WEED PEST CONTROL

Volume IX

(2014 version)

NEVADA STATE DEPARTMENT OF AGRICULTURE

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STUDY GUIDE FOR THE CONTROL OF

WEEDS

Volume IX

Preface and Acknowledgments

This manual was prepared as a general study manual for pest control operators to prepare them to meet the written test requirements. The information contained herein is basic and practical, and is not intended to serve as a complete guide but rather to give general information about weed pests and control along Nevada's rights-of-ways and weed pests commonly found in, or around, industrial and institutional complexes in Nevada. The information and recommendations are based on current data and industry standards.

Information contained herein is not intended to substitute for any pesticide label information, direction or requirement. In addition, information contained herein is furnished with the understanding that no discrimination is intended, and any reference to a commercially known product does NOT imply an endorsement by the Nevada Department of Agriculture. No endorsement, guarantee, warrantee or assumed liability of any kind, expressed or implied, is made with respect to the information contained herein. It is the pest control licensee's responsibility to follow all pesticide label directions and regulations pertaining to the control of weed pests in Nevada.

Due to on going pesticide and regulation changes, the Nevada Department of Agriculture assumes no liability for suggested pesticide use, control techniques, or regulation changes.

For Nevada's most current pest control NAC regulations go to:

http://www.leg.state.nv.us/NAC/NAC-555.html

For the most current NRS regulations go to:

http://www.leg.state.nv.us/NRS/NRS-555.html

Contributors of this manual included the Nevada Department of Agriculture; US Environmental Protection Agency, Pesticide Programs; Utah Department of Agriculture and Food; Utah State University Extension Service; and Paul Ohlenbusch and Donald Cress of the Kansas State University.

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POISON CONTROL CENTER

The American Association of Poison Control Centers (AAPCC) supports our nation's 57 Poison Control Call Centers through a single toll-free phone number. All local poison control centers in the United States use this national number although calls are routed through different centers depending on geographic location. Nevada calls are routed through the **Rocky Mountain Poison Control Center** which also services calls from Hawaii and Montana. This national hotline number will let you talk to experts in poisoning.

National Poison Control

1-800-222-1222

NEVADA DEPARTMENT OF AGRICULTURE
EXAMINATIONS

1) All Pest Control Examinations are monitored and/or video and audio recorded.

2) Anyone who cheats on an examination will be excluded from taking any pest control examination for a minimum of six months (NAC 555.340.7).

3) No cell phones, pagers or other electronic devices may be taken into the examination area or used at any time during an examination.

4) No unapproved study materials, notes or other aids may be taken into the examination area or used during an examination.

5) Tests must be paid for prior to examination.

6) Examinees should bring a sharp pencil, eraser, and simple non-programmable calculator.

7) Any examinee who writes, marks on or otherwise damages an exam booklet will be charged a $5.00 replacement fee. The exam will not be graded until the fee is paid.

NEVADA DEPARTMENT OF AGRICULTURE
EXAMINATION FEES AND SCHEDULING

All Operator examinations must be scheduled and paid for in advance. All fees are **NON-REFUNDABLE** regardless of whether the exam is taken, cancelled, or failed. Exams may be re-scheduled with a minimum of 48 hours notice.

Individuals who “no show” for a *Principal* exam or do not cancel a scheduled *Principal* exam with 48 hours notice, must pre-pay for all future exams.

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INTRODUCTION

Weeds can be unsightly and pose a safety hazard on rights-of-way properties. Weeds in the lawn are one of the more noticeable pests of the landscape. They not only detract from the aesthetic value of the home, but also waste water and fertilizer, harbor insects, and reduce the overall health of the lawn. Weed control is accomplished by various means of vegetation management. The course of action is dependent on the objective. There are many reasons to control weeds and brush, including but not limited to, fire safety, automobile safety, aesthetic values, economic impact, recreation degradation, and wildlife conservation.

There are a number of cultural and mechanical practices to reduce weed populations. Herbicides and mechanical control have been the main methods of controlling vegetation on rights-of-way and industrial and institutional sites for many years. Traditionally, herbicides have been cost effective, but that is changing. Vegetation management is now becoming more complex and less reliant on herbicides, due to increasing herbicide costs, off-site damages, and environmental pressures. Prevention of the introduction of weed species remains the most cost effective tool.

In severe and difficult cases, herbicides can be used to control some weeds. Pesticides must be used properly to avoid health and environmental problems. The objective of this manual is to educate the reader about weed pests and their control along Nevada’s rights-of-way and weed pests commonly found around industrial complexes, institutional complexes and dwelling units, including landscapes and turf in Nevada.

REASONS FOR VEGETATION MANAGEMENT

Weeds are usually described as plants growing where they are not wanted. Any undesirable grass or broadleaf plant species, from a small herbaceous plant to a woody shrub, vine, or tree, may be considered a weed if it is growing where it is not wanted.

This manual will present information in two broad categories, weeds in rights-of way settings and weeds in landscape and turf settings.

For rights-of-ways, the objectives of a well planned vegetation management program are to safely, efficiently and effectively maintain rights-of-way and rights-of-way facilities so that vegetation does not interfere with their intended use.

More than 15 million acres of land in the United States currently are in use as rights-of-way for electric power lines, telephone lines, highways, railroads, pipelines, navigation channels, airport runway approaches, drainage and flood control canals, spillways, levees and communications structures. All these require periodic vegetation management to assure they continue to be safe and efficient. One way to provide this management is with herbicides. Apply herbicides only as they are needed for safe and efficient use of the rights-of-way.

The aesthetic, economic and environmental benefits of a good vegetation management program include:

- Improved highway pavement management: Properly managed roadside vegetation improves air circulation and increases the amount of sunlight that reaches the pavement, which keeps it dryer and extends its life.
- Improved highway safety: Drivers have better visibility of signs, curves, intersections, traffic signals and driveways. Maintain a safe shoulder area and keep the deflection area behind guardrails free of trees and vegetation. In addition, manage vegetation to maintain a free-draining road surface, which reduces the potential for hydroplaning or skidding on ice.
- Preservation and enhancement of scenic resources: This includes planting, encouraging natural plant growth and selectively restricting plant growth to screen, preserve, create or enhance views.
- Providing wildlife habitat: Improving existing conditions (i.e., woods, woody vegetation, open turf, bare ground, unshaded streams, etc.) with shrubs and herbaceous plants may provide wildlife with cover, nests and food.
- Preventing the spread of weeds from vectors such as highways and rights-of-ways (roads and rights of ways remain the number one vector of weed spread) into non-infested adjacent lands.

Weed management in landscape plantings is often made difficult by the complexity of many plantings: usually more than one species is planted in the landscaped area and there is a mix of annual and perennial ornamentals. The great variety of ornamental species, soil types, slopes, and mulches creates the need for a variety of weed management options. There are also considerations regarding public concern about the use of chemicals to control weeds and their effect on water quality if the herbicide moves offsite through runoff. The choice of a specific weed management program depends on the weeds present and the types of turf or ornamentals planted in the area. Because of the many variables, weeds in landscape plantings are usually controlled by a combination of nonchemical and chemical methods.

Most weeds in turf have little or no woody tissue and are herbaceous (e.g., plantains, dandelion).

Weeds reduce the available habitat for native plants, animals and birds. Weedy areas in landscape plantings can provide habitat for desirable wildlife and beneficial insects, but they can also harbor rodents and arthropods such as ticks, mites, and fleas that might attack humans and domestic animals or carry diseases that may infect humans and domestic animals. Weeds can also serve as alternate hosts for some fungal pathogens and insects that might attack desirable plants.

Many weed species possess efficient methods of seed dispersal, such as wind dissemination of winged or hairy seeds or the ability to spread rapidly by rhizomes, runners, or tubers. Weeds occupy bare and sparsely vegetated areas and are often the first to emerge in the spring, leaving little nutrition and moisture for desirable plants.

Pesticide Usage Considerations

Licensed pesticide applicators can quickly and efficiently improve the appearance and function of rights-of-way and landscapes. Clearing brush and herbaceous weeds is time consuming and labor intensive. However, herbicides and plant growth regulators can control vegetation to improve visibility, landscape beauty, safety and the function of sites. The applicator must match the pesticide to the site, pest and the physical site conditions before undertaking control.

Urban and rural areas, waterways and adjacent farmland used for crop and animal production, organic production sites, neighbors, etc. all pose diverse and special problems when using pesticides in for rights-of-way and landscape upkeep.

Always plan the use of pesticides in advance. Include practices that reduce spray drift, runoff, wash-off and other types of off site pesticide movement.

Because of the wide variety of areas that rights-of-way traverse, review the pesticide label for special environmental and safety hazards. A principal concern, when using chemicals in rights-of-way is containing the treatment within the rights-of-way themselves. In all cases, take steps to avoid or minimize the effect of treatments on areas adjacent to the rights-of-way.

WEED MANAGEMENT PROGRAMS

Weeds may be classified based on their morphology and life cycle. Both of which are covered in this section.

The goal of a well designed weed management program is to produce the type of vegetative cover required. This can usually be done without a total reliance on herbicides by combining the use of herbicides with mowing and other management practices.

Critical considerations in planning a weed management program include:

- type of vegetative cover desired.
- species of vegetation present.
- species of vegetation absent.
- soil characteristics and topography.
- off site vegetation.
- herbicide characteristics.
- available control and management options.
- adjacent uses.

Soil Characteristics

Texture: Soil texture refers to the relative amounts of sand, silt, and clay particles in a particular soil. Soil particles have cation exchange sites (negative charges on their surfaces). Cation exchange sites are the main binding sites in most soils, though there are also fewer anion exchange sites and non-polar binding sites in many soils. Clay soil partials, the smallest of the soil particles, have the most cation exchange sites. Silt and sand have fewer cation exchange sites and are generally not considered a factor in herbicide binding.

Organic Matter. As with clay particles, organic matter also has cation exchange sites. However, organic matter has many more cation exchange sites than the smallest clay particles. Therefore, its ability to attract other particles (such as water, sodium, calcium, ammonia, as well as, herbicides) is much greater.

pH. The effectiveness of some herbicides is affected by pH. Certain pH ranges or extremes may reduce or enhance the effectiveness. When herbicide labels have cautions involving soil pH, observe them.

Slope. Slope has a major influence on the fate of herbicides. As slope increases, water runoff potential increases. Herbicides can be moved off site by surface runoff or internal soil drainage, potentially damaging or killing non-target species.

Cation Exchange Capacity

Soil particles are negatively charged and attract positively charged molecules. These molecules can be nutrients, water, herbicides and other soil amendments. A soil particle's ability to react with these molecules is called the cation exchange capacity (CEC). If the CEC number is low, not many molecules are able to bind (react) to the particle surface. If the number is high, a larger number of molecules can bind to the particle's surface. Soils have a wide range of CEC values with sand-based soils having numbers below 10, clay and silt soils having values of 15 to 25 and organic soils approaching 100.

Many herbicide application rates are CEC dependent. That is why they will indicate on the label that you need to use lower rates on coarse-textured soils (sand) and higher rates on fine soils (clay and silt). Some herbicides are simply not used on organic soils. This is because the high CEC of organic soils binds the product so tightly that it is not effective and will not give the desired weed control.

Herbicide Characteristics

Herbicide absorption to soil. Many herbicides are chemicals that have positive or neutral charges. However, acids (i.e. 2,4-D and glyphosate) can have negative charges, and some herbicides can have both positive and negative charges. Positive charged particles can be attracted to negative charged sites on soil particles. Whether the herbicide particles will be absorbed on soil particles is determined by the size of the charge on both particles, the distance between the particles (amount of water in the soil), concentration of herbicide and other salts in the soil solution, and the rate of movement of water through the soil. The unabsorbed particles are moved through the soil by a process known as leaching.

Persistence. Persistence of an herbicide in the soil depends on its chemistry, rate of application, soil texture, organic matter, precipitation, temperature, and movement. Herbicides can move with surface flow or leach through the soil profile (diluting effect).

Environmental Factors

Soil moisture. Soil-applied herbicides must be in moist soil to be taken up by plant roots. This requires water in the form of precipitation or irrigation.

Temperature. Temperature determines the rate at which plants grow, absorb, and translocate herbicides. At low temperatures, plant roots may not be active and will not take up the herbicides, or the plant roots may be so inactive that the herbicide works very slowly. At high temperatures, the herbicide may evaporate (volatilize). Also, make certain you have read the label and understand at what minimum temperature some herbicides can volatilize and have indirect effects on nearby vegetation, animals and humans.

Humidity. A foliar-applied herbicide will enter the leaf more easily and rapidly at high humidity than at low humidity. At low humidity, plant leaves have denser cuticles or wax layers, which restrict herbicide absorption.

Precipitation. Rainfall soon after a foliar applied herbicide treatment may decrease effectiveness if the herbicide is washed off the leaf. Rain increases soil moisture, so soil applied herbicides can be more readily absorbed by the weeds. However, excessive rainfall may move the herbicide too deep, past the root zone of the weeds. A hard rain may move surface applied herbicides out of the target area. This is especially true if the soil surface is packed or sloping.

Wind and temperature. A hot, dry wind will cause the stomates (openings on the plant leaf surface) to close, the leaf surface to become thicker, and/or the cuticle layer to harden. These factors make it harder for herbicides to penetrate the leaves. Wind also increases the risk of herbicide drift to non target sites.

Solubility. The water solubility of a soil-persistent herbicide has a definite effect on the length of time the herbicide will persist and remain active in soil. The lower the solubility, the greater the amount of precipitation it takes to activate the chemical and the longer it will persist in the weed-germination zone

The degree to which a residual herbicide is absorbed by soil particles will also determine the time it will remain effective and prevent growth of vegetation. The more highly absorbed the longer the residual.

Photo-Decomposition. In the winter months, during periods of low sunlight intensity, the breakdown of soil-persistent herbicides from ultraviolet rays is less than during the summer. Incorporating the herbicide into the soil after application, along with added moisture or mechanical incorporation, will reduce photo-decomposition.

Specialized Area Considerations

Aquatic areas. When treating areas adjacent to aquatic sites, such as ponds, use herbicides that are labeled for that purpose. Avoid drift and vaporization, and keep spray out of the water. Avoid lateral movement or runoff from the treated area into the aquatic habitat.

Desirable vegetation. These areas include gardens, crops, ornamentals, etc. Do not apply herbicides to areas where the roots of desirable plants may absorb the chemical. Desirable plants located off the rights-of-way often have much of their root systems under the rights-of-way.

Sloping areas. These areas, if stripped of vegetation by the use of herbicides or other means, will be subject to soil erosion. Maintain covers on these areas by planting desirable vegetation or use of selective herbicides that leave desirable plants.

Metal surfaces. Certain herbicides are corrosive. When you apply herbicides, avoid spraying automobiles, buildings, and other metal surfaces, either directly or through drift.

Use of Herbicides Around People and Livestock

All pesticides must be handled and applied with care following all label directions. Avoid splash or spray contact, and keep exposure to a minimum. Wear the appropriate personal protective equipment as directed on the labels. Keep herbicides in containers that are properly labeled and keep them properly stored and secured. Never dump unused herbicides where they can contaminate water supplies. Mix just enough spray solution for the job. Spraying excess solution over an area at the treatment rate is better than to dump excess mix onto a small area. Avoid spraying herbicides or particles on yourself or other people and animals that are in or near the treatment area.

Herbicides sprayed on plants may present variable exposure hazards to livestock, and labels should always be read before purchase and use. Livestock may be poisoned by eating unused herbicides left in open containers or by drinking water contaminated with herbicides. Consult pesticide labels for any grazing restrictions on rights-of-way where livestock are allowed to graze.

