University of Nevada
Cooperative Extension

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A Green Industry Professional's Guide to Integrated Pest Management (IPM)

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A partnership of Nevada counties; University of Nevada, Reno; and U.S. Department of Agriculture

Cover photo by Wendy Hanson Mazet, University of Nevada Cooperative Extension.

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Introduction

A Green Industry Professional's Guide to Integrated Pest Management (IPM) is designed to help green industry personnel understand IPM and to aid in implementing a pest control plan. This guide is limited to landscape pests; it does not pertain to structural pests or pests of agricultural crops.

This publication does not contain all the information necessary to identify and control pests. Wherever possible, the reader will be referred to additional websites for further information.

Additional aid in identifying weeds, insect pests or plant diseases can be obtained from the Nevada Department of Agriculture and University of Nevada Cooperative Extension. For a list of Nevada Department of Agriculture office locations, go to *http://agri.nv.gov/Contact/Contact/*. For a list of University of Nevada Cooperative Extension offices go to *http://www.unce.unr.edu/contact/offices/*.

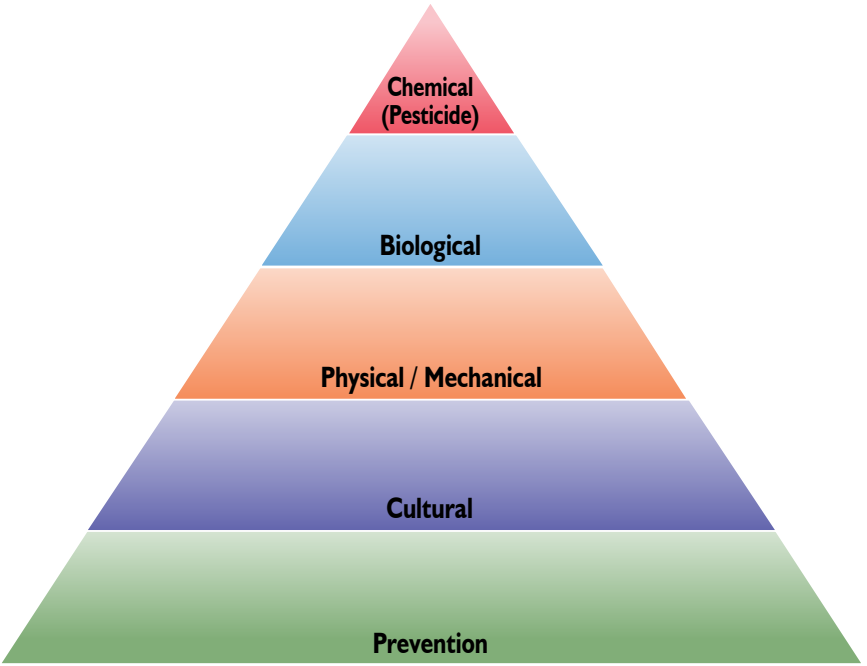
Additional aid in identifying wildlife pests can be obtained from the Nevada Department of Agriculture, *http://agri.nv.gov/Resource_Protection/*, and the Nevada Department of Wildlife, *http://www.ndow.org/*.

The Property Weed Report — Initial Site Visit, Property Weed Report — Follow Up Site Visit, Property Insect Pest Report — Initial Visit, and Property Insect Pest Report — Follow Up Site Visit forms can be found online at: *http://www.unce.unr.edu/programs/sites/IPM/IPMRecordKeepingForms/*. Download these forms to use as they are, or modify them to fit your needs.

What Is IPM?

Integrated Pest Management (IPM) is a sustainable approach to managing pests by combining cultural, physical, biological and chemical tools in a way that minimizes economic, health and environmental risks.

IPM is the strategic use of multiple strategies to control pests. Often, our first impulse is to apply a pesticide at the first sign of a problem. IPM helps develop a pest control plan that can prevent or limit pest problems in the future. IPM control strategies are commonly shown as a pyramid. The major emphasis is on the base of the pyramid, preventing pest problems, and the use of chemical controls is limited to situations where it is really needed. IPM is not a no-pesticides approach to pest management. IPM control plans consider all available methods to control pests. Specific IPM principles will be discussed on Page 20.



What Are Pests?

Pests are organisms that damage or interfere with crops, ornamental landscape plants, homes, structures or wildlands.

Photo by Terry Spivey, USDA Forest Service, Bugwood.org.

This deer becomes a pest when it jumps the fence and begins consuming crops or plantings in landscape settings.

Landscape pests can be divided into four groups: weeds, insects, plant diseases and wildlife. Below is a list of websites that will help identify pests and provide further information.

http://manageNVpests.info Managed by University of Nevada Cooperative Extension, this site contains information on IPM, including photo galleries of noxious and nuisance weeds, pest insects, beneficial insects and exotic insects.

http://agri.nv.gov/Plant-Industry/ Nevada Department of Agriculture plant industry site, with links to the entomology, noxious weeds, and plant pathology departments. For wildlife problems, the link is *http://agri.nv.gov/Resource_Protection/*.

http://ipm.ucanr.edu University of California statewide IPM programs website with home, landscape and agricultural pests. It has a weed gallery, exotic and invasive pest information, and beneficial insects gallery.

http://icwdm.org/handbook/index.asp Prevention and control of wildlife damage handbook. This site was funded by the National IPM Network and USDA - CSREES.

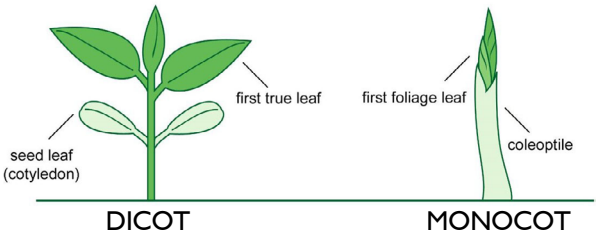
http://www.nevadapesticideeducation.info This site is managed by University of Nevada Cooperative Extension to educate certified pesticide applicators in pesticide safety.

