crickets, praying mantis and walking sticks. Their life cycle is simple. They have strong chewing mouthparts. Their rear wings are membranous and are covered and protected by the front pair. Most are large insects and many are pests.



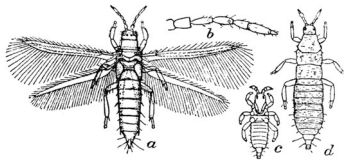
Mallophaga: Chewing lice. Small, wingless, chewing insects, the chewing lice have a simple life cycle spent entirely on the host. The head is wider than the thorax. Most attack birds, domestic fowl and mammals as ectoparasites (external parasites), but not humans.



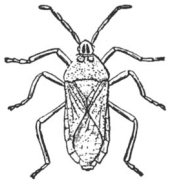
Anoplura: Sucking lice. These small ectoparasites suck blood from mammals, are wingless, and their long, pointed heads are narrower than their thorax. The life cycle of sucking lice is simple. These insects irritate livestock, reducing their vitality. They also transmit diseases to animals and humans.

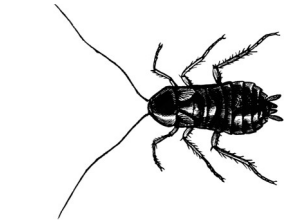


Thysanoptera: Thrips are minute insects and may be winged or wingless. If winged, there are four narrow wings with long hairs. They have a complete life cycle and feed by rasping-sucking plant juices. Most feed on flowers, buds, and leaves. Some are predaceous species to other insects.

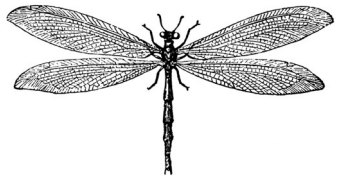


Hemiptera: This order contains the true bugs, including boxelder bugs, leaf-footed bugs, stink bugs, assassin bugs, big-eyed bugs, minute pirate bugs and bed bugs. They can be recognized by the X formed by the wings. This order includes both pests and beneficial insects. This order also now includes 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.

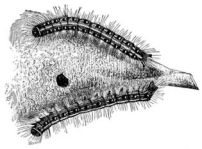




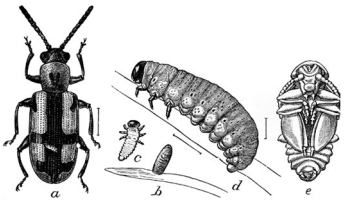
Blattodea: Cockroach family. Cockroaches have an oval, brown to black body, two pairs of membranous wings, if present, and long antennae. Their head is bowed down and covered with a pronotum. They run rapidly and hide from light.



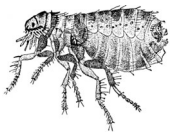
Neuroptera: Antlions and lacewings are in this order. Most of the members of this order are predacious. The adults have wings that have numerous veins, giving them a net-like appearance. Larvae can be destructive. They have chewing mouthparts. They have complete life cycles and many are important aquatic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

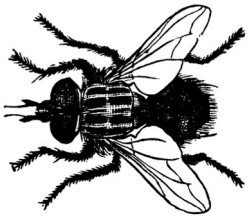


Coleoptera: This is the largest order of insects, with over 300,000 species. Most can be easily identified by the hardened forewings, called elytra. This order contains both beneficial and injurious species of beetles. The larvae are grubs and are economically important. They have a complete life cycle.



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.

Branch Dieback: Wood-boring insects, such as the bronze birch borer, damage plant vascular tissues, resulting in dieback of the infested limbs or branches. Branches damaged by other causes and weakened trees in general are particularly susceptible to insect borers. Diseases, environmental stresses, cultural problems, insects or a combination of these factors may cause branch dieback.

Bronzing: From a distance, trees heavily infested with spider mites appear discolored. Close examination of infested foliage reveals a bronze discoloration of the leaves. To confirm a diagnosis of spider mite injury, tap infested branches over a white piece of paper. Dislodged spider mites appear as tiny specks moving on the paper. Evergreen trees and shrubs located along dusty roadways, in areas of reflected heat or in windy hot sites, are most susceptible to mite infestations.

Cankers and Swelling: Many beetle larvae and caterpillars bore into tree trunks or limbs, causing the infested tissues to swell or form cankers. When these swellings are cut open, insect tunnels and sawdust-like frass is visible. Insect borers attack trees that are weakened or damaged by other causes. In some cases, borers and plant pathogens are associated with the same canker.

Locust borer is an example of a round-headed borer that causes swelling on infested tree trunks and branches of black locust trees.

Chewed or Skeletonized Leaves: Leaf beetles and some sawflies chew off one surface of a leaf, leaving the opposite surface and veins intact. This type of insect damage makes the leaves look like lacy skeletons. Elm leaf beetle and pear slugs are two examples of leaf skeletonizers. Most caterpillars and adult beetles chew entirely through leaves, leaving small to large holes or irregularly shaped, jagged leaf edges. If leaves are still growing when a chewing insect feeds, the leaves may later develop smooth edges around the holes. Only insect feeding causes these symptoms.

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

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

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

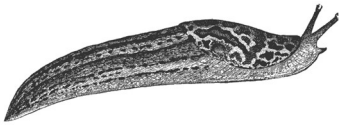
Integrated Pest Management (IPM) control methods:

- **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

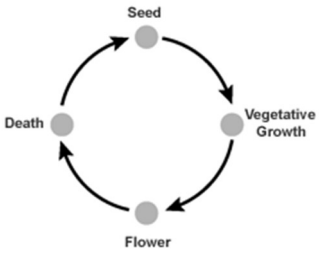
Weeds are:

- **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

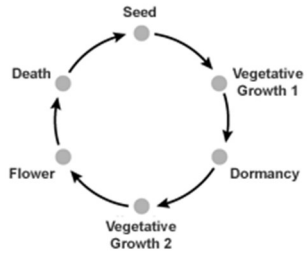
bluegrass.