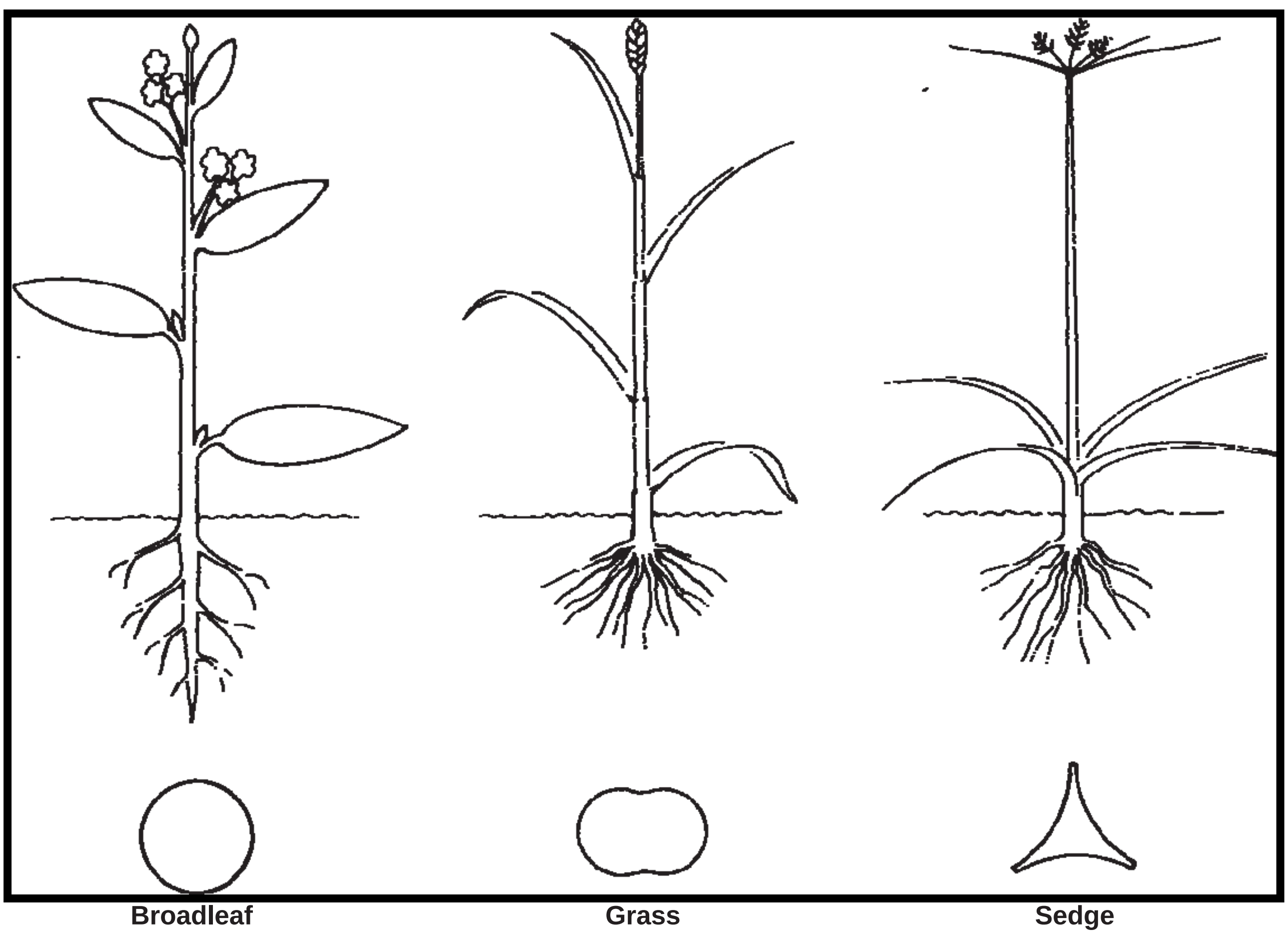
Certain unpalatable or poisonous plants may become more palatable to livestock after being treated with herbicides. Be sure that livestock cannot have access to poisonous plants treated with herbicides. Observe grazing and hay cutting restrictions where pastures are to be treated.

Identifying Weeds:

Weed classification based on morphology

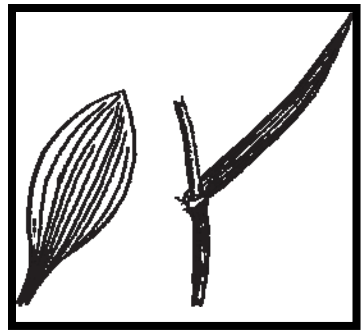
Accurately identifying undesired vegetation, or weeds, is the first step in developing an effective management program. This is particularly true if planning to use herbicides since many herbicides only control certain plant species. Plant identification manuals are available through various agencies, including university, government and private companies. If unable to identify a plant, send or take specimens, including flowers if possible, to your local Nevada Cooperative Extension office or local Nevada Department of Agriculture office. Be cautious to not spread seeds or propagative parts when transporting specimens to a new location for identification. Place the specimen in a clear plastic bag or trash bag if possible. Dispose of the specimen in a sealed plastic bag in the trash.

Weeds include any undesired plants that are unsightly, potentially harmful, or hazardous to animal or human health. A weed may be simply, defined as a plant 'out of place.' Weeds can be grouped into three categories, according to the manner of their morphologically; grasses, sedges, and broadleafs.



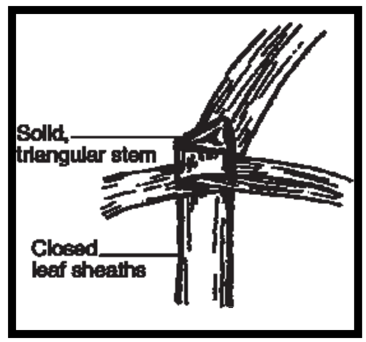
Monocots (grasses or glasslike plants that include sedges and cattails)

Grasses: True grass weeds have hollow, rounded stems and nodes (joints) that are closed and hard. The leaf blades have parallel veins, are much longer than they are wide, and arise alternately on each side of the stem. Grass weeds in turf include crabgrass, goosegrass, sandbur, and annual bluegrass. These weeds are annuals, completing the life cycle in one year. Some perennial grasses such as bentgrass and bermudagrass grass are familiar weeds of many turf areas in Nevada.



One of the frequent grass weed problems in turf is the presence of an undesirable turf species growing with the dominant or desirable turfgrass. For example, turf managers frequently wish to control St. Augustinegrass in a bermudagrass turf, or common bermudagrass may be present as a contaminant in a hybrid bermudagrass. It is possible in some cases to selectively control the undesirable or weedy turf species by proper management and herbicide selection. Some grass weeds include foxtail, Cheatgrass, Medusahead, goosegrass, crabgrass, poa annua, fescues and ryegrass.

Sedges: These important "grasslike" weeds are not true grasses but are characterized by a solid, triangular stem with leaves extending from each side in three directions. There are annual sedges and the predominant, difficult-to-control sedges and bromes such as nutsedge. Rhizomes radiate from the plant and bear a single bulb or tuber at the end, which may produce new plants. Nutsedges have seedheads and produces a series of bulbs on the radiating rhizomes called "tuber chains."



When monocots germinate, they have a single cotyledon. The cotyledon does not emerge above the soil surface, and the first leaves seen are true leaves. All monocots have narrow leaves with parallel veins, and they usually have a fibrous root system. Monocots most commonly reproduce by seed, stolons (creeping stems above the soil surface) or rhizomes (creeping stems below the soil surface). The growing point in monocots is at or below the soil surface, until reproductive structures develop. However, monocot weeds may not be desirable in turf or landscapes; they are often desirable in rights-of-way sites.

Dicots (Broadleaf plants):

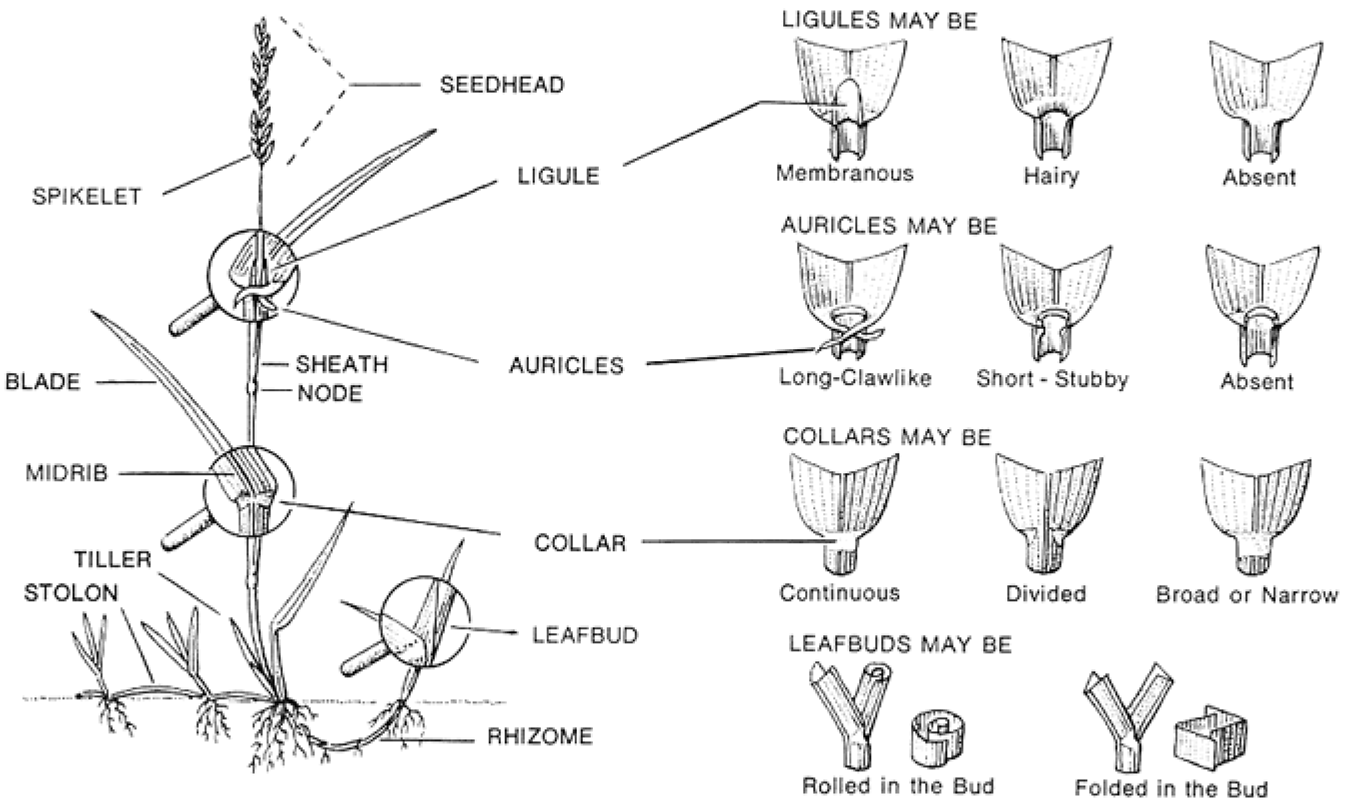
Broadleaf weeds

This highly variable group of plants mostly have showy flowers and leaves with netlike veins. They are easy to separate from grasses due to their leaf structure and habits of growth. Their presence causes a visual change in the overall texture of a turfgrass. Many broadleaf weeds can adapt to the close mowing culture of turf and appear quite different from the pictures and descriptions given of mature specimens in identification guides. Some broadleaf weeds include spurges, clovers, bindweed, chicory, dandelion, curly dock, pepperweed, pigweed, mallow and thistles. Some owners may consider some broadleaf weeds as desirable weeds. Mostly broadleaf weeds are summer annuals.

Dicots have two cotyledons that generally emerge from of the soil following germination. The cotyledons are sometimes called seed leaves and often do not look like the later true leaves. Dicots usually have broad leaves (thus, the term broad-leaved plants) with veins that form a netlike pattern; the plants generally have a tap root. All species can reproduce by seed. Nevertheless, some have vegetative buds either in the crown or on the taproot, and still others reproduce by spreading rootstocks.

Dicots are either herbaceous or woody plants. Woody dicots include brush, shrubs and trees. Brush and shrubs have several stems and are usually less than 10 feet tall at maturity. When trees are present, the brush and shrubs are considered under story. Trees usually have a single stem and are more than 10 feet tall at maturity. Woody plants may be evergreens or deciduous. Some woody plants can spread vegetatively, as well as, by seed (e.g., sumac). In contrast to monocots and herbaceous dicots, woody plants can be controlled at anytime of the year if appropriate methods are selected.

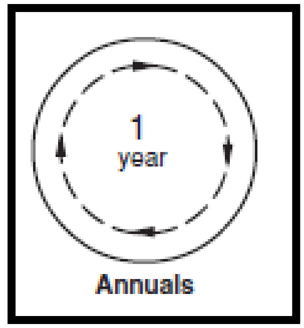
Parts of a grass plant



Life Cycles of Weeds

Weeds are also categorized according to how long they live and the season in which they grow. The categories are often mentioned on herbicide labels and are important in determining how best to control a particular weed.

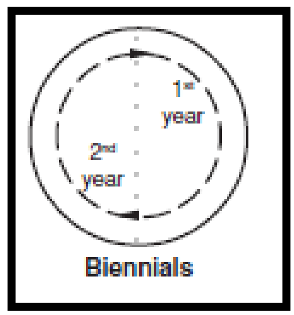
Annual weeds live less than 12 months. Annual weeds can produce a multitude of seeds during a single growing season, and generally are most troublesome in newly planted areas and in cultivated soil. Many seeds of annual weeds will germinate during the following year. However, some seeds may remain dormant in the soil for 50 years or more before they germinate and emerge as plants.



Summer annuals germinate from seed in the spring, flower and produce seed during the summer and die in the late summer or fall. They are best controlled in the seedling stage. Redroot pigweed, common lambsquarters and common ragweed are examples of broadleaf summer annuals. Grassy summer annuals include foxtails and crabgrass.

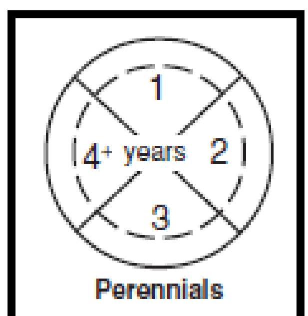
Winter annuals usually germinate from seed in the late summer and fall, overwinter as low growing plants, flower and produce seed the next spring and then die. Winter annual weeds occasionally germinate in early spring and still produce seed by early summer. These weeds are easiest to control in the seedling or rosette stage of growth. Shepherds purse and pennycress are broadleaf winter annuals, and downy brome and cheat are winter annual grasses.

Biennials are weeds that live for two growing seasons and have tap roots. They germinate from seed in the spring or summer and produce a rosette of leaves on the soil surface. Biennials overwinter in the rosette stage and require a cold period to flower. The following year, they flower, produce seed and then die. They are most serious in pastures, roadsides and neglected areas. Control of biennials is best achieved when they are in the seedling or rosette stage the year they germinate or in the rosette stage the second year. Once the flower stalk is formed (known as the bolting stage), biennials are difficult to control with herbicides. Examples of biennials include musk thistles, common mullein and wild carrot. There are no biennial grasses, brush or trees.



Perennials are weeds that live for more than two years and may live almost indefinitely. Perennials can reproduce by seed only (e.g., dandelion) or by spreading vegetatively from:

- Stolons (e.g., ground ivy),
- Rhizomes (e.g., cattails),
- Spreading rootstocks (e.g., Canada thistle and field bindweed), and
- Tubers (e.g., nutsedge).



Perennials may germinate from seeds in spring or summer but normally do not flower during the season they are established from seed. Their top growth becomes dormant each winter and their survival depends on underground structures. Non-woody perennials resume growth the following year from buds on the crowns, roots or tubers.

They flower and set seed that year and each year thereafter. Perennial weeds are the most persistent and difficult to control. However, not all perennials are undesirable in rights-of-way, particularly if a permanent ground cover is desired.

Common Forms of Weeds

While there are a great many species of weeds, most terrestrial weeds may be placed into one of five convenient groups; grasses, grasslike sedges; grasslike monocots, forbs and woody plants. Woody plants are further divided into shrubs and trees.

Shrubs usually have multiple stems and are less than ten feet tall, while trees usually have a single stem (trunk) and are usually more than ten feet tall (when mature). Shrubs also form an under story when found with trees.