Weeds

The term "weed" refers to a plant growing where it is not wanted. Among weeds, there are some important distinctions. **Noxious weeds** are weeds designated by the state as requiring control. **Nuisance weeds** are weeds that have not been designated as noxious, but occur commonly in our area. Weeds are plants that are:

- Competitive: They grow well in spite of interference from other plants.
- Persistent: They will return year after year. They reproduce vigorously and spread seeds effectively.
- Harmful: They may be harmful to native plants, livestock and wildlife, and to the environment in general.

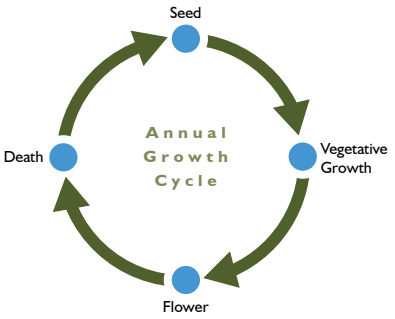
Weeds can be subdivided in several ways. A common way to subdivide weeds is by class: Dicots versus Monocots. Dicots have two seed leaves and are also called broadleaf weeds. Monocots have one seed leaf; these are grasses, sedges and rushes. Dicots commonly have a coarse taproot and net-like leaf veins. Monocots commonly have fibrous roots and parallel leaf veins. Understanding the class of the weed you wish to control becomes important when you choose to use a chemical control. Some herbicides are grass-selective (kill monocot plants), and some are broadleaf-selective (kill dicot plants). There are also nonselective herbicides that will kill all plants.

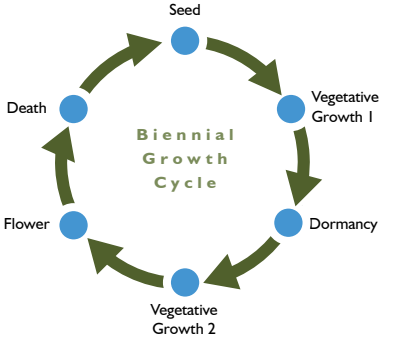


For the purposes of discussion in this publication, we will focus on subdividing weeds by their life cycle.

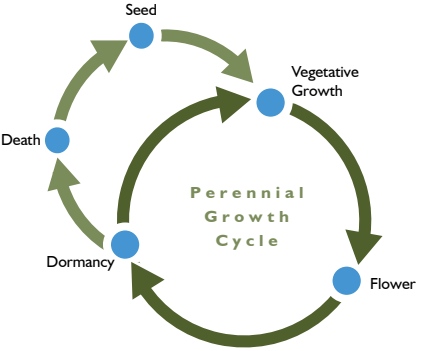
Life cycle. All plants grow through stages: seed to seedling, to vegetative growth, to flowering and seed production, to death.

Annual plants complete all plant growth stages in one growing season.
Biennial plants complete all plant growth stages in two growing seasons. The first year includes seedling and vegetative stages; the second year includes vegetative, flower and seed development, and then death.





Perennial plants complete all life stages in one growing season (except death). They survive more than two growing seasons and have a seedling stage only during the first growing season.



Why should you care?

Most weeds are easiest to control at the seedling stage.

Herbicides are most effective when applied to actively growing plants. Growth stage affects herbicide performance.

Annuals and other weeds establishing from seed. Control of annual weeds is most effective when seeds are germinating and when plants are very young. Preemergence herbicides can be used to kill germinating seeds. Plants that survive are easy to hand-pull when they are young. In unplanted areas, the first crop of weeds may be allowed to germinate, and the young plants are killed with herbicides or tillage. Annual weeds are most resistant to control after flowering, and you risk allowing seed to be produced and distributed, further adding to the seedbank. The seedbank is the viable seed present in the soil from previous weed infestations.

Photo by Nate Weber, Crop Production Services.

Photo by Melody Hefner, University of Nevada Cooperative Extension.

Control of annual weeds (left) is most effective when seeds are germinating and when plants are very young. Biennial weeds are most susceptible to herbicides at the rosette stage of development (right) during the first year and early second-year growth.

Biennial weeds. In addition to preventing seed germination and hand-pulling young plants, biennials are most susceptible to herbicides at the rosette stage of development, when the plant is sending carbohydrates to the roots for storage. After bolting (production of flowering stems), susceptibility to herbicide drops. Control efforts should focus on prevention of flowering, to avoid adding to the seedbank.

Perennial weeds. Control of perennial weeds involves prevention of seed production, but also control of growth from vegetative reproductive structures. Many perennial weeds are difficult to control by hand-pulling or tilling. Chemical control is most effective when these weeds are both actively growing and moving carbohydrates to the roots for storage. An effective time to control perennial growth is just before the early flower bud stage, when root reserves have been depleted and carbohydrates from the leaves are beginning to move downward to the roots. Applied herbicides will move with carbohydrates to the roots until the flowers open. Another good time is during the fall, when plants are moving carbohydrates to the roots for storage over winter. Perennial weeds are least susceptible to herbicides at emergence of new shoots or during seed development.

An effective time to control perennial growth is just before the early flower bud stage (above) or during the fall, when plants are moving carbohydrates to the roots for storage over winter (right).

Photos by Melody Hefner, University of Nevada Cooperative Extension.

It is beyond the scope of this publication to identify all noxious and nuisance weeds in the state of Nevada.

Here is a list of resources to help you identify weeds:

Nevada Department of Agriculture noxious weed list *http://agri.nv.gov/Plant/Noxious_Weeds/Noxious_Weed_List/*

University of Nevada Cooperative Extension Nevada Noxious Weed Field Guide *http://www.unce.unr.edu/publications/files/nr/2010/sp1001.pdf*

University of Nevada Cooperative Extension Integrated Pest Management Common Nuisance Weed photo gallery *http://www.unce.unr.edu/programs/sites/ipm/gallery/*

University of Nevada Cooperative Extension publications on weeds: *http://www.unce.unr.edu/publications/search/* click on "key words" and enter "weeds."