- **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.

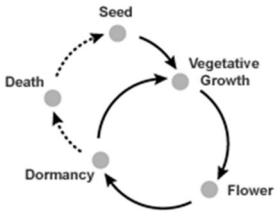
Plants can be classified, categorized or grouped using many different criteria. Life cycle is one classification method, as we just discussed. Plants can also be categorized by physiology, poisonous potential, or legal status. Habitat, or where the plants grow, is a logical way to subdivide plants that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

<u>Classification by Habitat</u>

- **Aquatic plants** are those that can survive submersed in water for all or most of the time. These plants have special adaptations that allow them to survive immersed in water. They are divided into two major groups: vascular plants and algae.
  - **Vascular aquatic plants** have roots, stems and leaves. These plants are most often perennials.
    - Emergent plants are those that have most of the plant above the water surface. Examples are cattails, purple loosestrife, reeds and rushes.
    - Rooted floating plants are those that have all or part of the plant

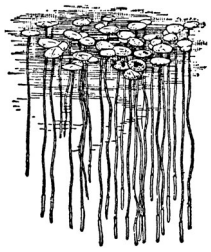


Perennial growth cycle

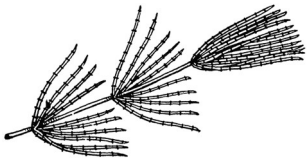


Cattails

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

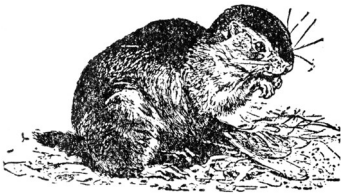
or plague, along with them. Live trapping followed by an approved method of euthanasia is recommended. The American Veterinary Medical Association has specific guidelines for euthanasia.

- **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

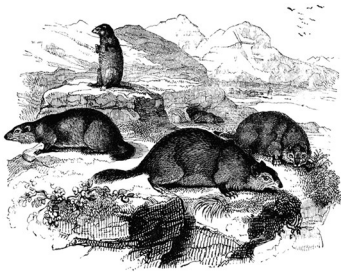
- **Ground Squirrels:** Four species cause problems to crop and ornamental plants in Nevada: Richardson's, Belding's, Townsend's and California ground squirrels. They may also damage irrigation lines by chewing, or they may damage landscape and buildings by burrowing. The best time for control is after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

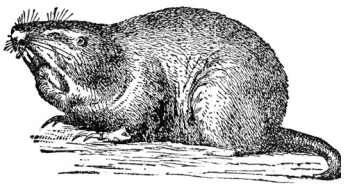
Rodenticide baits should be used in bait boxes to limit unintended injury or death to non-target species.



Marmots

Meadow vole

Mole



Pocket gopher

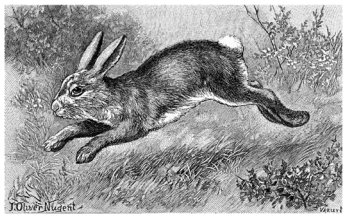
impossible. Rodenticide baits should be used in bait boxes to limit unintended injury or death to non-target species. Live trapping and subsequent euthanasia are also used to control ground squirrels. Check traps often, and use caution to prevent unintended injury or death to non-target species. Strychnine 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.

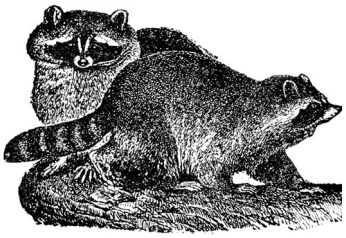
- **Wood rats or pack rats:** Wood or pack rats will set up house in sheds, attics, garages and other structures. They are messy and carry disease. Like all rodents, their teeth continue to grow their whole lives. They must gnaw or chew on things to wear away their teeth. They can cause structural damage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

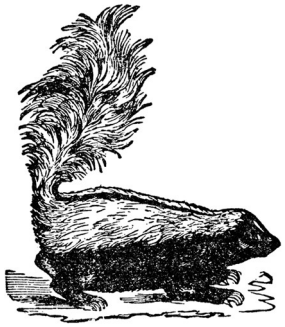
Deer mouse



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

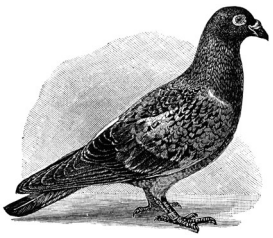
box-style trap to reduce the potential for getting sprayed.

- **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.

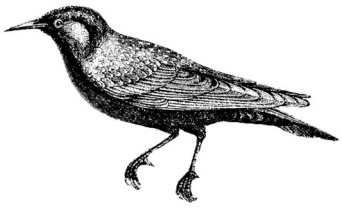
  Caution must be used when dealing with bird pests, as many birds are protected under the Migratory Bird Treaty Act (MBTA). As with all other pests, you must first identify the pest causing your problems. The following common bird pests are <u>not protected</u> by the MBTA.

  - **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.

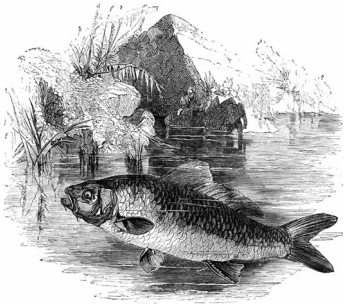
- **Fish Pests**<u>:</u> Fish become pests when they are introduced into waters where they compete with more desirable species. Exotic species such as carp were introduced to North America from Asia. Carp has become one of the most serious fish pests. Also, game fish such as pike, bass or trout, when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

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