Noxious Weeds

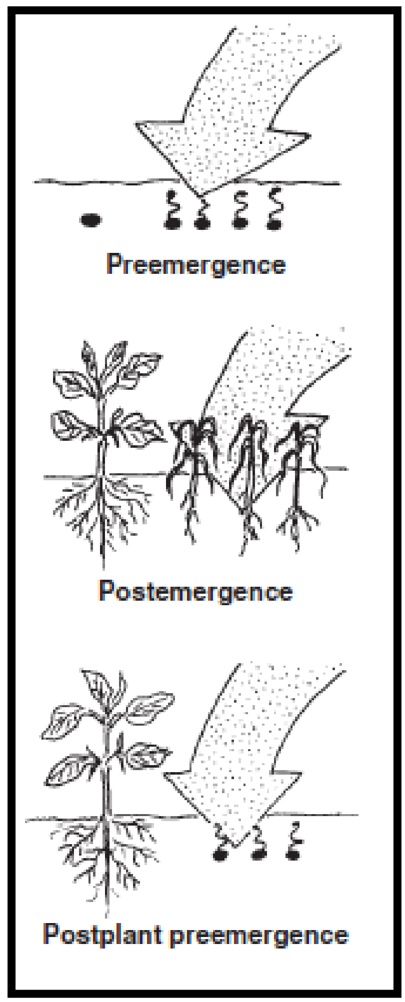
Noxious weeds are competitive with desirable vegetation and may spread to adjacent properties. Noxious weeds are weeds that must be controlled, according to state law. For a list of the current noxious weeds, contact either your local County Weed Abatement District or the Nevada Department of Agriculture - Noxious Weed Program Coordinator at 775-353-3673

Herbicide Classification

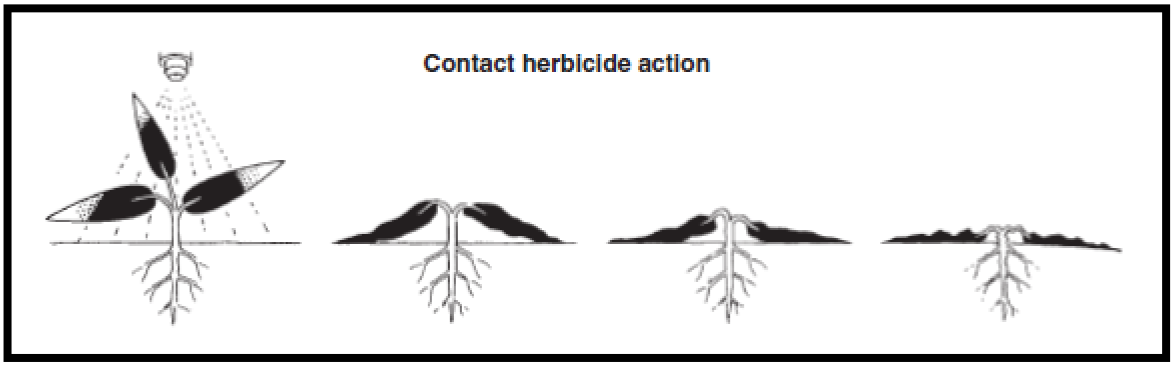
Herbicides may be placed into groups by chemistry, the way they are applied, mode of action, or the type of formulation. A simple classification scheme is as follows:

Selective herbicides have true physiological selectivity if they are applied to a mixture of plant species growing on the same site. Selective herbicides control only certain species while causing little, if any, significant injury to others. Selective control allows the desired plants to grow normally as the affected plants are controlled. For example, 2,4-D can be used to control broadleaf weeds without adversely affecting grass growth and seed production.

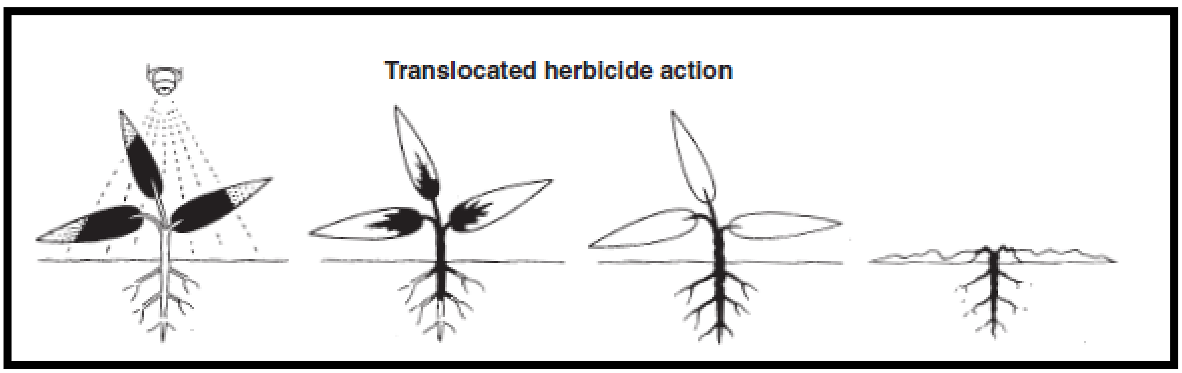
Nonselective herbicides damage all plants they contact. They can be applied selectively by directing their placement. For example, johnsongrass may be controlled in a stand of crownvetch by applying Roundup® with a rope-wick type of applicator when the johnsongrass grows higher than the crownvetch around it.



Contact herbicides are not translocated and affect only the leaf or stem tissue that is sprayed. They usually affect plant functions rapidly after application, causing leaf burn symptoms. Contact herbicides can control annual weeds, but established perennial plants will regrow. Examples of contact herbicides are MSMA and paraquat.



Systemic (translocated) herbicides are absorbed into the foliage or roots and translocated to other parts of the plants. Because these processes are slow, it may be days before the herbicide reaches its site of action and inhibits growth. The target site of action may be an enzyme, cell membrane or the chloroplast where a plant traps carbon dioxide for sugar production. Systemic herbicides are effective for control of perennial weeds that may regenerate new growth from buds on shoots, roots, rhizomes, or stolons.



Bare-ground or soil-sterilant herbicides are applied to prevent all plants from growing on the site for six months or more. These herbicides are frequently used to control vegetation around buildings, in fence rows and areas where a fire hazard exists. Because herbicide rate influences persistence, several herbicides may serve as a temporary sterilant if high rates are applied. Avoid herbicides with high water solubility or vapor pressure because of the possibility of leaching into ground water and offsite movement.

Plant-growth regulators are substances for controlling or modifying plant-growth processes without appreciable phytotoxic effect at the rate applied, either to themselves or other species. They are generally applied to the foliage and do not have soil persistence. Because they do not create bare ground, they help prevent erosion.

Pre-emergence herbicides are chemicals applied before the emergence of the species to be controlled. These are generally soil-applied and are translocated into the plant through root uptake.

Pesticide Application Equipment

The equipment used to apply pesticides depends on the target organism, the type of application, and the pesticide formulation. No matter which type of equipment is used, there is one requirement: it must apply the proper amount of pesticide uniformly over the target area. The rate of pesticide being applied must be known. Always follow the pesticides label directions for specific equipment requirements. Details of calibration are addressed in chapter 7 of the Nevada *Pesticide Applicator Core Study Guide* Volume I.

Components of Pesticide Application Equipment

The tank is a major component of the sprayer. It should be large enough to avoid frequent refilling, but small enough to provide maneuverability. Stainless steel, fiberglass, and polypropylene are considered the best tank materials because of their corrosion resistance. Stainless steel is the most expensive, and buyers must weigh their need for durability against cost. Every tank should have shutoff valves on all outlets so that any liquid in the tank can be held without leaking out of the pump, strainers or other parts of the system that are serviced most frequently.

The amount of agitation needed depends on the type of pesticides applied. Liquid concentrates, soluble powders, and emulsions require little agitation; usually the flow from the bypass hose is enough. Wettable powder (WP) suspensions require vigorous agitation to prevent settling. Tanks with square corners require more specialized agitation than round tanks. Two methods exist for agitating spray material in the tank:

(1) paddles or a propeller to provide mechanical agitation; or

(2) the use of return flow of material from a pump to provide hydraulic agitation.

When hydraulic agitation is used, a simple bypass line from the relief valve is not enough. There should be a separate agitator line from the pressure side of the pump to the bottom of the tank with appropriate valves to control the amount of agitation.

Strainers are used to prevent scales, rust flakes and other foreign material from plugging nozzles or other working parts of the sprayer. They are installed as necessary on the intake line, pressure line or as a part of the nozzle.

A good spray pump must deliver the required pressure and volume within its normal working capacity plus have reserve capacity to allow for wear. If abrasive materials are used, it must be able to pump them over a long period of time without loss of performance. Metal parts must resist corrosion if corrosive materials will be used. Seals should be compatible with the types of materials to be used. Common pump types include roller, centrifugal, and diaphragm. Care should be taken to make sure proper plumbing methods are used for the chosen pump type.

Pressure control is one of the most important aspects of proper application. Pressure determines the quantity of spray material delivered by the nozzles. Pressure control protects pump seals, hoses and other sprayer parts due to damage from excessive pressure and bypasses any excess spray material back to the tank.

Relief valves and pressure unloading valves are two types of pressure controls. A relief valve simply bypasses spray material not needed by the booms directly back to the tank. This then requires the pump and engine to keep working as though one were spraying, even when the booms are turned off. However, unloading valves maintain working pressure on the discharge end of the system, but move the overflow back into the tank at lower pressure, reducing strain on the engine and the pump. Bypass or unloading valves are used with positive displacement pumps, including roller and diaphragm. Centrifugal pumps do not require bypass or unloading valves as pressure is controlled by throttling the pump output to the appropriate level. When selecting the appropriate pressure control, be sure that the flow capacity matches that of the pump being used.

A pressure gauge is essential on any sprayer. Without one, it is impossible to tell how the sprayer is functioning. If pressure does not remain constant, the amount of liquid coming out of the nozzles will vary. Mount the gauge so that it can be seen easily. Pressure gauges often fail because they become clogged with solid particles or are allowed to freeze in winter. A glycerin filled diaphragm type gauge is more expensive, but will last much longer.

Consider four main points when selecting sprayer hoses: composition, construction, working pressure and size. High quality hoses and fittings may be expensive, but are cost effective when used over a long period of time. The hose should be resistant to chemical action of the spray solution. The working pressure of the hose should be greater than the maximum pressure that the pump delivers. Hose size should be matched to the flow volume and pressure requirements. If the hose in the pump suction line is too small, the pump may not get enough pesticide mixture or may cavitate, causing low pressure or pump damage. If the hose in the pressure line is too small, volume at the nozzle(s) will drop because of severe pressure drop through the line.

A nozzle is an atomizing device that meters the liquid, breaks the liquid into droplets, and forms a pattern of distribution. A complete nozzle assembly consists of the body, screen, cap and tip. The function of the nozzle body is to attach the screen and tip to the boom. Several different nozzle body designs are available. All designs perform adequately, but each design has advantages for specific spraying jobs. Nozzles accommodate a variety of replaceable tips or discs to meet spraying requirements. Manufacturers of sprayer nozzles can supply data sheets for the delivery rate, usually in gallons/minute at different pressures for their nozzles. The application rate of any tip is dependent on the sprayer speed, nozzle tip spacing, and operating pressure of the tip.

Nozzle tips and discs are made of aluminum, brass, ceramic, plastic, stainless steel or tungsten carbide. Tungsten carbide, ceramic, and stainless-steel tips are more resistant to abrasive wettable powders and are more expensive than brass tips, but provide the most economical long-term value. Nozzle tip types commonly used to apply herbicides to rights-of-way with ground equipment include flat fan, off-center (OC), boomless and whirling disc.

The flat-fan nozzle is normally used for broadcast spraying, such as broadleaf weeds in turf. The deposition pattern is elliptical with tapered edges. Flat fans require 30 to 50 percent overlap to provide even distribution. At 15 to 30 psi, the flat fan delivers small to medium droplets. Newer flat fan type nozzles designed to reduce drift problems include the turbo flat fan, drift guard flat fan, and raindrop flat fan.

The most commonly used flat-fan nozzles have a spray angle of 65, 80, or 110 degrees. Use of the 110-degree tip allows the operator to keep the boom relatively low to reduce the drift hazard, and give a uniform distribution of spray material over the entire length of the boom.

Low-pressure sprayers with specialized booms or off-center nozzles are widely used for roadside and railroad yard maintenance. Specialized booms include those used to spray under guardrails and around other obstructions. Many variations exist, and their use depends on maintenance requirements.

Off-center nozzles produce a wide, flat fan spray deposition pattern, distorted to one side. Thus, a properly equipped spray or hyrail truck can uniformly apply herbicides to a wide roadside rights-of-way or multiple railroad tracks in a yard maintenance program.

The Radiarc® sprayer is a precision, boomless, low-volume application device that will apply pesticides in a uniform pattern. Its large droplet size and narrow droplet spectrum provide precise targeting with accurate, sharp edges to the spray swath. The spray device oscillates to make a uniform mechanical distribution of pesticide sprays at low-volume applications while reducing drift. The Radiarc sprayer is specifically designed to disperse particulates, suspensions, wettable powders and emulsifiable concentrates.

Boomless sprayers, a modification of OC nozzles, have a central nozzle or cluster of nozzles that produce a wide spray pattern that results in a wide swath similar to that laid down by a boom-type sprayer. Deposit is fairly uniform over the swath.

Factors Affecting Spray Drift

The term physical drift or drift loss may be defined as the movement of airborne liquid, in the form of small droplets, from the target area at the time of application. Vapor drift, or volatilization, may also occur and should be minimized through product selection, and by observing meteorological restrictions on the application. Drift is complex and involves several factors such as particle size, air movement and temperature gradient, humidity, type of terrain, vegetation being treated and non target elements (trees, structures, roads, bodies of water), as well as pesticide formulation, diluent (carrier), release height, aircraft speed, and others.

Swath displacement, or the shifting of the applied material, will occur if there is a cross wind during application. Pesticide spray particles moving off target are generally considered as drift. Minute amounts of drift are unavoidable with many types of applications. The key is to manage drift and keep it at a level that is low enough to cause no adverse effect. Some problems of drift are:

(1) the loss of pesticide,
(2) crop damage and possible unwanted residues on crops,
(3) destruction of beneficial insects,
(4) detectable movement into human and domestic animal habitats, and
(5) movement into and damage to wildlife environments.

Many drift effects are not large or long-lasting, but the threat of drift can be highly significant to the general public. Bad publicity from drift can be escalated by adverse TV, radio, and newspaper coverage, and stressful relations with neighbors. Where drift-loss from pesticide application cannot be eliminated, proper management can significantly reduce potential problems.

One of the best tools for controlling drift is spray droplet size management. Spray nozzles produce a range of droplet sizes rather than one uniform droplet size. This droplet size range is usually described by its volume median diameter (VMD). VMD is the diameter at which half the spray volume is made up of droplets larger and half is made up of droplets smaller than the VMD. This median measure is a convenient and useful method of describing a spray but gives no indication of the range of droplet sizes present.

Spray droplets less than 100 micrometers (one micrometer = approximately 1/25,000 of an inch) in diameter at the nozzle, and larger droplets that become smaller than 100 micrometers in diameter before reaching the target, are generally considered to represent the drift potential of applied sprays. Small droplets may provide the best coverage and enhance efficacy of some products, but large droplets reduce the potential of drift. Since both large and small droplets cannot be effectively produced at the same time, some reasonable and acceptable tradeoff must be developed to achieve reasonable pest control while controlling drift.

Select application equipment that will produce the largest droplet sizes consistent with the mode-of-action requirements of the pesticide. Set nozzles as low as possible to diminish wind effects, but not so low as to induce streaking from improper overlap. Use low spray pressures to minimize the amount of small driftable fines produced by the nozzle tip. Spray during periods of light wind from a direction that will cause potential drift to move away from sensitive areas. Consider the use of drift suppressing additives to the spray material to reduce the amount of driftable fines produced. Avoid spraying during periods of high temperatures and low relative humidity, which will increase evaporation rates and drift potential of the spray material.

Drift Control Agent

Special adjuvants and application systems have been developed to help overcome some drift problems. Three of these are:

- foams (tank-mixed, conventional formulation with an additive).
- invert emulsions (three systems: mixed at nozzle, mixed at pump, or tank-mixed).
- spray-additive stabilizer (thickeners in dry form mixed with conventional formulation in tank with agitation).

Though they differ in method, all three have similar advantages: better control of both particle drift and vaporization, and more highly visible spray, enabling you to see where you are placing it.

Cleaning the Sprayer

First rinse the sprayer with a material that acts as a solvent for the herbicide. Kerosene and fuel oils carry away oil-soluble herbicides such as 2,4-D ester. Chemicals that form emulsions when mixed with water are oil-soluble. After the oil rinse, a rinse with water containing detergent will help remove the oil. Oil-soluble herbicides are the hardest to remove. 2,4-D amine salts are water-soluble.

For most water-soluble herbicides, repeated rinsing with water is usually enough. Hormone-type requires extra precautions. If Banvel® or 2,4-D was used, fill the tank with water and ammonia. Add household ammonia to 25 gallons of water. Pump enough solution through the hose and nozzles to fill these parts completely. Then fill the tank, close, and leave for 24 hours before rinsing thoroughly with water. A three-percent suspension of activated charcoal can be used to absorb 2,4-D after the preliminary rinsing to decontaminate the sprayer. Agitate the suspension for two to three minutes and drain, then rinse thoroughly with clean water.

For materials that are sulfonylurea herbicides (Oust®, Telar®, Escort®), the use chlorox® may help in the cleaning process. However, remember once materials like Oust® or Telar® are used in a spray tank, that tank is dedicated to non selective weed control only. READ THE LABEL carefully, as severe damage to desirable vegetation can result if the tank is reused to do selective weed control. Don't use sulfonylurea herbicide products if you only have one spray tank in your operation.