University of California Statewide Integrated Pest Management Program Weed Photo Gallery *http://ipm.ucanr.edu/PMG/weeds_intro.html*

Photo by Melody Hefner, University of Nevada Cooperative Extension.

These are dandelions infesting a pasture.

Common Pest Insects and Mites

Less than 5 percent of all insect species are pests. For identification and control purposes, it is important to recognize the differences between insects and mites. Insects have three body parts (head, thorax and abdomen), three pairs of legs and one pair of antennae. Insects also commonly have one or two pairs of wings in the adult stage. Mites are similar to spiders. They have two body parts (head and abdomen) and four pairs of legs; they do not have wings or antennae.

Aphids: *There are many species of aphid (right), all of which have sucking mouth parts. They may reproduce sexually or asexually, with multiple life cycles in a growing season. In addition to damaging plants, aphids can be vectors of disease.*

Photo by Eugene E. Nelson, Bugwood.org.

Photos by Whitney Cranshaw, Colorado State University, Bugwood.org.

Elm leaf beetles: *Both adults (above right) and larvae damage leaves. Early hatch larvae (above left) are small and black; late instar larvae (above center) are yellow with black stripes.*

Eriophyid mites: *Not visible with the naked eye, these mites cause discoloration and leaf curl (right). Damage appears similar to herbicide damage. The mites feed within plant tissues, making them difficult to control.*

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Photo by David Cappaert, Bugwood.org.

Photo by Steven Katovich, USDA Forest Service, Bugwood.org.

Leafminers: *Larvae (above left) feed on the insides of leaves, causing discoloration (above right) and subsequent leaf drop during heavy infestations. There are many species; most are host-specific.*

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Photo by University of Georgia Plant Pathology, Bugwood.org.

Leafhoppers: *There are many species, and they are usually host-specific. These insects are very small and difficult to see with the naked eye. A 10x hand lens may help (near left). Damage shows as stippling on the undersides of leaves (far left).*

Thrips: *Feeding damage by adults and larvae (right) can cause discoloration and stunting of leaves and flowers. Some thrips species are also vectors of plant disease. Thrips have several generations per year.*

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Harvester ants: *These ants (left) live in large colonies. They will clear all vegetation surrounding their nest and along their foraging paths. They eat plants, seeds and insects. They cause damage to crops, pastures and lawns. They have a stinging bite.*

Root weevils: *There are several species, and most are host-specific. Larvae (near right) damage plant roots and crowns. Adults (far right) cause minor damage to leaves.*

Photo by David Gent, USDA Agricultural Research Service, Bugwood.org.

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Photo by Jerald E. Dewey, USDA Forest Service, Bugwood.org.

Sequoia pitch moth: *(Adult above) Larval feeding causes trees to produce abundant pitch masses (right). Avoid injuring trees to prevent these pests from laying their eggs.*

Photo by Susan K. Hagle, USDA Forest Service, Bugwood.org.

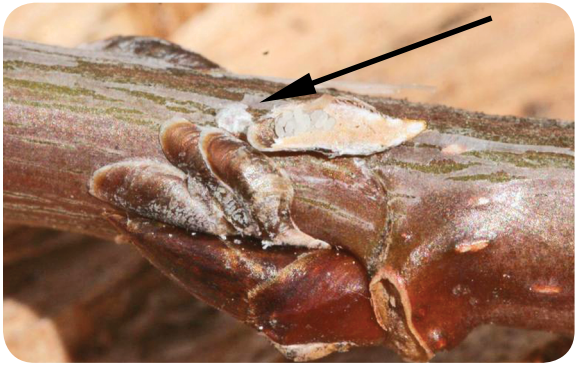


Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Scale: *There are many species of scale insects. Small and armored, they are difficult to control except at the crawler stage. Oystershell scale (left) is a common scale pest of many landscape plants. The scale insect at the top of the photo (arrow) has been overturned to show eggs.*

Photos by John A Weidhass, Virginia Polytechnic Institute and State University, Bugwood.org.

Spider mites: *These web producers, generally found on the undersides of leaves (far left), are a common landscape pest. Damage starts as speckling on leaves (near left); leaves turn yellow and drop as the infestation increases.*

Photos by David Shetlar, The Ohio State University, Bugwood.org.

Billbugs: *Billbugs are a type of weevil. The larvae (far left) of these insects (adult, near left) feed on the roots and crowns of turfgrass. The stems of affected plants are easily detached at the soil surface.*

Photo by Alton N. Sparks, Jr., University of Georgia, Bugwood.org.

White grubs: *Another common lawn pest, these root feeders also damage landscape plants (left). Entire portions of lawns turn brown and are easily peeled back from the soil. They are the larval stage of over 60 species of beetles.*

Common Plant Diseases

Many plant diseases are difficult to control once established. A focus on prevention through good cultural practices will limit the incidence of disease on landscape plants.

Signs versus symptoms. Signs are actual pests, including mycelium, spores, bacterial streaming and nematodes. Symptoms are the plant's response to the pathogen and include wilt, leaf necrosis, chlorosis, galls, deformations and dieback. Symptoms indicate the presence of disease; signs allow identification of the pathogen.

Fungal diseases. Most plant diseases in Nevada are caused by fungi. Signs to look for are visible spores and mycelium. Generally, these are internal and hard to see. Symptoms are variable and may include necrosis, wilt, leaf chlorosis, dieback, galls and deformation. Three main categories are common in Nevada:

Phytophthora: Not a true fungus, it is an oomycete or water mold. There are over 60 species that can infect many different plant species. It most often causes root, crown and fruit rots; damping-off of seedlings; leaf, twig and fruit blights; and dieback. It affects vegetables, ornamentals, fruit trees, forest trees, shrubs and succulents. Spores can travel in water and wet soil, and are long-lived in soil or plant debris. Cultural controls are important to prevent and control this disease. Reduce standing water and soil moisture. Increase soil drainage, and decrease soil compaction. Stop the spread by limiting soil and plant debris movement. Properly dispose of plant debris. Sanitize equipment, and use sterilized soil/growing media.

Fusarium: This includes many species and many varieties within species. Most often, this fungus causes root/crown rot, wilt, dieback, chlorosis and blight. It can cause one-sided wilt/chlorosis in plants. It is long-lived and widespread in soils, both natural and manmade; it can be a nursery, landscape, forest and agricultural pest. Control is similar to *Phytophthora*. *Fusarium*-resistant cultivars are available.

Powdery mildew: Many different fungal species cause powdery mildew. Genera include *Erysiphe*, *Sphaerotheca* and *Leveillula*. Signs are easily seen and include spores and mycelia. Symptoms include leaf chlorosis, spots, necrosis and reduced growth or production. Powdery mildew control must include cultural practices: Reduce standing water/humidity, site plant in a sunny area, increase air circulation and avoid excess fertilizer. Chemical controls include fungicides, sulfur products and horticultural oils.

Photo by Georgia Forestry Commission, Bugwood.org.

***Powdery mildew** on a rose plant. The fungal mycelia cover the leaf surface, giving the typical powdery appearance.*

Bacterial diseases reproduce rapidly and kill plant tissue. The most common sign is bacterial ooze. Symptoms are varied and include wilt, rot, decay, galls, blight and scorch. A common bacterial disease in our area that affects certain fruit trees and roses is **fireblight.**

Photo by P. G. Psallidas, Benaki Institute, Athens, Bugwood.org.

***Fireblight** on a pear tree, forming a characteristic blackish shepherd's crook. Young leaves, shoots and fruit are affected.*

Viral diseases. You cannot see virus particles with the naked eye. They are generally spread by insects or grafting. Symptoms include mosaics, chlorosis, fasciation (stems grow together) and phyllody (abnormal growth in floral structures).

Nematodes. Most nematodes that attack plants are microscopic. Symptoms of nematodes include root galls, seed galls, cysts, wilt and dieback.

Common lawn diseases. These include **fairy ring** (*Basidiomycetes*), **bacterial wilt** (*Xanthomonas*), **brown patch** (*Rhizoctonia*), **dollar spot** (*Sclerotinia*), **snow mold** (*Microdochium nivalis*), **Anthracnose** (*Colletotrichum*), **powdery mildew** (*Blumeria*), **Pythium blight**, and **melting out** (caused by multiple fungi).

Signs and symptoms of lawn diseases vary, depending on which function in the grass plant is affected. Spores are visible on diseases such as rusts, smuts, mildews and slime molds. Fruiting bodies are seen with *Rhizoctonia* and Anthracnose. Bacterial diseases and dollar spot show no visible signs. Symptoms of lawn diseases can include leaf yellowing and death, and root rot.

Chemical and mechanical controls of lawn diseases vary, depending on the actual disease, but some common cultural controls can be used. Fertilize properly, ensure proper drainage and aeration, use resistant cultivars, reduce drought stress, mow properly, and limit standing water on grass blades.

Photo by Lester E. Dickens, Bugwood.org.

***Fairy ring**, a fungal lawn disease, forms characteristic rings that increase in size.*

Photo by William M. Brown, Jr., Bugwood.org.

Photo by Barb Corwin, Turfgrass Diagnostics, Bugwood.org.

***Snow mold** (left) and **dollar spot** (right). Snow mold is generally pinkish, while dollar spot forms small-diameter, light-brown circular patches.*

Wildlife Pests

Unfortunately, there is no single solution to managing nuisance wildlife safely and effectively. Your options depend on the species of animal, where you live, and you or your client's comfort level with different methods of control.

The first step is to properly identify the species of animal. The following websites provide additional information:

- Internet Center for Wildlife Damage Management *http://icwdm.org/handbook/index.asp*
- Nevada Department of Agriculture, Wildlife *http://agri.nv.gov/Wildlife/*
- Nevada Department of Wildlife, Nevada Wildlife *http://www.ndow.org/Nevada_Wildlife/*
- University of Nevada Cooperative Extension, Pesticide Safety Education Program, Vertebrate Pest Management *http://www.unce.unr.edu/programs/sites/pesticide/files/pdf/VertebratePestsNDOA.pdf*
- U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS), Wildlife Damage Management *http://www.aphis.usda.gov/aphis/ourfocus/wildlifedamage*

Shooting is generally not an option, as there are regulations regarding discharge of firearms in most urban areas.

While you can live-trap some nuisance wildlife, relocation is not allowed. The trapped animals must be destroyed, since they may carry disease, and relocation could spread the disease. Many of these diseases are transmissible to humans. Always use caution when dealing with wildlife, and never approach wildlife that are acting strangely.

To be successful at controlling nuisance wildlife, you will need an exclusion plan. For example, it does little good to remove raccoons from the attic if you do not discourage more raccoons from taking up residence. Similarly, you can kill the blacktailed jackrabbit in the yard, but unless you fix the hole in the fence, another blacktailed jackrabbit will crawl through.

Exclusion requires the following:

- Seal off all entry points into the home. This includes attics, chimneys, eaves, sheds, outbuildings and pet doors.
- Refrain from feeding wildlife. You will often attract unwanted animals.
- Remove as many temptations as possible. Ask your clients to bring pets and their food dishes in at night, and eliminate water sources. Cover the compost pile.
- Limit access to the temptations you cannot remove. Better fencing or buried fencing may discourage nuisance wildlife. Suggest your clients secure their garbage cans and wait until their collection day to put out the garbage.