For wettable powder herbicides, see that none of the powder remains in the tank. A thorough rinsing with water is usually sufficient. Thoroughly clean all equipment immediately after use. See the pesticide label for directions for cleaning the sprayer also.

Effects on Non Target Organisms

Pesticides on non target organisms may cause direct, immediate injury or, if used in the same place over a long time, may cause harm to the environment. The following sections will discuss the effects of pesticides on non target plants, bees and other beneficial insects, livestock, fish and wildlife, and endangered species.

Phytotoxicity is injury to plants because of exposure to a chemical. Phytotoxic injury can occur on any part of a plant: roots, stems, leaves, flowers or fruits. Nearly all pesticides can cause plant injury, particularly if applied at too high a rate, at the wrong time or under unfavorable environmental conditions.

As expected, the most phytotoxic injury is caused by herbicides designed specifically to kill plants. All herbicides kill plants by interfering with one or more of the vital processes of plant life. These processes include germination, cell division, photosynthesis, respiration and protein synthesis.

Herbicides may damage desirable plants they are meant to protect or other plants on adjacent land. Injury to desirable plants occurs most frequently when the chemical has a narrow range of selectivity between those plants and the target weeds. Damage to plants in adjacent areas primarily occurs because of drift or over spray. Damage is sometimes caused by surface runoff, particularly from sloping areas.

Persistent herbicides may injure succeeding plants at the site long after the original application. Injury to succeeding plants is particularly common when abnormally cold or dry weather inhibits degradation of the herbicide or when application rates are unusually high.

Damage to fish and wildlife can result. The potentially harmful effects of pesticides on fish and wildlife have been the focus of widespread concern, particularly since the early 1960s. There is, without question, valid cause for concern.

Damage to fish and wildlife may be either a direct and immediate consequence of improper pesticide application (e.g., direct fish kills resulting from over application or drift into an aquatic environment), a result of contamination of wild plants used as a food source or a result of indirect pollution of fish and wildlife habitats, principally through soil erosion, surface runoff and leaching. In the case of pollution, pesticides with longer persistence are a significantly greater hazard. Those that are both persistent and cumulative pose the greatest risk.

Pesticides may either kill fish and wildlife or, at sub lethal doses, cause harm, including reduced growth, behavioral changes and decreased reproduction. Sub lethal effects may be the most serious problem for wildlife; many of the highly publicized effects of the chlorinated hydrocarbons on wildlife, notably on fish eating and raptorial birds, have been linked to reduced reproduction.

Pesticides have been implicated in the decline of numerous species of native plants and animals. To minimize the harm pesticides can do to federally endangered and threatened species, and to ensure that these species and their habitat will no longer be jeopardized, the EPA is developing a new program of use restrictions under the Endangered Species Act (ESA). In the new program, pesticides harmful to native plants and animals will have a warning statement about their use within the geographic range of any endangered or threatened species. The statement will instruct users as to what actions they need to take to safeguard endangered and threatened species (for more information on the ESA and pesticides see Chapter 5 in the Nevada *General Urban-Structural Pest Control* manual volume 1 or obtain a current information pamphlet from a Nevada Department of Agriculture office or your local cooperative extension office).

Biological Control of Weeds

Weed scientists are beginning to take a look at the potential of biological methods for the control of weeds. Under certain circumstances, this approach may be possible, although there are few methods discovered, up to now, which could be considered practical on commercial landscape sites or highway rights-of-way.

Insects with a feeding preference for specific weeds hold the best promise. Currently, there are about 90 weed-feeding insect species that have been introduced into the United States to control around 45 species of weeds.

Recent work with plant pathogens has demonstrated their potential in weed control. For instance, a newly discovered race of the fungus *Verticillium dahlias* has been found to attack seedlings of velvetleaf weed, *Abutilon theophrasti*, prevalent in the Midwest. Research indicates that the fungus remains with the host plant and carries over in the soil but does not attack crop plants. More information on biological control of weeds can be found in Appendix B of this manual.

PRECAUTIONS WHEN USING HERBICIDES WITH MEDIUM TO LONG SOIL PERSISTENCE

- ♦ Understand the characteristics and limitations of the herbicide, and take necessary precautions. The greatest danger in the use of soil sterilant herbicides is damage to desirable plants. Some of these herbicides are very deadly to trees and shrubs, and tiny amounts will kill desirable plants, as well as, weeds. Always use the chemical that is safest for the area where it has to be applied. Leave a "buffer" or "safety zone" between the treated area and desirable plants. Some of these herbicides should be used only where there are no desirable plants for a considerable distance; others can be used with a fair amount of safety near trees, shrubs, or desirable plants. Some compounds are more soluble than others and leach into the soil with relatively little horizontal movement. Some will last only one year, while others may persist in the soil for two or more years. Know what you buy, and know what it will do after you apply it.
- ♦ Don't apply soil sterilants over the root zone of desirable plants. Determine the root spread of trees and shrubs near the treated area. Roots of trees and shrubs will sometimes extend at least four times their height. Also, don't apply soil sterilants to soil in which roots of desirable plants may grow.
- ♦ Don't apply these chemicals in areas where they may be carried with runoff water from rainfall or irrigation or into soil where desirable plants are growing or may be planted later.
- ♦ Apply these chemicals in such a manner that they won't be moved by wind. Incorporate, them into the soil, soon after application, with water or by mechanical means. Some granule type herbicides are more likely to move than liquid or wettable powder formulations.
- ♦ Once a soil sterilant has been applied and mixed with the soil, there is no quick way to remove it or neutralize its effect. Replacing the treated soil may help. Charcoal mixed with the treated soil will tie up and absorb part of the chemical. Diking around treated areas and flooding with water may help to leach water-soluble sterilants but may not help much with the more permanent types.
- ♦ Plan carefully and follow directions. The decision to use soil sterilants should be weighed carefully. When properly used, soil sterilants can save valuable time, labor, and expense.

FACTORS AFFECTING HOW HERBICIDES WORK

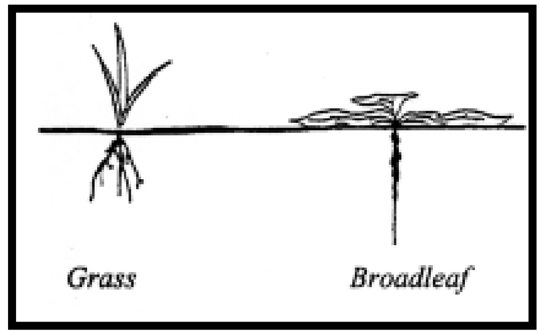
Stage of Growth

Grasses and broadleaf weeds go through four stages of' growth:

- Seedling
- Vegetative
- Bud and flowering
- Maturity

Seedling (All Stages)

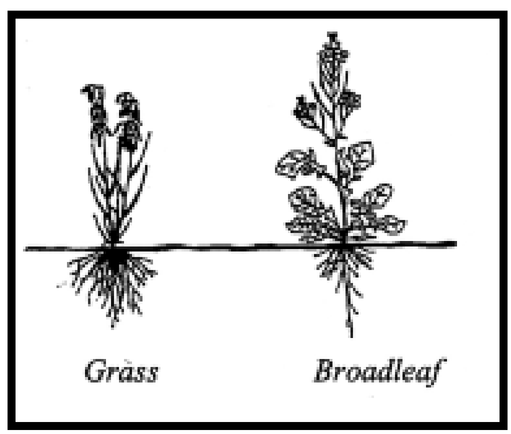
The seedling stage of growth is the same for annual, biennial and perennial weeds. They are all starting from seed. The weeds are small and tender, so less energy is required for control at this stage of growth than at any other stage. This is true, whether mechanical or chemical control is used. Herbicides with foliar and/or soil activity are commonly used and are usually effective at this stage.



Annuals & Biennials

Vegetative. During the vegetative stage of growth, energy produced by the plant goes into the production of stems, leaves and roots. Control at this stage is still possible but sometimes harder than at the seedling stage of growth. Cultivation, mowing, and post emergence herbicides are effective controls.

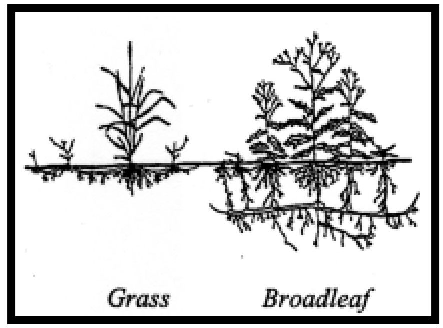
Bud and Flowering. When a plant changes from the vegetative to the flowering stage of growth, most of its energy goes into the production of seed. As plants reach this more mature stage, they are usually much harder to control by either mechanical or chemical methods.



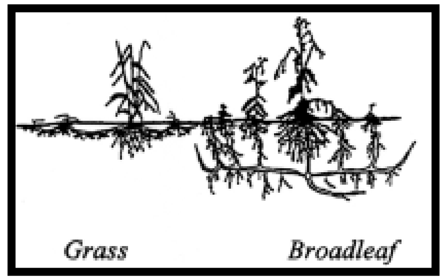
Maturity. Maturity and seed set of annuals completes the life cycle. Chemical control is usually not effective at this stage, since there is little or no movement of materials in the plant. Once the seeds are mature, neither mechanical nor chemical controls can harm them.

Perennials

Vegetative. When the plant is small, part of the energy used to produce stems and leaves come from energy stored in the underground roots and stems. As the plant grows, more energy is produced in the plant leaves. Some of this is moved to the underground parts for growth and storage. Herbicides usually provide good control at this stage.

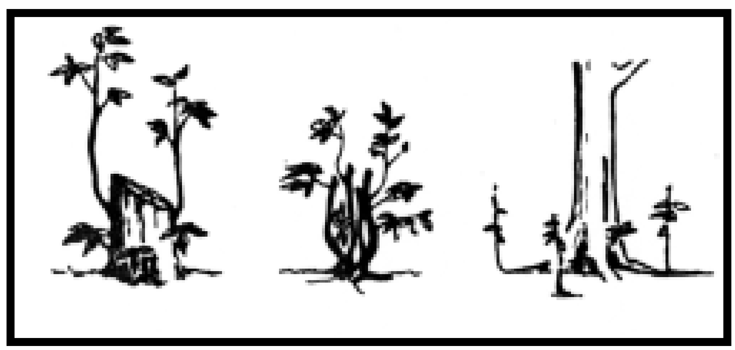


Bud and Flowering. At this stage, the plant's energy goes into the production of flowers and seeds. Food storage in the roots begins during these stages and continues through maturity. Chemical control is more effective at the bud stage than at the flowering stage. Chemical control during the flowering stage may reduce the viability of the seeds.



Maturity. Only the above ground portions of these plants die each year. The underground roots and stems remain alive through the winter and send up new plant growth the next spring. Chemical control is usually less effective at this stage. Chemical control has been found to be very effective in the fall, when the plant is mature and starting to go dormant for the winter.

Woody Plants

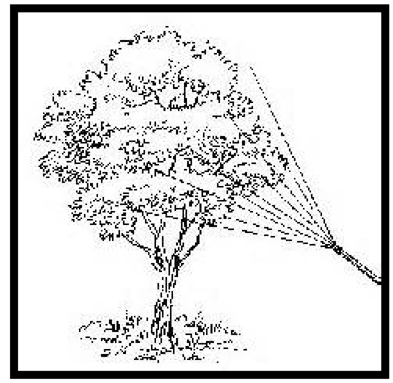


Woody plants go through the same four growth stages as other perennial plants. They don't die back to the ground during the winter, but deciduous trees lose their foliage. Woody plants can be controlled with herbicides anytime, but control is best when the plants are small. Foliar treatments can be used anytime when the woody plants have actively growing leaves. They usually work best as the leaves reach full size. After a first frost in the fall is also a very good time for chemical control on woody plants.

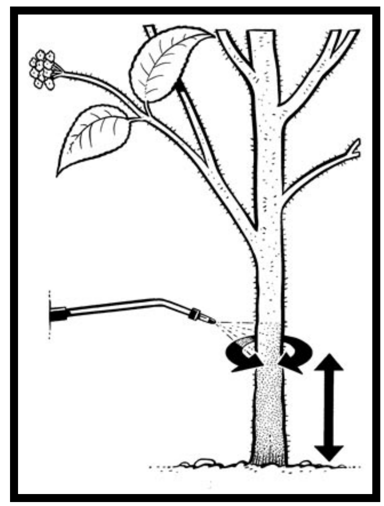
Woody Plant Control

Woody plants may be controlled mechanically or chemically.

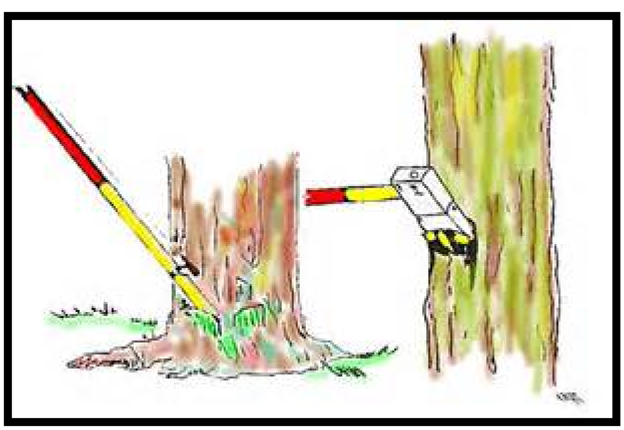
Foliar spraying. Herbicides are applied to the foliage of woody pants. Spraying woody plants at a young stage of growth is best.

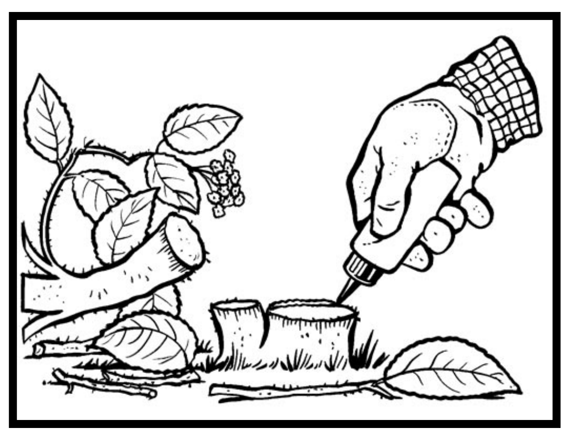


Basal spraying. Herbicides are applied in oil to lower parts of stems and exposed roots. It is best to fell large trees and then treat the stumps.

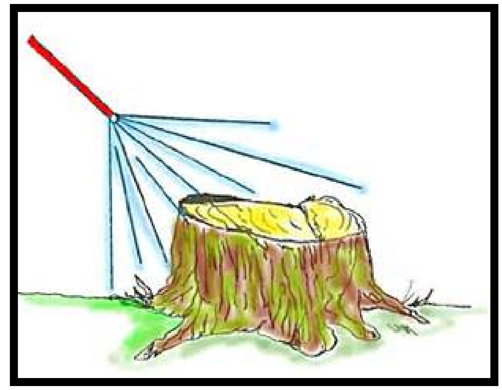


Cut-surface treatment. The herbicide can be applied to the sapwood through frill or notches. Another alternative is injection.

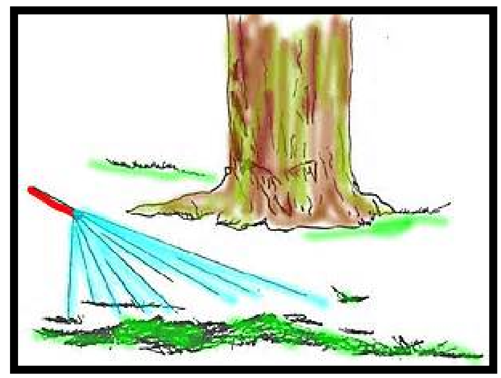




Stump treatment. Close-cut stumps and exposed roots also may be treated with herbicides in oil. It is best to treat immediately after cutting. All sprouts must be treated.



Soil treatment. Applications are made to the soil around the base of plants. Generally, granular herbicides are used. These must be in moist soil for results to occur.