The tables on Pages18 and 19 list common nuisance wildlife in Nevada. Legal status, hunting and trapping restrictions, exemptions, and other control measures are given for each species. This information is taken directly from Dealing with Nuisance Wildlife, University of Nevada Cooperative Extension FS-11-40, *http://www.unce.unr.edu/publications/files/nr/2011/fs1140.pdf*. This fact sheet also discusses large carnivore control issues, Endangered Species Act, Migratory Bird Treaty Act, Game Animal Status and Furbearing Status issues to consider while developing a wildlife pest control plan.

Mammals

Legal Status	Bats●	Badgers	Beavers	Bobcats	Chipmunks●	Coyotes	Deer	Fox	Ground Squirrels	Blacktailed Jackrabbits	Marmots	Voles (Meadow Mice)	Wood Rat / Packrat	Cottontail Rabbits & White-tailed Jackrabbits	Racoons	Skunks
Game species							✓							✓		
Furbearing species			✓	✓				✓								
Protected, sensitive or threatened species	✓				✓											
Unprotected species		✓			✓	✓			✓	✓	✓	✓	✓		✓	✓
Management Guidelines																
May not be hunted, trapped or harassed at any time.	✓															
Hunting is approved in the established season with an appropriate license.			✓	✓			✓	✓						✓		
Trapping is approved in the established season with an appropriate license.			✓	✓		✓		✓								
Hunting without a license is approved.		✓			✓	✓			✓	✓	✓				✓	✓
Live trap and euthanize. Do not relocate.					✓				✓		✓		✓		✓	✓
Use rodenticide bait according to label instructions and apply in a bait station.									✓		✓	✓	✓			
Eliminate hiding places and cover, such as rock and debris piles and low-growing vegetation.					✓				✓	✓	✓	✓	✓	✓	✓	✓
Exclusion techniques: Eliminate access; install barriers to keep animals out; install barrers when animals are away; use fine-mesh wire to protect trees and other sensitive plants; repair holes in fences and buildings.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

● *Only five species of bats are protected.*

● *Palmers and Hidden Forest Uinta Chipmunks are protected under state law.*

Birds

Legal Status	California Quail	Crows	Raptors - Owls, Hawks, Turkey Vultures, Eagles	Pigeons (Rock Doves)	Starlings	Waterfowl - Ducks, Geese, Coots	Woodpeckers & Flickers	Swallows	House Sparrows (English Sparrows)
Game bird	✓	✓				✓			
Protected by Migratory Bird Treaty Act (MBTA)		✓	✓			✓	✓	✓	
Not protected by MBTA - introduced feral species				✓	✓				✓
Management Guidelines									
Capture, killing or possession prohibited unless you obtain a special permit issued by U.S. Fish & Wildlife Service and Nevada Department of Wildlife.	✓	✓	✓			✓	✓	✓	
May only be hunted during established season with appropriate license and/or permit.	✓	✓				✓			
May be hunted at any time without a license. Note: Discharge of firearms is prohibited in some areas.				✓					✓
No permits are required to scare or harass birds, but you must do so before nesting or egg laying occurs. May not harm nest or eggs. Remove nests only when eggs or young are not present.			✓			✓	✓	✓	
Exclude by installing a barrier. Remove sources of food and water. Frightening devices may also have limited effectiveness.	✓	✓	✓	✓	✓	✓	✓	✓	✓
Live trapping and euthanasia is approved. Relocation is not effective, as birds will return from more than 50 miles away.				✓	✓				✓
Chemical pesticides may be applied by a state-licensed applicator.				✓	✓				✓

Excerpted from Dealing With Nuisance Wildlife, University of Nevada Cooperative Extension Factsheet FS-11-40 https://www.unce.unr.edu/publications/files/nr/2011/fs1140.pdf.

IPM Principles

Now that we have discussed common pests of the landscape, let's move on to the four IPM principles.

IPM Principle #1: Identify the Pest

Identification will help you come up with an effective management strategy. Some pests or pest signs are easy to identify. The presence of a mouse or mouse droppings makes identification easy. Other signs can be misleading. For example, what looks like a plant disease may, in fact, be caused by environmental factors, such as water stress or herbicide damage. Additionally, many pests produce similar damage. Using an insecticide on a plant disease will not control your pest problem and may damage the plant. Once you have identified the pest, learn all you can about its life cycle. Some pests are more susceptible to control during certain stages of their lives.

IPM Principle #2: Tolerate a Certain Level of Pests

IPM strives to have people work toward "management" rather than "eradication." Obviously, the goal is to completely eradicate mice or cockroaches in our client's homes. In the landscape, we need to practice a little more restraint. There is a complex food chain at work in the landscape. Most insect pests have natural enemies, other insects or animals that prey on them. These natural enemy insects are commonly referred to as beneficial insects. Beneficial insects need prey or hosts. If you eradicate all the pests, you have eliminated the food source for beneficials. They will move to another site or die. Beneficial insects can also be harmed by insecticides. When you eliminate beneficial organisms from your site, you inherit their job! Keep beneficial insects in the landscape, using them as a willing workforce in pest control.

IPM Principle #3: Monitor at Regular Intervals

It is important to monitor for pests at regular intervals. Don't wait until a pest problem is out of control. Regularly check the properties you manage for signs of pests. If the property had a pest problem in the past, good recordkeeping may aid in your pest management plan. Note the pest, time of year, host plant or location on the property, what you did, how it worked, and when you think you should monitor for the pest again.

When monitoring for pests in the garden or landscape, don't forget to monitor for beneficial insects and note their numbers.

IPM Principle #4: Establish Action Thresholds

An action threshold is the pest population or density that indicates control measures need to be implemented. Action thresholds vary from pest to pest, site to site, and person to person. For agricultural crop pests, the threshold is economic. This is the pest population level that produces damage equal to the cost of controlling the pest. Urban landscapes and homes have a different set of thresholds. Some people are absolutely unwilling to tolerate even one pest in their landscape. This is an emotional threshold. Sometimes the appearance of a pest, or the damage it causes, triggers an aesthetic threshold. Homeowners do not like the way the pest makes their landscape look. Health and safety thresholds can also trigger a pest control response. For example, black widow spiders at the playground of a day care facility can trigger a health and safety action threshold.