FACTORS AFFECTING FOLIAGE APPLICATION

Location of Growth Points

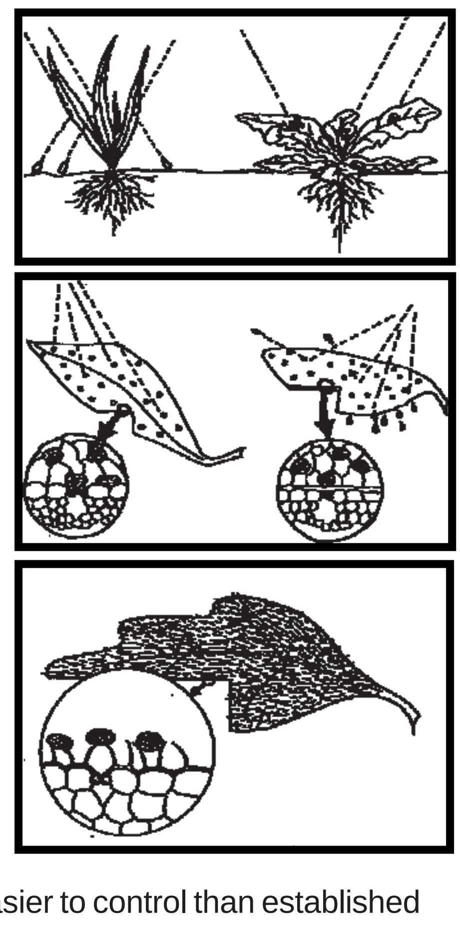
The growing point of a grass seedling is protected below the soil surface until seed stalks are produced. The plant will grow back if the herbicide or cultivation does not reach the growing point. Creeping perennial grasses have buds below the soil surface.

Many woody plants, either cut or uncut will sprout from any point where buds are found. These include roots, collar (base of trunk), trunk, or stem and limbs.

Seedling broadleaf weeds have an exposed growing point at the top of the young plant. They also have growing points in the leaf axils. Herbicides and cultivation can reach these points easily. The established perennial broadleaf plant is hard to control because of the many buds on the roots, stems and crown.

Physical Characteristics

Physical and species characteristics greatly affect the ability of herbicides to gain entrance in the weed. By considering each one, more effective control will be achieved.



Leaf shape affects the amount of herbicide to be used. Herbicide sprays tend to bounce or run off plants with narrow, vertical leaves. Broadleaf plants tend to hold the spray. If recommended on the label, add an adjuvant to increase spray retention.

Wax and cuticle formation affects the absorption of the chemical by the weed. The herbicide must penetrate the leaf surface to be effective. A leaf with a thin cuticle allows the spray solution good contact with the leaf surface. On a leaf with a thick, waxy surface, the spray solution tends to stand up in droplets. The wax and cuticle are thinner on young weeds. This is another reason for applying herbicides at the early growth stage.

Hairs on the leaf surface tend to keep the spray solution from entering. The droplets stand up on the hair and don't contact the leaf surface. Seedling weeds usually have fewer and shorter hairs. This is another reason for early control.

Size of the plant is another important consideration. Seedling weeds are easier to control than established weeds. As a plant increases in size and development, it becomes harder to control.

Plant size - Seedlings, being small and tender, are easier to control than established weeds.

Species vary in growth habit and susceptibility to herbicides. In some cases this is due to the plant characteristics listed above. In other cases, it is related to the plant's ability to metabolize (break down) the herbicide.

Precipitation - Rainfall occurring soon after a foliar herbicide treatment may wash it off, decreasing its effectiveness.

Humidity - A foliar herbicide will enter the leaf more easily and rapidly at high humidity than at low humidity. At high humidity, the leaf is tender and has a thinner layer of wax and cuticle.

Temperature may affect the amount of time required for the herbicide to do its job. As the temperature increases, the herbicide may work more quickly. However, when the temperature is 90°F or above, even selective herbicides may cause leaf burn to sensitive, nontargeted plants.

Wind and temperature can also affect the weed. A hot, dry wind will cause:

- the openings on the plant surface to close.
- the leaf surface to become thicker.
- the wax layer to harden.

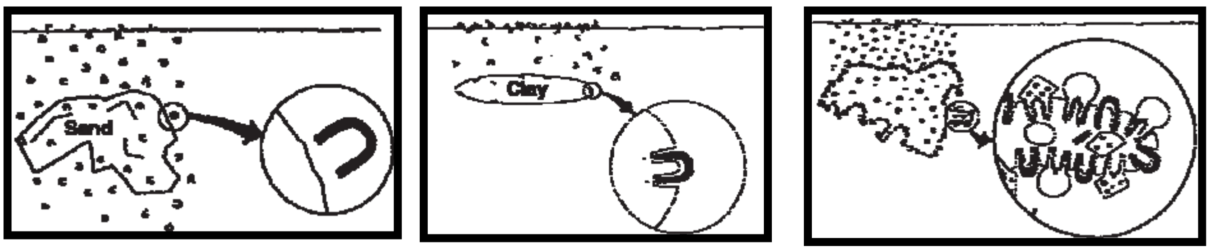
These factors make it harder for herbicides to penetrate the leaves.

FACTORS AFFECTING SOIL APPLIED HERBICIDES

Herbicide Characteristics

Soil particle tie-up. One of the properties of many herbicides is ionic bonding which resembles magnetism in its action. Some herbicides are not electrostatic at all; others have strong electrostatic properties. Those without an electrostatic charge move down through the soil quickly. Others with positive magnetic charges tend to be tied up on the negative charge sites of soil particles.

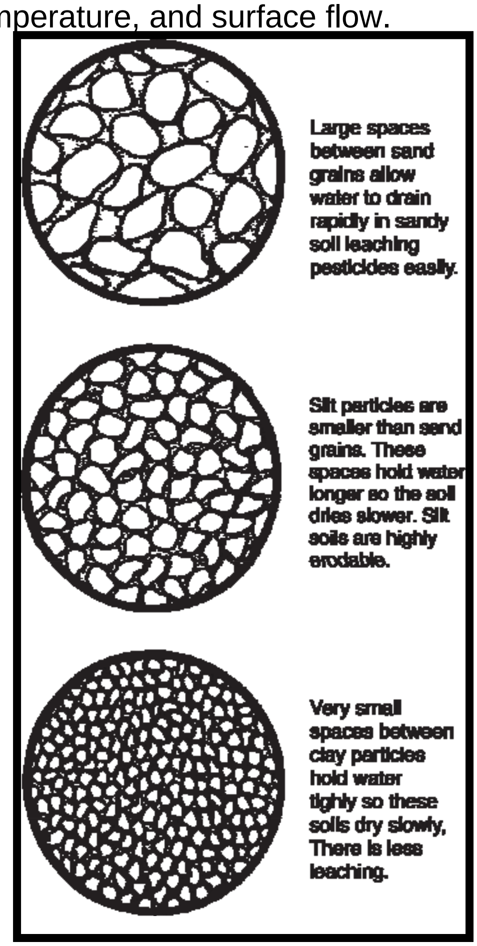
Sand **Clay** **Organic Mater**



Leaching is related to herbicide characteristics and soil factors. Herbicides and soils vary from non-leachable to completely leachable.

Persistence of an herbicide in the soil depends on herbicide characteristics, rate of application, soil texture, organic matter, precipitation, temperature, and surface flow. Herbicides can:

- Remain concentrated at the soil surface.
- Partially leach (diluting effect).
- Move through the soil in a front, allowing new weeds to grow above.



Soil type

Two factors affect the movement of herbicides that are applied to the soil:

- Texture of the soil -- how much sand, silt and clay the soil contains
- Organic matter in the soil

Texture: <u>Sand</u> is coarse and does not have many charge sites. The magnet shaped particles are herbicide molecules moving down through the soil. The magnified circle shows the herbicide particle moving past the sand surface. It does not tie up.

<u>Silt</u> has more sites than sand but fewer than clay and organic matter.

<u>Clay</u> is fine and has many charge sites. The positively charged herbicide particle has fit into the negatively charged slots on the clay particle. It is tied up

and will not continue moving through the soil.

Organic Matter: Organic matter has many more negative charge sites than even the finest particles. The magnified circle in the illustration below shows not only herbicide particles tied up on the organic matter, but also particles of other materials such as water, sodium, calcium and ammonia.

WHAT ARE RIGHTS-OF-WAY?

Planning

The objective of right-of-way vegetation management is to maintain a definite type of cover or bare ground. Consider the type and species of vegetation present and what type and species, if any, are desirable. Once you decide, you can plan a management program.

Rights-of-way are areas involved in common transport. Examples include:

- Federal, state, county and township highways and roads;
- Electric utility lines (including transformer stations and substations);
- Pipelines (including pumping stations);
- Public airports;
- Railroads;
- Public irrigation waterways;
- Public surface drainage systems, or ditches;
- Telephone and other communication networks; and
- Bicycle, hiking, bridle and other public paths or trails outside established recreational areas.

Plant growth along rights-of-way must be controlled to make sure the right-of-way is:

- Safe;
- Attractive;
- As inexpensive as possible to maintain; and
- Not harmful to the environment or surrounding area.

NON SELECTIVE VEGETATION CONTROL: GUARD RAILS, POSTS AND STORAGE AREAS

Reasons for Non selective Vegetation Control

Non selective weed control reduces the need to trim by hand around signs, guard rails, posts, fences, etc. The bare ground result of spraying around guard rails and other highway structures enhances visibility for motorists and highway crews responsible for maintenance. Keeping yards and storage areas cleaner and safer with complete weed control is desirable. Pre treating stabilized shoulders with a non selective residual herbicide can extend the life of the shoulder substantially.

Guard rail and shoulder weeds collect winter sand and runoff from the road pavement. Eventually, the sand builds up dikes or berms that slow water runoff from pavement, creating large puddles and ice patches. On fill slopes, trapped runoff is channeled against these berms, building up velocity before finding a discharge point over the slope. A concentrated discharge usually causes erosion and slope failure. Although machine grading can remedy this problem on open shoulders, guard rail sections are another matter. Mowing weeds under guard rails by hand is dangerous to workers as well as time consuming and expensive. Applying soil residual herbicides gives complete control of all guard rail weeds. One treatment will usually last a growing season.

Planning the Control Program

With a non selective weed control program, it is necessary to plan ahead to make the best use of personnel and equipment. Regular site monitoring should be done. Usually, the best results from soil residuals come when they are applied before the weeds emerge or when they are small. This means late winter to early spring. If experience has shown there has been lateral movement of residual herbicides in previous years, apply lower rates later in the season with a contact herbicide to minimize further movement. Some areas that have been treated for several years may not need treatment at all.

Equipment

By adjusting boom and nozzle combinations, the same type of low pressure equipment used for other types of weed control also can be adapted for use along guard rails. Generally, it is sufficient to treat a 3-foot strip under the guard rail. This can be done with a single hand held spray bar with a single nozzle, or a spray bar with one nozzle may be placed high enough to clear the rail posts on a fixed mount on the truck. Equipment that automatically adjusts to obstacles is available, making hand held spray bars unnecessary.

A nozzle arrangement that can be useful in this situation is the mounting of two smaller, off center nozzles approximately 15 inches apart and 15 inches above ground level, on a bar in line with the direction of travel. By adjusting the nozzles so that the forward nozzle is angled in the direction of travel and the other toward the rear, shadowing is eliminated. The pattern width is determined by adjusting the nozzle angle.

Vegetation in Pavement Cracks and Joints

Herbicides can substantially reduce damage to pavement from vegetation growing in cracks and joints. Vegetation can expand the crack, which then collects silt and moisture and encourages more growth and further pavement deterioration. A systemic herbicide such as glyphosate (Roundup®) is ideal for control in this situation. Soil residual herbicides could extend the life of an application to cracks, etc. However, consider this option carefully because rain can move a residual herbicide from the joint or pavement surface and carry it to nearby non target sites.

Tree and Shrub Management

Trees and shrubs are controlled along roadsides to maintain visibility, particularly along curves, at corners, intersections and in advance of signs. Suppressing trees and woody vegetation along roadsides can reduce shading as well as uneven thawing and pavement drying in the winter. Woody vegetation also impedes the functioning of ditches and drainage ways. Timely spraying of woody vegetation generally controls poison ivy in planned work locations and near homes, schools and playgrounds, which may otherwise be untreated because of the lack of time and funds.

Methods Used

Several methods of managing woody vegetation are available to roadside managers and certified pesticide applicators. Most of these combine mechanical cutting with pesticide treatment of stumps and/or regrowth.

Ideally, identify and chemically treat areas of woody plant invasion before the plants become so mature that they require cutting. This can often be accomplished by spraying in a manner similar to broadleaf weed control, with the spray directed from the edge of the pavement. A variation of this is cutting extensive areas of woody vegetation in one operation and scheduling a foliar treatment of the regrowth for the following spraying season. In areas where brownout or standing dead vegetation can be tolerated, foliar treatment of larger plants is an alternative. Always cut large trees at the ground level in areas and treat the stumps with a basal herbicide.

After woody species are under control, control extensive regrowth with periodic mowing, spot spraying of regrowth, low-volume basal applications or combinations of methods to avoid extensive cutting and broadcast spraying.

Planning the Management Program

Follow a woody vegetation management program of cutting and treating stumps annually, except during spring, when upward sap flow makes this application less effective. Timing is not as important as in broadleaf or guard rail treatment. However, depending upon the area, planning what pesticides to use is important. Residual pesticides should not be used on slopes where avoiding injury to downhill vegetation is required. When brownout is a concern, time foliage treatments toward the end of the summer, thereby reducing the duration of a brownout.

Fosamine (Krenite®) might be the herbicide of choice because it prevents growth the following season, but does not cause brownout of the foliage at the time of treatment. Fosamine also can eliminate brownout problems if the woody vegetation is cut and sprayed at the end of the first growing season after it has re sprouted. The amount of herbicide used is significantly reduced in this type of treatment.

Equipment for Woody Vegetation Management

For stump treatment on a moderate scale, backpack sprayers will probably suffice. Large scale treatment may require the use of a hose and handgun supplied by a power sprayer. Low pressures are sufficient. Use the same sprayers as those used for guard rail application. This equipment can be used to apply herbicides to poison ivy.

If a water based spray for foliage spray is used, a high-pressure sprayer with hose and handgun will be faster and give better coverage than low pressure equipment. Remember that these are for special uses only.

Problems and Precautions in Woody Vegetation Management

Foliar brownout is unsightly and may cause criticism from the public, so it is imperative that this work be performed with professionalism and sensitivity.

Wear waterproof foot gear and cover for the legs when ground spraying in tall grass and woody vegetation. Also, applicators should wear long sleeved shirt, gloves, and protective eyewear. This prevents excessive exposure to the herbicide. When leaving these areas, avoid walking through valuable plantings to prevent damage caused by residues on clothes. Also avoid walking through areas recently treated to reduce exposure via absorption through clothing.

UTILITY RIGHTS-OF-WAY VEGETATION MANAGEMENT

Telephone and Electric Power Lines

Vegetation management is necessary along telephone and electric power line rights-of-way for two reasons: to control tall woody plants that could interrupt overhead transmission line performance, and to improve accessibility for maintenance, emergencies and routine and aerial inspections. A well-managed rights-of-way increases both food and protection for wildlife and other animals.

More than four million acres of transmission line rights-of-way in the United States represent a substantial wildlife habitat. Rights-of-way that cut through forest areas, with the subsequent growth of herbaceous plants, bushes and young trees, support more animal life than the original tree cover. Wildlife such as rabbits, deer, fox and birds that normally live along the forest edge find food and shelter along rights-of-way.

The soil beneath telephone and electric power lines should not be bare. This area is often planted with desirable perennial grasses that provide erosion control, support maintenance equipment and compete with tall or vining brush that should not be allowed to grow onto the lines.

Control of most undesirable vegetation in desirable grasses can be obtained with occasional mowing or treatment with a selective herbicide.

Transformer Stations and Substations

Total vegetation control (TVC) is required in these areas. They must be kept free of vegetation to prevent short circuits and to alleviate fire hazards that could result from dead vegetation. These sites are usually covered with gravel. Treat the soil periodically with non selective herbicides that have a relatively long soil residual activity that prevents weeds from growing through the gravel. Be aware of the potential for herbicide movement off-site.

Pipelines

Pipelines do not require TVC, but brush should be kept to a minimum to allow for maintenance and aerial inspection. Establishing perennial grass after the pipes are laid will help control erosion. Mechanical removal or periodic treatments with selective brush herbicides help maintain these areas.

Railroads

Railroads are similar to other rights-of-way in that they pass through a variety of privately and publicly owned lands. Vegetation control on railroads is different than other utility rights-of-way in that most of the area treated is owned by the railroad. The treatment can be more easily planned and managed. Herbicides are primarily applied with ground equipment.

Reasons for vegetation management along railroad

- Allowing inspection of track, ties and roadbed;
- Improving working conditions;
- Increasing safety;
- Reducing the potential for track side fires;
- Conforming with state, city and local laws;
- Reducing the source of weed seeds to farmers' fields;
- Preventing overgrowth and noxious weeds in urban and suburban areas;
- Improving the appearance of the railroad; and
- Maintaining visibility at road crossings.

Areas for Railroad Vegetation Control

- *Ballast section:* Maintains drainage; allows inspection of ties, fastenings and switches, increasing the life of ties; keeps weed seeds out of traction motors on diesel engines; and prevents wheel slippage.
- *Shoulder adjacent to ballast section:* Promotes drainage and reduces potential for track-side fires.
- *Shoulder:* Allows unrestricted vision and train inspection.
- *Bridges, buildings and other structures:* Maintains fire safety.
- *Yards:* Maintains safety, convenience and appearance.
- *Low switch stands and dwarf signals:* Assures visibility.
- *Inside of curves:* Allows for train inspection.
- *Under communication lines:* Maintains uninterrupted service.
- *Area adjacent to tracks:* Helps keep trains from fouling.
- *Highway grade crossings:* Allows unrestricted view for both autos and trains.
- *Signs (mile posts, whistle boards, etc.):* Assures optimal view.

Problems Common to Railroad Vegetation Management

Drift. As with any other type of herbicide application, drift that can injure ornamentals and crops adjacent to the rights-of-way must be avoided. Precautions include using low-pressure, low-mounted booms and nozzles, special application devices coupled with drift-control adjuvants and stopping operations when pesticide begins to drift from the rights-of-way.

Brownout. Brownout is not as big a problem as it is along highways because the area along the railroad is not as visible. Alternative treatments in visually sensitive areas should be considered. These could include basal applications or pesticide substitution.

Encroachment of hard-to-kill species. When the same ground is treated year after year with the same herbicides, certain vegetation may not be controlled and may become the predominant species in time. When this happens, switch herbicides to a different herbicide family. Long-range planning can help avoid this problem.

Logistics. Railroad vegetation-management programs must work with and not impede regular rail traffic using the same rails. In other rights-of-way application, there is little if any restriction on the normal use of the highway or utility line. In railroad vegetation management, know train schedules, plan for track delays (a good time to check equipment) and be alert and prepared to stop at road crossings.   Normally, the sprayer should be off the tracks before dark.

WEEDS IN ORNAMENTAL AND TURF

Weeds growing in ornamental and turf areas are found where soil has been exposed or disturbed by compaction, planting activities, or maintenance activities such as sidewalk edging. For example, goosegrass and knotweed readily colonize heat-stressed and compacted soil sites along sidewalks or on athletic fields. They also occur where turf is weakened by drought, thatch accumulation, diseases, or insects. Fertilizer spills, chemical spills, and dog urine can also leave bare spots in which weeds will grow. Weeds are usually common where the grass species being grown is not well adapted to its environment.

In Nevada, weeds constantly compete throughout the year with turfgrasses for space, water, nutrients, and light. These unwanted plants increase maintenance costs, may act as alternate hosts for insects and diseases, and may cause discomfort to man and animals through the production of allergy-causing pollen, skin irritants, toxic substances, and spines or burrs. The most obvious impact of weeds in the landscape is aesthetic or a general lack of neatness, leading to a loss of visual appeal. In turf, weeds affect the quality, and can affect the real estate value. The variable leaf width, color, and growth habit of weeds disrupt the uniformity of texture associated with high-quality turf.

Monitoring for Weeds

Monitoring for actively growing weeds should be done periodically. It is essential that all monitoring results are reported completely and accurately by site and date so that future surveys will cover the same areas. Recorded weed information allows the manager to develop a weed history of an area. This will result in a more accurate prediction of future weed management needs.

Regular visual inspections of turfgrass areas should be conducted to look for actively growing weeds as well as newly germinated weed seedlings. Weeds are most likely to be found in areas where some type of disturbance has taken place.

Certain weed species tend to be found in certain habitats, so monitoring for a particular weed should be based on knowledge of its biology. For example, crabgrass is an annual weed that needs light to germinate. Crabgrass seedlings are also most likely to be found in bare or thinning areas. If they are not found in areas such as this, it is unlikely that they will be found in a shaded area of denser turf.

Weed mapping is a good management tool to plan for future sprays, especially for preemergence herbicide applications and soil sterilants where you can't see the weeds at application, but also weed mapping is a good tool to evaluate efficacy of all herbicide treatment plans. Noxious weeds, when encountered, should be reported to the Nevada Department of Agriculture noxious weed database for mapping via EDDMaps (http://eddmaps.org/). Noxious weed inventories assist the Department with planning, management and prevention of noxious weeds in the state.

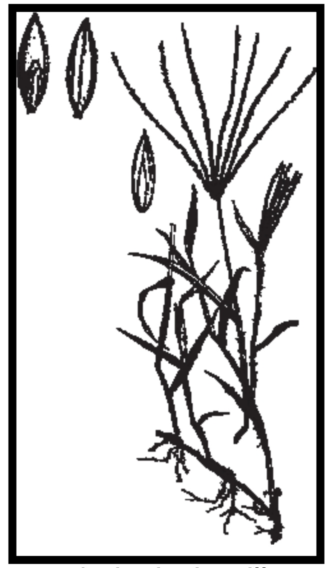
Action Thresholds for Weeds

Action thresholds are population levels at which pest management efforts must be instituted. It is extremely difficult to set specific action thresholds for weeds because the problems caused by weeds are largely aesthetic rather than medical or economic. Turfgrass or landscape managers should establish action thresholds for the area by maintaining records and scouting weed populations. Action levels will be lower in high use areas such as around buildings and picnic or rest areas than they will be in large, unused, or parking areas. Vigorous weed competitors such as crabgrass, clovers, and quackgrass should have a lower action threshold than other weeds.

SOME IMPORATANT WEEDS OF CONCERN IN NEVADA

Pesticide applicators should be able to recognize common weeds found in Nevada. Incorrect identification can result in control application mistakes. Such mistakes may have minor consequences, or they may lead to regulatory enforcement actions. It is impossible to include all weedy plants here — only representative weeds causing problems in Nevada are discussed. Applicators are encouraged to consult weed or plant guides such as the *Weeds of the West, Nevada Noxious Weed Field Guide* or similar references.

Crabgrass



Crabgrasses (*Digitaria* species) include both annuals and perennials. They are easily recognized by the seedheads, which consist of several slender spikes that spread out like the fingers of a hand. Young seedlings have erect stems. Older stems bend at the nodes, which gives plants a spreading, messy look.

Crabgrass will be found in lawns, ornamental landscapes, and vegetable gardens. Large crabgrass also grows in orchards, vineyards, and other agricultural areas. Crabgrass has many other names including crowfoot grass, watergrass, and summer grass. It grows in most parts of Nevada, except at high elevations and areas that receive no summer water. It is often confused with goosegrass and the perennials dallisgrass and bermudagrass.

Smooth Crabgrass is a low-growing, summer annual that spreads by seed and from rootings of the joints (culm nodes) that lie on the soil. It dies with the first frost in the fall. Unmowed, it will grow upright to about 6 inches, but even if you mow it as short as 1/4 inch, it still can produce seed.

Seedling leaves are light green and smooth. They are very conspicuous in the lawn with their lighter green color. True leaves are dark green but still smooth, and the leaf blade is from 1/4 to 1/3 inch across, up to 5 inches long, and pointed. Crabgrass often forms patches in lawns, and plants can grow together to form large clumps. The projection at the base of the leaf blade, known as the ligule, is small and inconspicuous, and the collar region lacks the clasping, prominent outgrowths or auricles present on some grasses. The leaf sheath and upper leaf surface are smooth, but a few hairs can be present on the lower leaf surface. Sometimes a reddish tint is visible at the base of the leaf.

The inflorescence, or flower stalk, has branches that originate from the main stem at 1/8- to 1/4-inch intervals. The branches are 1/2 to 2 1/2 inches long at the end of the stalk.

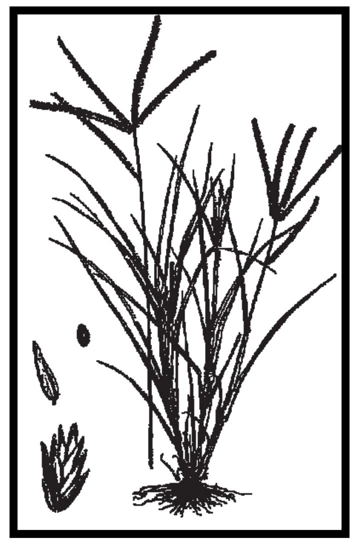
Large Crabgrass, when found in turf, large crabgrass is a low-growing, summer annual that spreads by seed and from rootings of nodes that lie on the soil. Unmowed, it can grow 2 feet tall. It won't tolerate close mowing as well as smooth crabgrass. As a result, smooth crabgrass is a more common weed in lawns. Seedling leaves are light green and hairy. True leaves are generally 3 inches long and hairy on the upper surface of the leaf and leaf sheath. The collar region and flower stalk are similar to that of smooth crabgrass, but the branches are longer about 2 to 5 inches at the end of the stalk. It is reported that seed production from a single, large crabgrass plant can be as high as 150,000.

Foxtails

The upright stems of these annual grasses (*Setaria* species) are over 1 foot tall and are topped by dense seedheads with numerous, long bristles. Yellow foxtail and foxtail barley can be found in Nevada.

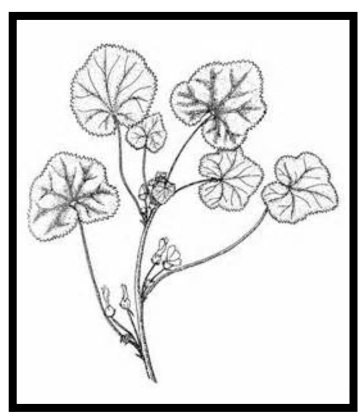
Foxtails of the genus *Setaria* are summer annual grasses consisting of a complex of many biotypes. Yellow foxtail is found in the Mojave Desert, southwestern Great Basin east of the Sierra Nevada, and Sierra Nevada, up to about 3900 feet (1200 m). Foxtail barley is a widely distributed native cool season perennial or annual grass that is found throughout Nevada up to an elevation of about 9800 feet (3000 m). It is occasionally weedy on agricultural land and other disturbed, often moist places. Foxtail barley is susceptible to the same fungal pathogens that cause black stem rust of grains and wheat rust. Foxtails inhabit agricultural land and other disturbed areas. Yellow foxtail also inhabits turf. All grow in moist or dry soil and tolerate a broad range of environmental conditions.

Goosegrass



Also called wiregrass, this annual weed (*Eleusine indica*) thrives in full sun and disturbed soil. The stems, leaf blades, and seedheads lie flat on the ground in a rosette pattern. It can tolerate close mowing. The flowering heads have from two to six flattened, fingerlike branches. This grass is widely distributed in Nevada. It is a problem weed in cultivated areas, lawns, pastures, and unused places. Goosegrass is normally found in compacted areas or areas of heavy wear; it inhabits agricultural land and other disturbed places, especially those that receive some summer water, and grows close to the ground. It is a widespread and highly variable species that tolerates a broad range of environmental conditions, but does not survive frost. Goosegrass is susceptible to viruses that cause diseases such as sugar cane mosaic.

Mallows



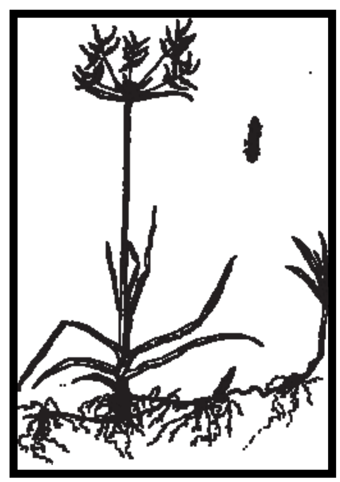
Weedy mallow plants are found growing widely in Nevada. All are from the family Malvaceae, which includes a number of desirable plants, most notably cotton, hibiscus, and okra. One species of this family *(Althaea officinalis)* is actually the original ingredient to make marshmallows. That species is not found in Nevada and although some of the wild mallow species can be eaten, mallows are less than desirable when found growing in crop fields, orchards, lawns, gardens, and landscapes.

These annuals begin growing with the first rains in the fall and quickly develop a deep taproot that becomes woody and makes the plant very difficult to remove by hand or even with tools. Fruit is sometimes described as looking like a tiny wheel of cheese, giving it the common name of cheeseweed. The most widespread of the weedy mallows in Nevada are *Malva neglecta* (common mallow or cheeseweed), and *M. parviflora* (little mallow, which is also called cheeseweed).

Common mallow *(M. neglecta)* is often referred to as an annual, winter annual, or biennial plant because it can be found growing all year. Seedlings have heart-shaped seed leaves (cotyledons) with smooth edges and first true leaves appear to be nearly circular or heart-shaped with the notch located where the long petiole attaches to the leaf. The leaf has five to seven rounded lobes and has a somewhat crinkled appearance. The mature leaves are similar to the first true leaves but are larger and alternate on the stem. Although the plant growth habit is spreading, the plants can reach two feet tall. The plant has a single deep tap root. White to light pink to light purple flowers are found in the leaf axils. The flowers have 5 petals, but each petal is notched at the tip so it may appear that there are 10 petals. The petals are about two times longer than the sepals (the leaflike structures at the base of the flower). The fruit is a round, smooth, flattened buttonlike structure that looks like a small, green, somewhat flattened pumpkin or wheel of cheese. Each of its 10 to 12 sections has one seed.

Little mallow *(M. parviflora)* is an annual with similar appearance to common mallow. Primary differences are found in the petal length, which are about the same length as the sepals and the fruit is wrinkled. The plant tends to have a more upright growth habit and can grow bushlike up to 5 feet tall. This species flowers from March to September in Nevada. Studies on the flowering and seed development of little mallow in Australia have found that the plant flowers 49 to 92 days after germination, but seeds mature only 15 days after flowering.

Nutsedge

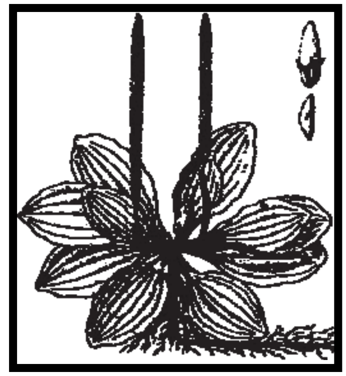


This aggressive weed (*Cyperus* species) spreads by underground, nutlike tubers. Its leaves are attached at the base of a single fruiting stem. Several seed clusters on stalks of different lengths arise from three bracts, leafy structures at the base of fruiting stems that may or may not look like leaves. The decision to control nutsedge will depend on the severity of the weed problem and the soil moisture conditions. Yellow nutsedge (*C. esculentus*) is native to North America.

Nutsedges are common weeds in landscapes and gardens in Nevada. They thrive in waterlogged soil, and their presence often indicates drainage is poor, irrigation is too frequent, or sprinklers are leaky. Once established, however, they will tolerate normal irrigation conditions or drought.

The most common species of nutsedge in Nevada is yellow nutsedge, *Cyperus esculentus*, Purple nutsedge, *C. rotundus* may occur in southern Nevada.

Plantain



This widespread weed (*Plantago sp.*) is a stemless perennial herb with fibrous roots. The basal rosette of oval leaves is often unnoticed until flower spikes appear from the center. Its leaves are smooth with several prominent parallel veins. It is common in lawns and pastures as well as other disturbed moist areas in Nevada. The leaves and seeds are known to be used in medicinal remedies. Birds eat the seeds and help spread the plant to other sites.

Broadleaf and buckhorn plantain (*Plantago major* and *P. lanceolata*) are major weeds of turf, ornamentals, gardens, waste areas, forage legumes, and pastures. Broadleaf plantain is also known as common plantain and dooryard plantain.

Broadleaf plantain is a perennial plant that grows best in moist areas with full sun or partial shade and compacted soil. Its fibrous root system is primarily found in the top 18 inches of soil. The smooth, oval leaf blades are 2 to 6 inches in length with five to seven ribs that parallel the leaf margins. The leaf veins converge at the base into a broad petiole (leaf stem) that may be up to 5 inches in length. The upright flowering stalk terminates in a long cylindrical spike head that may be 2 to 6 inches in length. Seeds are small (1/16 inch in diameter), reddish brown, and angular.

Buckhorn plantain is a perennial plant that has a taproot and longer, narrower oval leaves than broadleaf plantain. Its leaves measure 3 to 12 inches in length, are 3/4 to 1-1/2 inches wide, and have three to five ribs. The blade merges smoothly into the petiole, which is shorter than that of broadleaf plantain. The base of the leaf stalks and the crown of the plant are covered with tan, woolly hairs. he flowering stalk of buckhorn plantain is much longer than that of broadleaf plantain; it measures from 12 to 18 inches. Its dense spike of flowers is about 1 to 2 inches in length and shorter than the spike of broadleaf plantain. Seeds are black, shiny, boat shaped, and about 1/16 inch in length.