IPM Principle #4: Establish Action Thresholds (continued)

Sometimes clients will call when an action threshold for a pest in their landscape has been reached. Other times, the client will expect that you will have set thresholds for pests. Each property and client will be different, but it is important to have set thresholds for different pests that will indicate you need to initiate a control program. If you are expected to set action thresholds for your clients, make sure you communicate the thresholds so the client is aware and their expectations are met. The following photos of landscape problems are provided to help you consider and discuss how and when you would set an action threshold and initiate a pest control plan.

Photo by Wendy Hanson Mazet, University of Nevada Cooperative Extension.

Has the weed infestation in this landscape reached an action threshold? (Red circles indicate weed seedlings.)

Has the weed infestation in this hardscape reached an action threshold?

Photo by Sean Gephart, Nevada Department of Agriculture.

IPM Principle #4: Establish Action Thresholds (continued)

Has the weed infestation in the lawn below reached an action threshold?

Photo by Wendy Hanson Mazet, University of Nevada Cooperative Extension.

Photo by Sean Gephart, Nevada Department of Agriculture.

Has an action threshold been reached in the lawn to the left?

Photo by Sean Gephart, Nevada Department of Agriculture.

This landscape is well beyond the action threshold for weed pests.

IPM Principle #4: Establish Action Thresholds (continued)

This verbena plant is infested with thrips. What is the action threshold for this pest?

What if the whole delivery of plants to the nursery or landscaping job site is infested with thrips? What is the action threshold?

Photos above by Chazz Hesselein, Alabama Cooperative Extension System, Bugwood.org.

This quaking aspen is infested with western tent caterpillars. What is the action threshold for this pest? What if the infestation is found in other trees in the landscape?

Photo by William M. Ciesla, Forests Health Management International, Bugwood.org.

IPM Principle #4: Establish Action Thresholds (continued)

Photo by Ward Upham, Kansas State University, Bugwood.org.

The lawn at left and the field in the photo below are infected with dollar spot, a fungal disease. What is the action threshold for this disease?

Photo by Barb Corwin, Turfgrass Diagnostics, Bugwood.org.

Photo by Sean Gephart, Nevada Department of Agriculture.

The weed shown at left is puncturevine, a noxious weed. What is the action threshold for this weed?

Steps to Developing a Pest Control Plan

1. Identify the pest.
2. Identify its life cycle. Pests are most susceptible to control during a particular stage of their life cycle.
3. Determine the size of the infestation. Have you reached an action threshold?
4. Monitor for beneficial insects or natural enemies. Do you have beneficial insects already preying on your pest?
5. Develop a pest control plan using a variety of strategies.
6. Track your results and modify your plan for the best possible results.

Photo by Eric Coombs, Oregon Department of Agriculture, Bugwood.org.

Monitor for pests and beneficial insects.

IPM Control Methods

Okay, you've identified your pest, you've monitored for pest numbers, and you've reached an established action threshold. Now what? IPM recommends combining two or more control methods for the most effective long-term solution.

Prevention

Prevention is the most economical and easiest pest control method. Prevention strategies seek to prevent pest infestations from occurring in the first place, or they minimize the conditions that contribute to pest infestations. Combined with other strategies, prevention can lead to effective long-term control. Some prevention strategies are listed below.

- Select plant varieties that are adapted to and will flourish in Nevada's challenging climate. Healthy, vigorous plants are less susceptible to diseases or other pest problems.
- Choose pest-resistant plant varieties. For example, many roses are susceptible to powdery mildew. Resistant rose varieties have been developed and can be used in areas where powdery mildew is a problem.
- Before planting, inspect all new stock to make sure diseases, insects, weeds and other pests are not present. Remove weeds from nursery containers before you place the plants in a landscape.
- Choose disease-, weed- and pest-free plants, seed, mulch and soil amendments.
- Select hardscape materials and products that eliminate habitat or food for pests.

- Clean tools and mechanized equipment after each site to prevent spread of pests. Clean vehicles, especially tires, if you've been in a weed-infested area. Properly dispose of all plant debris to prevent the spread of pests.

Cultural Controls

Cultural controls seek to manage your client's landscape by making it as difficult as possible for pests to be successful.

Here are some useful tips:

Eliminate clutter, including trash, brush, debris or leaf piles, where pests may hide and nest.

Properly dispose of plant debris so it will not become a source for further pest infestation.

- Dispose of diseased or insect-infested materials properly. Double bag and remove this material from the property. Do not allow it to be spread to any other property.
- Dispose of weed plants and plant parts properly. Do not allow weed plant parts or seeds to escape on the property or to any other property.

Eliminate food and water sources for pests.

- Empty containers that collect rain or irrigation water. This eliminates a water source for plant pests and also eliminates potential mosquito breeding sites.
- Regularly empty trash cans and replace liners to reduce insect and rodent pest problems.
- Clean out rain gutters to allow proper drainage.

Eliminate access to the landscape by pests. Fix holes in the fence.

Reduce problems in the landscape.

- Apply mulch to retain water and limit competition from weeds.
- Mow lawns at least 3 inches high, and water deeply.
- Check the sprinkler system several times during the growing season to make sure it is functioning properly.
- Water and fertilize landscape plants appropriately.
- Group plants with the same water needs to ensure they are not stressed.

Physical or Mechanical Controls

Physical or mechanical controls are methods that reduce pest infestations by disrupting the pests or providing a physical barrier to prevent pests from infesting an area. One of the simplest methods is handpicking insects or hand-pulling weeds. These methods work best in situations where the pests are visible and easily accessible. Physical or mechanical disruption of

Photo by Scott Roberts, Mississippi State University, Bugwood.org.

Photo by James H. Miller, USDA Forest Service, Bugwood.org.

Physical controls can be barriers, such as the fence to the left. Mechanical controls can be as simple as hand-pulling weeds (above).

pests also includes mowing, hoeing, tilling or cultivating. Another method is washing. A strong spray of water may interrupt the life cycle of many insect pests while causing little damage to host plants or the surrounding environment. Physical barriers, such as fences, netting, sticky barriers, plastic mulches, bird spikes, row covers, plant cages, and paper or plastic tree collars, can help prevent or, at least, deter pests. Traps are another physical or mechanical method and include mechanical traps, such as snap traps, sticky traps and light traps.

Biological Controls

Biological controls use living organisms to control pests. Biological controls include predators, parasites, weed feeders and pathogens. Predators include lacewings and ladybird beetles (ladybugs) that eat other insects, and hawks and owls that prey on rodents. Parasites feed on their hosts, eventually killing the host. Certain wasps, flies and nematodes are common parasites of landscape insect pests. Weed feeders include grazing animals, fish and insects. These control agents help reduce the spread but rarely control or eradicate a weed infestation. Pathogens are diseases, viruses, bacteria or fungi that can infect plants, insects and vertebrate animals. A common pathogen used for biological control is *Bacillus thuringiensis*, a bacterium that controls mosquitoes, flies and other insects in their larval stage. It is sold as a pesticide.

These are assassin bug nymphs consuming a blow fly.

Photo by Chazz Hesselein, Alabama Cooperative Extension System, Bugwood.org.

Chemical Controls

Chemical controls include a variety of pesticides. According to the National Pesticide Applicator Certification Core Manual, a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating a pest, and any substance or mixture of substances intended for use as a growth regulator, defoliant or desiccant. Pesticides are formulated to kill pests or interrupt their life cycle.

Examples of pesticides include:

- Insecticides – kill or interrupt the life cycle of insects.
- Herbicides – kill or interrupt the life cycle of plants.
- Fungicides – kill or interrupt the life cycle of fungi.
- Rodenticides – kill or interrupt the life cycle of rodents.

Any use of pesticides requires the applicator to **read, understand and follow label directions**. The pesticide label will list the sites and the pests the pesticide controls. It will also indicate the Personal Protective Equipment (PPE) the applicator is required to use while mixing and applying the pesticide.

General-use pesticides may be applied by anyone, but restricted-use pesticides (RUPs) must be applied by a certified applicator or a licensed applicator, someone who applies pesticides for hire. For more information on the differences between these two types of applicators, go to: *http://agri.nv.gov/Pest-Control/*.

Pesticide safety is a complex issue. For more information and for study materials to become a certified applicator, go to *http://www.nevadapesticideeducation.info*. Licensed applicators, those who apply pesticides for hire, are required to take a more stringent exam. For more information, go to *http://agri.nv.gov/Plant/PEST/Exam_Qualifications/*.

Beneficial Insects — Here's Your Workforce!

Beneficial insects are predators, preying on insect pests, such as aphids, thrips, scale, mealybugs, caterpillars and other immature or nymph stages of pest insects. They are a free workforce that helps keep insect pests at a tolerable level. Chemical insecticides applied to control pests will kill these beneficial insects as well. Monitor for beneficial insects as you monitor for pests. For more information, go to http://manageNVpests.info and click on the beneficial insects photo gallery.

Ladybird beetles: *This common beneficial insect is a voracious aphid-eater. Almost everyone recognizes the adult stage, but few recognize the larval stage, shown below the adults in the photo to the right. The larvae are better predators than the adults. Look for both life stages as you monitor for pests.*

Photo by Wendy Hanson Mazet, University of Nevada Cooperative Extension.

Photo by Whitney Cranshaw, Colorado State University, Bugwood.org.

Photo by Joseph Berger, Bugwood.org.

Green lacewings: *The larvae (above left) are great predators, eating soft-bodied insect pests, such as aphids, mealybugs and whiteflies, and their eggs. Adults (above center) are pale green with four see-through wings. They may produce five to six generations per year, providing continuous predation throughout the growing season.*

Photo by Wendy Hanson Mazet, University of Nevada Cooperative Extension.

Snakeflies: *Both the adult (above) and larvae (lower left) of this beneficial insect are great predators. Snakefly larvae feed on eggs and larvae of various insects. Adults feed on aphids and other small insects.*

Photo by Maja Jurc, University of Ljubljana, Bugwood.org.

Photos by Frank Peairs, Colorado State University, Bugwood.org.

Photo by David Cappaert, Bugwood.org.

Photo by Bradley Higbee, Paramount Farming, Bugwood.org.

Syrphid flies: *The larvae (above left) of this fly are aphid predators. One larva can consume 400 to 500 aphids in its lifetime. They have three to seven generations per year. The adult flies must feed on pollen before they can reproduce. They prefer wild carrot and yarrow flowers. These flies resemble wasps or bees, but do not sting (above center).*

Minute pirate bugs: *Nymphs and adults of this predator feed on aphids, chinch bugs, whiteflies, spider mites and thrips. They are only about 1/8-inch long, so they are often overlooked (adult, above right).*

Assassin bugs: *Adults (below left) and nymphs feed on pest and beneficial insects, along with spiders and snails. They eat caterpillars and other immature stages of insects. Nymphs of the assassin bug resemble the adult, but do not have wings.*

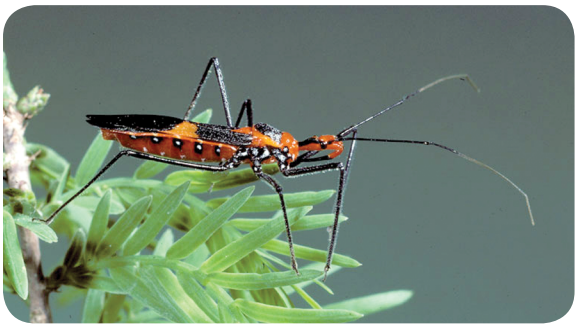


Photo by Gerald J. Lenhard, Louisiana State University, Bugwood.org.