Thistles

Bull thistle (*Cirsium vulgare*) can be a major problem in lawns, gardens and pastures. Bull thistle is also commonly found along trails, roads and vacant fields. The leaves are deeply indented, dark green on top and paler on the lower surface, and each lobe is spine-tipped. The other plant parts are also armed with spines. The flower heads are large, rosy purple, and few in number.

Bull thistle is a widespread biennial thistle originally from Europe and Asia, but now introduced throughout North America. Although it is intimidating in appearance and can sometimes form large infestations, this thistle is not as challenging to control as many others.

Bull thistle has a two year life cycle, flowering and setting seed in the second year. Seeds are short-lived on the soil surface but can persist for many years when they are buried, such as form cultivation activities. Seed germination generally occurs in the fall and spring. Basal rosettes form and continue to grow until winter and can grow quite large, up to 3 feet in diameter. Rosettes that are not large enough by spring may not flower until the following year. Flowering usually starts in mid-June and continues into early fall. Plants can be self-pollinated or insect-pollinated. Bull thistle does not reproduce vegetatively and does not have rhizomes.

Canada thistle, a perennial broadleaf plant, is found in most of the western states. It is scattered throughout Nevada to about 5900 feet (1800 m). Canada thistle inhabits agricultural land and other disturbed locations. According to some taxonomists, four varieties or biotypes exist that differ in growth habit, leaf characteristics, seed germination, and development.

Canada thistle is a state-listed noxious weed in Nevada and many other states. It is important to control plants before they regenerate food reserves in their roots or produce seed. Do not let this weed move to new areas and eliminate it from noncrop locations.

Canada thistle stands erect to 3-1/3 feet (1 m) tall and grows in clumps or patches. Its stems are slender and hairless or nearly hairless. Leaves are oblong to lance shaped, mostly 2 to 8 inches long (5–20 cm), prickly, and are alternate to one another along the stem. Sometimes leaf bases extend down the stem joints as prickly wings that are 1/2 of an inch (1 cm) long. Leaf edges range from nearly smooth to shallow lobed and toothed. The upper leaf surface is hairless to nearly hairless and the lower surface is sometimes sparsely woolly. Rosette leaves are either few or lacking altogether.

The extensive root system consists of a network of vertical and creeping horizontal roots. Although most roots occur in the top 1-1/2 feet (45 cm) of the soil, vertical roots from 6-1/2 to almost 10 feet (2–3 m) deep are common.

Sowthistles, are among the most common weeds in farms and gardens in spring. They can be seen at any time of the year in mild climates, but commonly germinate from late fall to early spring with the highest numbers of mature plants present in spring and early summer. Flowers are yellow and mature into fluffy white seed heads. Annual sowthistle, *S.* sowthistle, *S. oleraceus*, is widespread in Nevada.

Russian thistle Russian thistle is a large and bushy annual broadleaf plant. It occurs throughout the western states, more often in drier areas. Recent taxonomic work has demonstrated that what has been named *Salsola tragus* likely consists of several morphologically similar species that differ in flower size and shape. Besides *S. tragus*, these include *S. australis, S. iberica, S. kali, S. pestifer,* and *S. ruthenica.* Russian thistle is common throughout Nevada, especially on loose sandy soils and inhabits agricultural land, roadsides, and other disturbed places.

Russian thistle can create a fire hazard or hinder traffic when it breaks off from its main stem and dries up. At this stage, it is commonly called tumbleweed. It is also an alternate host for the beet leafhopper, *Ciculifer tenellus*, which vectors the virus that causes curly top disease in melons, tomatoes, sugar beets, and other crops. Common soil-applied (preemergence) herbicides generally provide good control of this weed, but the seeds can germinate from up to 2.5 inches deep, so control may be poor where incorporation is shallow.

Mature plants are large and bushy with rigid, purple-streaked or green stems that typically curve upward giving the plant an overall round shape. They generally grow to about 3 feet (1 m) tall but can grow much larger usually with a similar height and width, or taller than wide. Leaves are somewhat bluish green, fleshy to leathery, hairless or covered with stiff short hairs, and 1/3 to 2 inches (8–52 mm) long and up to 1/25 of an inch (1 mm) wide. Leaf tips are sharply pointed to spine tipped. Upper stem leaves are reduced (bracts), stiff, and prickly. After they turn grayish brown, the plants break away from the roots at the soil line, becoming tumbleweeds that scatter their seeds as the plant skeletons are blown around.

Puncturevine

Puncturevine or goathead is a prostrate, summer annual, mat-forming, broadleaf plant with an extensive root system. It is listed as a noxious weed in Nevada, puncturevine produces many burs with sharp spines that can injure humans and animals, as well puncture bicycle tires. In addition, leaves contain compounds called saponins, which can be toxic to livestock (especially sheep) when eaten in quantity. It is prevalent in areas with hot summers, and is found throughout Nevada. It inhabits agricultural land, especially cotton fields and other disturbed sites.

The stem weevil, *Microlarinus lypriformis*, and the seed weevil, *M. lareynii*, are two introduced biological control agents that can keep puncturevine populations in check, but the suppression is cyclic and not always effective.

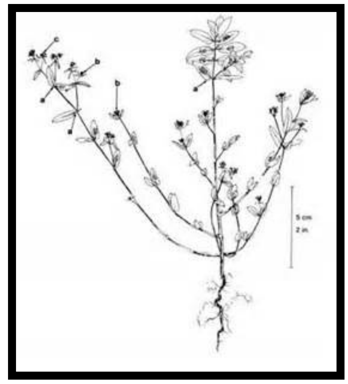
Plants grow prostrate over open ground, but when shaded or competing with other plants they can grow nearly erect. Stems occasionally grow over 3 feet (1 m) long, have many branches, are green to reddish brown, and spread radially from the crown. Stems and leaves are covered with hairs. Leaves are mostly 2/17 to 1/5 of an inch (3–5 cm) long, finely divided into three to seven pairs of leaflets, and opposite to one another along the stem.

Bromegrasses

Bromegrasses consist of a large group of species including both perennial and annual grasses. Some are valuable as forage and others are important weeds

Downy brome, also commonly known as **cheatgrass**, is a summer or winter annual, 4 to 30 inches tall, reproducing by seed. Leaf sheaths and flat blades are densely covered with soft hair. Ligules are short. Inflorescence is dense, slender, usually drooping, 1-sided, 2 to 6 inches long. Spikelets are nodding, slender 3/8 to 3/4 inch long. Awns are 3/8 to 5/8 inch long, usually purplish at maturity. Downy brome is primarily a weed of roadsides, fencerows, waste areas, pastures, rangelands, hay fields, landscapes and occasionally a contaminant in winter small grain crops.

Spurge



Spotted spurge *(Euphorbia maculata)* is an annual plant native to the eastern United States. In Nevada, it is the most common species of the spurge family, which also includes creeping spurge (*E. serpens*) and petty spurge (*E. peplus*). These weeds invade many of the state's crops, affecting vegetables, trees, citrus, turf, ornamental beds, and container ornamentals.

Spotted spurge grows close to the ground, often forming a dense mat. Its dark green leaves, which grow in pairs called “opposites,” are 1/8 to 1/2 inch long and about 1/8 inch wide. Frequently a red spot will mark the leaf halfway down its center vein.

Flowers, fruit, stems, and leaves are hairy. The short stems have a separate stipule or little scalelike appendage at their base, although you may need a 10X hand lens to see them. Broken stems and branches secrete a milky, poisonous sap. Although spotted spurge sap is being studied as a cure for various skin cancers, in general, the sap of all members of this genus is an eye and skin irritant.

Spotted spurge produces tiny, pinkish flowers that consist only of stamens and pistils grouped in small, flowerlike cups, called cyathia, in the leaf axils, the area where the leaf joins the stem. The fruit is a three-celled seed capsule that is 1/16 inch or less. Each cell contains one seed that is about 1/25 inch long. The plant's central taproot system is capable of extending more than 24 inches into the soil.

Although spotted spurge is the major spurge weed in Nevada, several other species of spurges appear regularly as weeds in the state; ground spurge (*E. prostrata)*, creeping spurge, garden spurge (*E. hirta)*, nodding spurge *(E. nutans)*, and thyme-leafed spurge (*E. serpyllifolia)*. Ground and creeping spurges are troublesome weeds throughout Nevada, while the others may be an occasional problem in landscapes.

Dandelion

Dandelion *(Taraxacum officinale),* also known as lion’s tooth, puffball, blowball, and monk’s head, is a major problem in turf, ornamental plantings, meadows, pastures, and alfalfa. The genus *Taraxacum* consists of about 40 species worldwide, but only two are found in Nevada. *Taraxacum californicum* is found in mountain meadows and *T. officinale* is found as a weed throughout California.

Dandelion is a perennial that grows best in moist areas in full sun; however, it can survive some shade and dry conditions once established. Dandelion grows year-round in California except in the coldest intermountain areas where it is dormant during the winter. It produces a strong taproot that is capable of penetrating the soil to a depth of 10 to 15 feet, but it is most commonly 6 to 18 inches deep. Buds grow from the uppermost area of the root, producing a crown that can regenerate "new" plants even though the plant is cut off at or below the soil surface. Sections of the root as short as 1 inch in length are also capable of producing new plants. There are no true stems; rather the leaves are clustered in a rosette at the base of the plant. Leaves vary in length from 2 to 14 inches and from 1/2 to 3 inches wide. Margins of the leaves are deeply serrated forming the typical "lion's tooth" outline from which the name is derived (dent-de-lion = tooth of the lion).

Pepperweed

Perennial pepperweed *(Lepidium latifolium),* an introduced plant from southeastern Europe and Asia, is invasive throughout the western United States. It can establish in a wide range of environments and is a common problem in flood plains, irrigation structures, pasture, wetlands, riparian areas, roadsides, and residential sites. Perennial pepperweed is a problem weed in nearly all of Nevada, and is listed as a noxious weed of concern. Populations form dense monocultures that are easily spread by root fragments and seed. Perennial pepperweed has many common names including tall whitetop, perennial peppercress, ironweed, perennial peppergrass, and broad-leaved pepperweed.

Perennial pepperweed is a member of the Brassicaceae (mustard) family. Stems range from 2 feet to over 4 feet tall. Mature plants have numerous erect, semi-woody stems that originate from large, interconnected roots. Roots are long, minimally branched, and enlarged at the soil surface forming a semi-woody crown. The foliage is glabrous and green to gray-green in color. Rosette leaves are ovate to oblong with entire to serrate margins on long petioles. Rosette leaves are about 4 to 11 inches long and 1 to 3 inches wide. Stem leaves are sessile and lanceolate, have entire to toothed margins, and become smaller toward the top of the stem. Small, white flowers form dense clusters arranged in panicles at the tip of each stem. Perennial pepperweed is often confused with **hoary cress** *(Cardaria draba)*; also called whitetop. However, unlike the taller perennial pepperweed, hoary cress stems are less than 3 feet tall and have leaves that clasp the stem and lack an obvious petiole.

Clovers

White clover is a creeping perennial broadleaf plant. Except for deserts, it is found throughout Nevada, to about 4900 feet (about 1500 m). White clover invades agricultural land and other disturbed sites including agricultural crop fields, orchards, vineyards, forest clearings, mountain meadows, lawns and planting beds.

Branching stems grow between 4 to 12 inches (10–30 cm) long, creep along the ground, and root at stem joints (nodes) producing large clumps. Leaves alternate with one another along the stem and consist of three leaflets. Each leaflet is 1/4 to 1/2 of an inch (0.6–1.2 cm) long, nearly hairless and may have a whitish crescent in the center. Although **strawberry clover**, *Trifolium fragiferum,* is similar in appearance, it does not have the whitish crescent that is often found on white clover leaflets.

Burclover is an annual broadleaf plant. It is found throughout most of Nevada, to about 5000 feet (1500 m). It inhabits agricultural land, turf, and other disturbed areas. Burclover is good forage for livestock and is sometimes cultivated for pasture or as a cover crop. However, Burclover fruit is prickly.

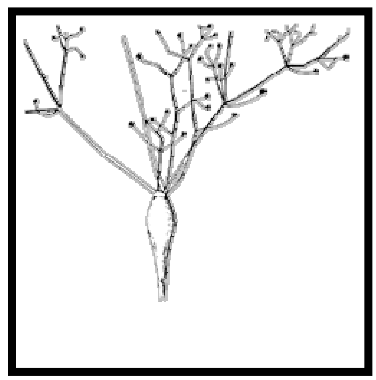
Stems grow to 2 feet (60 cm) long and tend to trail along the ground, but may grow upright. Leaves divide into three round leaflets, resembling those of clover and usually have reddish-tinged mid veins. Leaflets have serrated edges.

Bindweed

Field bindweed, a perennial broadleaf, is considered one of the most problematic weeds in agricultural fields throughout temperate regions worldwide. It is abundant throughout Nevada and grows up to an elevation of about 5000 feet (1500 m). Field bindweed is troublesome in many crops, but particularly difficult in potatoes, beans, and cereals. It can harbor the viruses that cause potato X disease, tomato spotted wilt, and vaccinium false bottom.

Leaves of the mature plant look similar to those of the younger plant, but they are lobed at the base. Leaves are attached to flattened stalks that are grooved on the upper surface. Stems grow to several feet long. They trail along the ground or climb on upright plants such as shrubs. Wild buckwheat trailing stems are often mistaken for those of field bindweed.

Buckwheats

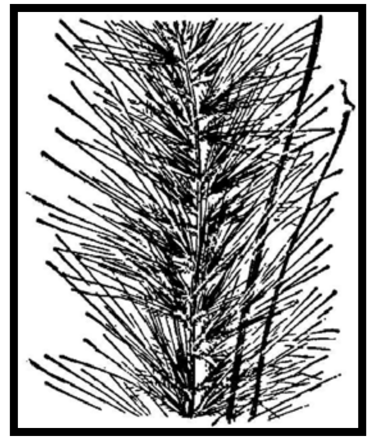


The buckwheat family (Genus Polygonaceae) has 1200 species of trees, shrubs, herbs, and vines worldwide and is well represented in the Great basin and Mojave Desert. Buckwheat, rhubarb, and sorrel are edible members.

Species in this genus vary in growth form from herbaceous annuals and perennials to woody shrubs. Most of the species in the Mojave Desert region can be readily recognized by their general appearance. They are mainly found in road medians, roadsides, and other disturbed sites. The herbaceous species are called **skeleton weeds**. Their basal rosettes of leaves are rather inconspicuous, but their inflorescences are distinctive. One to several of them arise from the basal rosette and branch profusely, often trifurcately, from a few inches to 2 feet (60 cm) tall. The flowering stems are leafless or nearly so, and bear tiny flowers at each node. Then they dry out and persist as skeletons for a year or more. Each of the desert species has distinct skeletal forms, several of which are very attractive and are used in dried arrangements.

Invasive Grasses

Several non-native species routinely used and planted in the nursery trade have become invasive pests and have been placed on Nevada's Noxious Weed list. The two Invasive plants are most commonly seen in Southern Nevada are Arundo or giant reed (*Arundo donax*) and crimson or green fountaingrass (*Pennisetum setaceum).*



Fountain grass (*Pennisetum setaceum*) is a coarse invasive perennial grass with a densely clumped growth form and erect stems usually one and a half to five feet tall. Leaves are narrow, flat, arching, up to 2 ft. long, and purplish. Flowering occurs from summer through fall, when off-white/pinkish plumes develop about 1 ft. The Flowerheads are prominent, nodding, and feathery resembling bottlebrushes six to fifteen inches long, with many, small, light pink to purple flowers. Fruits are dry achenes with long bristles. Crimson fountain grass is native to Africa and was introduced in Hawaii in 1914 and the Southwestern United States in the 1940s. Plants were introduced for ornamental purposes and have become invasive in the southern Nevada.

Giant reed (*Arundo donax*) is a robust perennial grass nine to thirty feet tall, growing in many-stemmed, cane-like clumps, spreading from horizontal rootstocks below the soil, and often forming large colonies many yards across. Individual stems or culms are tough and hollow, divided by partitions at nodes like bamboo. First-year culms are un-branched, with single or multiple lateral branches from nodes in the second year. The pale green to blue-green leaves, which broadly clasp the stem with a heart-shaped base and taper to the tip, are up to two feet or more in length. Leaves are arranged alternately throughout the culm, distinctly two-ranked (in a single plane). Giant reed produces a tall, plume-like flower head at the upper tips of stems, the flowers closely packed in a cream to brown cluster borne from early summer to early fall. Culms may remain green throughout the year, but often fade with semi-dormancy during the winter months or in drought. Giant reed can be confused with cultivated bamboos and corn, and in earlier stages with some large-stature grasses such as *Leymus* (ryegrass), and especially with *Phragmites* (common reed), which is less than ten feet tall and has panicles less than one foot long with long hairs between the florets. Giant reed is native to the Mediterranean Basin and was introduced in to North America in the early 1800's and in to southern California by the 1820's. Plants were introduced in Nevada for ornamental purposes and have become invasive in the southern Nevada.