Photo by Stephen Ausmus, USDA Agricultural Research Service, Bugwood.org.

Photo by R.J. Reynolds Tobacco Company Slide Set, R.J. Reynolds Tobacco Company, Bugwood.org.

Parasitic wasps: *These tiny black insects are very small, usually less than 1/8 inch (above right). They lay eggs on or in the body of host insects. After hatching, the larvae feed on and kill the host (left). They prey on aphids, whiteflies, scales, leafminers and caterpillars.*

Native Bees Are Essential to Pollination

There are over 1,000 native bee species in Nevada. Most of these bees are solitary and nonaggressive. Some of the most common native bees are blue orchard mason bee, Nevada bumblebee, alkali bee, leafcutter bee, mining bee, cuckoo bee and green sweat bee. All are good pollinators. Most rarely travel more than 300 to 400 yards from their nest to pollinate. Some, such as the mason bee, are out in early spring, pollinating fruit trees and other plants long before honeybees are active.

Clockwise from top left: blue orchard bee, bumblebee, leafcutter bee, bee fly, cuckoo bee, alfalfa leaf cutting bee and green sweat bee.

All photos from Bugwood.org. Clockwise from top left photos by: Scott Bauer, USDA Agricultural Research Service; David Cappaert; Whitney Cranshaw, Colorado State University; Whitney Cranshaw, Colorado State University; Joseph Berger; Pest and Diseases Image Library; Joseph Berger.

Ways You Can Protect Pollinators

- Limit use of pesticides to times when they are really needed.
- If pesticide application is required, apply early in the morning or late in the evening, when pollinators are not as active.
- Avoid spraying flowers, if possible.
- Communicate with local beekeepers to protect beehives.
- Some pesticides are toxic to bees, through direct contact from applications or from residues left on plants after application. Prior to purchasing or applying pesticides, read, understand and follow label directions. Pay special attention to the "Environmental Hazards" section of the label.
- Minimize pesticide drift to nontarget areas. Drift prevention tips can be found in the Nevada Certified Pesticide Applicator's Workbook at *http://unce.unr.edu/programs/sites/pesticide/files/pdf/PesticideUseAndEnvironment.pdf*.
- Be a source of good information for your clients and customers. Be prepared to answer questions about pollinators and pollinator protection. Bee Basics, An Introduction to Our Native Bees may be helpful. Go to *http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306468.pdf*.
- Consider becoming an expert in pollinator gardens, or plant a demonstration pollinator garden at your place of business. Check out Gardening for Native Bees in Utah and Beyond *http://extension.usu.edu/files/publications/factsheet/plants-pollinators09.pdf*.
- Learn about Extended Residual Toxicity (ERT or RT), the amount of time pesticide residues may be harmful to bees. Go to *http://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591_1.pdf* for more information.

Recordkeeping

Keeping records of activities on your client's property is a necessary part of IPM. Recordkeeping allows you to:

- Predict pest outbreaks, so you can start scouting early and initiate a control plan while the pest outbreak is still small. Detailed records can help you identify the proper time to start scouting for pests in the same landscape the following year.
- Detailed records can help refine your pest control plan. The records document what control strategies were used in the past, and their effectiveness.
- Recordkeeping for chemical controls is important to prevent using the same chemical or a chemical with the same mode of action. Using the same chemical can lead to chemical-resistant pests. Detailed records can help you apply pesticides with different modes of action, reducing the possibility of creating a resistant pest population and improving control.
- Detailed records also demonstrate to your clients that you really care about them and their property.
- If you are a certified applicator or a licensed applicator, Nevada State Law requires you to keep records for any Restricted-Use Pesticides you apply FOR TWO YEARS. You are required to be able to produce the records for Nevada Department of Agriculture and/or EPA employees if so requested.

Recordkeeping requirements include:

- Date of application
- Certified applicator's name
- Brand or product name
- EPA registration number
- Total amount of undiluted material applied
- Size of area treated
- Crop, commodity or site
- Location of the application
- Pest treated
- Start and finish temperatures
- Wind speed and direction

- **For more information** on recordkeeping requirements for restricted-use pesticides, go to http://www.unce.unr.edu/publications/files/ag/2003/sp0303.pdf. A hard copy of this publication can be obtained from the Nevada Department of Agriculture and from selected University of Nevada Cooperative Extension offices.
- **A summary** of Nevada Department of Agriculture recordkeeping requirements can be found at http://agri.nv.gov/uploadedFiles/agrinvgov/Content/Resources/Forms/Plant/Pest/record%20keeping%20requirements%2006-14.pdf.
- **What about general-use pesticides?** The Nevada Department of Agriculture recommends keeping the same records for these pesticides for two years also. While not required by law, all users of pesticides should keep records for their own protection. Your personal protection is not the only reason for keeping pesticide application records:
  - In the event there is a report of drift or unintended damage on a property adjacent to your property or a property you manage, you will have a record of the applications you have made.
  - The recordkeeping requirements above will also meet the 2015 changes to the recordkeeping requirements of the Worker Protection Standard (WPS). The Worker Protection Standard applies to ALL agricultural workers at farms, forests, nurseries or greenhouses. The WPS requires that records are kept FOR TWO YEARS for BOTH restricted-use pesticides and general-use pesticides. For more information on the Worker Protection Standard go to http://pesticideresources.org/wps/hosted/quickrefguide.pdf. For a comparison of the 2015 revisions and the older revisions go to http://epa.gov/sites/production/files/2017-01/documents/comparison_chart_wps_011117_cwpb.pdf.

Recordkeeping is essential for pesticide applications and IPM pest control plans. Recordkeeping can be customized to each applicator's or company's internal standards, as long as the minimum information required by the Nevada Department of Agriculture for pesticide applications is met. Sample recordkeeping forms are available at *http://www.unce.unr.edu/programs/sites/IPM/IPMRecordKeepingForms/*. Download these forms to use as they are, or to modify them to fit your needs.

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