EVALUATING RESULTS

After using any vegetation-management practice, inspect the area to evaluate the results. Keep in mind the type and species of vegetation treated together with the soil type and weather conditions during and after application. Know the objectives of the control program when evaluating the results. Occasionally, it is sufficient to suppress treated vegetation. In other cases, selective control is required. In still other cases, TVC is desired. In most cases, determine initial herbicide activity, and possible injury to adjacent desirable vegetation two to four weeks after application. Evaluate the results of TVC treatments after about two months and subsequently through the end of the season. Evaluating the effectiveness of brush and perennial weed control measures should be done at least 12 months and sometimes 24 months, after treatment.

Evaluation must be constant. Evaluations may result in rate adjustments, a change of products or timing of herbicide applications, and consideration for adding or adjusting nonchemical controls.

RESISTANCE TO PESTICIDES

As living organisms, pests must adapt to and overcome adverse conditions in order to survive. Plant pests must be able to survive harsh winters, and resist attack by parasites and predators. They have succeeded remarkably well. It is no surprise that pests also can adapt to control measures used against them.

Pesticide resistance is the inherited ability of a weed or other pest to tolerate the toxic effects of a pesticide. As pest populations develop resistance, increasing the rate or frequency of pesticide application may be needed, but not beyond label recommendations. Eventually, it will be impractical or impossible to control the pests with the pesticide to which they have become resistant. In some cases, other acceptable pesticides may not be available.

Hundreds of pest species, mostly insects, have become resistant to one or more pesticides. Keep in mind that not all populations of these pests are resistant. Any population of pests has the potential to develop pesticide resistance. As a result, where possible, Integrated Pest Management (IPM) should be utilized. IPM is developing a program plan that uses more than one treatment type, puts emphasis on prevention and reduces the chance for herbicide resistance.

The Development of Resistance

Where does pesticide resistance come from? The answer lies in the natural genetic diversity within a plant population. When organisms reproduce, offspring receive copies of the "parent" genetic material. Those copies are not always perfect. Mistakes, analogous to misspelled or missing words, may appear. Those are called mutations. Because the parent was already fine-tuned to its environment, most such mistakes are either harmful or of no consequence.

Sometimes a mutation benefits an organism. This includes mutations that confer pesticide resistance. Because pest populations are so large, it is likely that within a population, a small percentage of individuals will develop resistance to a particular pesticide. These resistant individuals survive when a pesticide is applied, and at least some of their offspring inherit the resistance. Because the pesticide kills most of the nonresistant individuals, the resistant pests will make up a larger percentage of the surviving population. Each time a pesticide is used, the percentage increases.

In most cases, pest populations that have become resistant to one pesticide also become resistant to other, chemically related pesticides. This is called cross-resistance. This occurs because closely related pesticides kill pests in the same way (e.g., all organophosphate insecticides kill by inhibiting the same function that is vital for insect survival). If a pest resists the toxic action of one pesticide, it usually can resist other pesticides that act in the same way, even pesticides from other chemical families that have the same mode of action.

Given that pesticide resistance is an ever-present threat, the need to understand what influences its development is important. This knowledge can allow one to recognize or predict the likelihood of pesticide resistance.

Important Factors That Influence the Development of Resistance:

- The frequency of pest resistance before use of the pesticide in question. Resistance may be absent from a pest population, or it may be present in a few or many individuals. Obviously, the absence of resistance is best
- The chemical diversity of the pesticides used. Using the same pesticide, or family of pesticides, will not kill pests that are resistant, and the proportion of resistant pests likely will increase.
- Persistence and frequency of use of the pesticide. Resistance often develops against pesticides that are applied often, and that have greater persistence.
- Specific mode of action: Pest populations are more likely to develop resistance to pesticides that attack a single structure or mechanism than those pesticides that attack several vital life processes.
- The proportion of the population exposed to the pesticide: When an entire pest population is exposed to a single pesticide application, most nonresistant individuals are killed, which increases the proportion of resistant pests among the survivors. Weeds, however, emerge sporadically and, at anyone time, many seeds lie dormant in the soil. As a result, many susceptible weeds are not exposed to an herbicide and, thus, continue in the population.
- The length of the pest's life cycle: As with any other inherited trait, pesticide resistance will increase faster if the pest has a short life cycle and many generations in a single season. This explains why insect populations show resistance faster than weed populations.

Herbicide Resistant Weeds

Many weed species have biotypes resistant to herbicides. Most of these biotypes resist triazine herbicides, such as hexazinone (Velpar®), and) occur in crop land, not rights-of-way.

A recent concern is that within several weed species there are already biotypes resistant to the new chemical groups of sulfonylurea and imidazolinone herbicides. Some of these herbicides are used on rights-of-way. One such herbicide is metsulfuron methyl (Escort®). Herbicides in these chemical groups have a precise mode of action: they prevent a specific enzyme (ALS) from functioning. This enzyme is essential for the production of three amino acids, and protein synthesis stops and plants die when this enzyme is blocked. In resistant biotypes, plants develop normally and the enzyme is unaffected. Farmers often use herbicides in these chemical groups for crop production. Thus, farmers and rights-of-way personnel could cause resistance problems for each other. Both sides should practice resistance management to avoid further resistant-weed problems.

Glyphosate (Roundup® and other products) is a valuable herbicide in agriculture production, rights-of-way sites and landscapes. When applied post-emergence glyphosate provides broad-spectrum, low-cost weed control. It is better than many other herbicides at controlling larger weeds, has very little to no soil activity and has low environmental and human health risks. For many applicators, glyphosate has simplified weed management.

Although the total number of glyphosate-resistant weed species is still low, the number of species is increasing. A weed's potential for developing glyphosate resistance is primarily guided by three factors: weed biology, intensity of glyphosate use, and glyphosate rate.

- Weed Biology: It is likely that certain weed species have greater genetic diversity, so there is a greater risk that they will develop herbicide resistance. Weed species that have already developed resistance to other herbicides may have a greater probability of developing glyphosate resistance.
- Intensity of Glyphosate Use: Increasing the intensity of glyphosate use (frequency and number of acres treated) increases the probability of selecting an herbicide-resistant weed. With continued glyphosate use, the number of resistant weeds will continue to multiply and create a resistant population. Herbicides do not cause the mutations that result in resistance. Rather, an extremely rare genetic trait that allows a weed to survive glyphosate may exist in the natural population. It is more likely to be found and increase when glyphosate is used frequently.
- Glyphosate Rate: It is less clear how rate affects glyphosate resistance development in weeds. Purdue University has reported that several known glyphosate-resistant weeds require eight to 10 times more glyphosate to be controlled than the normal, sensitive biotypes. This level of resistance means that labeled glyphosate rates will not control these weeds, and that making applications at labeled rates probably will not prevent resistance.

Although everyone would prefer a simple solution to herbicide-resistant weeds, adding diversity to our weed management programs is the key. Diverse practices provide additional benefits since many of these practices improve the overall level and consistency of weed control, add flexibility in scheduling applications, and reduce the risks of yield loss. Overall, applicators need to manage the intensity of herbicide use to reduce the potential for resistance.

Resistance Management

In the past, pesticide resistance was managed by switching herbicides. This was possible because new products continually became available. Today's new pesticides are more complex, difficult to synthesize and more expensive to develop and use, and even these products may become ineffective because of pesticide resistance. Obviously, switching products is no longer enough.

In developing a pest-management program, assume that the pests can develop resistance to any pesticide used against them. This means that greater emphasis must be placed on resistance management. This may seem like more work in the short run, but losing the use of a pesticide because of resistance could be more of a problem in the long run.

Resistance management attempts to prevent, delay or reverse the development of resistance. This complex task involves more than just herbicides. Incorporate the practices described below into a resistance management plan:

- Use an integrated pest-management program. Combine cultural, mechanical and chemical controls into a practical pest control program.
- Use pesticides with different modes of action. Where a pest must be controlled more than once a year, use pesticides with different modes of action. This way, pests resistant to the first pesticide will be killed by the second.
- Use pesticides only when needed, and use only as much as necessary. A pest population develops pesticide resistance only when the pesticide is used. Therefore, using the pesticide when not needed may unnecessarily increase the number of resistant pests. Likewise, do not apply more pesticide than needed to keep the pest population below damaging levels. If more is applied to try to eradicate the pests, it wastes not only money (because eradication is usually impossible), but will also kill an even larger proportion of susceptible pests. As a result, even more resistant pests among the survivors can result.

For more information on Herbicide resistance, go to the Herbicide Resistance Action Committee's web site at: http://www.hracglobal.com/Home.aspx

PESTICIDE SPILLS AND FIRES

Pesticide spills occur and sometimes pesticide storage facilities burn. Preparing a plan for handling spills and fires should be done in advance. Part of the planning process will involve who, what, why, and when of dealing with the situation. Assigning responsibilities for taking action, proper notification procedures for local and state agencies, and location and availability of equipment and supplies are some of the items that need to be covered. Spills require a different approach than fires. The following sections outline the general requirements to be met.

Pesticide Spills

It is a legal responsibility to clean up and decontaminate any pesticide spill that occurs during mixing, applying or storing pesticides (NAC 555.440). When a spill occurs, take immediate action.

- Attend to anyone exposed to the pesticide. Administer first aid and obtain medical care, if necessary.
- Clear the area of all people who are not helping to handle the spill. Be sure that everyone is wearing protective clothing and equipment to minimize exposure.
- Promptly confine the spilled pesticide to keep it from spreading and contaminating a larger area or body of water. Large spills of pesticides or spills of specific products require notification of state and federal agencies. The General Manual (S-12) provides emergency telephone numbers to call if the spill is too large to handle without help or if notification is required. Notification of local officials is required if the spill contaminates a body of water, a well, a drainage ditch or other similar area, or if the possibility exists that these water sources could be contaminated.
- Absorb a liquid spill on concrete or other solid surfaces with absorptive clay, vermiculite, pet litter, sweeping compounds, sawdust or sorbent products designed for absorbing liquid spills. Do not use sawdust or sweeping compounds on strong oxidizing pesticides because this presents a fire hazard. Absorb as much liquid as possible into the material. Then sweep or shovel the contaminated material into a leak-proof drum, and properly dispose of the drum as a pesticide waste.
- Cover the spill area with a material that neutralizes the pesticide. Examples of appropriate chemicals are hydrated lime, a solution of lye, ammonia, sodium hypochlorite (bleach), or strong detergent and water. Contact the chemical manufacturer to determine which of these materials to use.
- Contact the chemical manufacturer before rinsing the area with water. Collect this rinse water and hold for proper handling. Ideally, apply this rinse water on an area that is labeled for use of the pesticide while taking care not to exceed the labeled rate. If the pesticide rinse water cannot be used in this way, then it must be disposed of as a pesticide waste.

When a pesticide (especially an herbicide) spills on the soil, the area may be unsuitable for plant growth unless the contaminated soil is removed or the pesticide deactivated. Dig up the contaminated soil and distribute it over a large area that is labeled for the pesticide, taking care not to exceed the label rate. Otherwise, the soil is considered a hazardous waste, and must be disposed of at a hazardous-waste landfill. Removing contaminated soil may not be feasible except for small amounts of soil.

One option for small, localized spills, is the use of activated charcoal. Activated charcoal (carbon) deactivates many pesticides, including organic herbicides. Some herbicides, however, are formulated with inorganic components, such as chlorates or borates. Charcoal does not deactivate these inorganic components. The product's composition is listed on the label's statement of ingredients. Consult the herbicide manufacturer for specific guidelines in handling spills of herbicides with inorganic components.

Activated carbon, now widely used in diverse industries, is manufactured by heating or chemically treating organic matter to achieve a porous structure. This process produces a large surface area within a relatively small volume. Most activated carbons are purified by acid washes and water washes to remove impurities. They are available in both granular and powder form. The charcoal used with outdoor grills cannot be ground up to achieve the same pound-for-pound pore structure that is characteristic of activated charcoal.

Activated carbon can usually be purchased from a local pesticide dealer, who either carries the product or is able to find it. If activated carbon is not available locally, contact a chemical company supply house. Activated carbon is available in quantities from one to 50 pounds, depending on the supplier.

Before applying activated carbon, determine the approximate pesticide concentration in the contaminated area. Only be concerned with the amount of active ingredient, not with the total amount of product. For example, if the spill was 1 pound of a 50WP product, deactivating 0.5 pounds of active ingredient is needed. As another example, if the spill was 1 gallon of an 8E product, the need is to deactivate 8 pounds of active ingredient.

The most accurate method to determine the chemical concentration in an area is to run a chemical analysis on the contaminated soil. Sample the soil to the depth that the pesticide moved. A 3-inch deep sample is usually sufficient unless the spill occurred a considerable time before sampling, heavy rains fell before sampling or the soil is coarse and porous.

Some charcoals are formulated as powders to be applied dry. Others are treated so that they can be added to water and applied as a spray. Evenly distribute the carbon over the contaminated area. Using a rototiller or some other incorporating tool, thoroughly mix the charcoal to the depth that the soil is contaminated. Water the area thoroughly every day for at least three or four days before replanting. If possible, wait for several more days. The treatment's effectiveness depends upon the soil texture and organic matter content, the properties of the herbicide and the sensitivity of the plant species to be grown in the area. Before replanting the area, test it by spot planting to determine the effectiveness. If the plants die or are injured, water again for three or four days. This additional watering is usually sufficient for deactivation, but occasionally you will need to add more carbon.

Pesticide Fires

Although the majority of pesticide active ingredients are not flammable and do not by themselves constitute a fire hazard, many of the solvents used in liquid formulations are highly flammable. For this reason, consider all liquid pesticides as potential fire hazards. The risk of fire from a stored liquid pesticide is based on its flash point. Flash point is the minimum temperature at which a liquid gives off sufficient vapor in the surrounding air to form an ignitable mixture. Liquids are classified by the National Fire Protection Association as flammable (flash point below 100 degrees) or combustible (flash points above 100 degrees). Whenever large quantities of pesticides must be stored, install fire detection devices, and place a dry chemical fire extinguisher near the storage entrance.

Prepare a fire plan for each storage facility, and outline the appropriate measures to take should a fire occur. Indicate the proximity of pesticide wastes (e.g., surface water, sewers, wells) and how you will prevent contaminated runoff water from fire fighting from entering such waters. It is, in fact, sometimes better to let a fire burn to avoid what are often massive problems with contaminated water. Be sure to discuss the proper way to deal with a fire with the pesticide manufacturer, insurance carrier and local fire department.

PUBLIC RELATIONS FOR RIGHTS-OF-WAY APPLICATIONS

Rights-of-way operations are highly visible to the public. Because of this, they may be unusually open to criticism. However, much of the criticism may be avoided if you are considerate of public concerns, are knowledgeable and informed, and use extra care in applying pesticides.

Differences in Perception

Different groups will see pesticide applications in different ways. As an example, a brownout from a properly applied herbicide on an electric powerline rights-of-way may be the destruction of an adjoining property owner's landscape and view. The property owner may appreciate the need for rights-of-way maintenance, but not at the expense of his or her own landscape. Also, the potential for herbicide damage on the property owner's side may enter into the perception. The property owner may fear both a diminished landscape view and damage to plants on his or her property.

The best way to deal with many of the concerns of property owners before or during treatment is to answer their questions and to respond to their concerns clearly and directly. Be professional; view such questions as an opportunity to educate and improve communication with the public. Do not patronize property owners. They are not impressed by applicators who say that they know what they are doing, or that there is no law requiring them to tell the property owner what they are doing.

Carelessness

Many problems of pesticide application can be resolved by improving operational practices. Most operational problems are within the operator's control. They are not "unavoidable accidents". Commonly occurring violations or misuses result in significant and visual off-target impacts. These misuses include careless mixing or pesticide transfers with resulting spills, roadside disposal of leftover spray mixture at the end of the day, contamination of surface water through drift, spills or improper disposal and injury to off target vegetation due to drift, volatility or soil lateral movement of pesticides.

Misuses relating to actual application usually are due to carelessness. It is possible to follow label instructions and still be careless. Being careless includes the following:

- Being unfamiliar with the area to be treated prior to application.
- Failing to take all possible steps to avoid drift (NAC 555.400(7)).
- Failing to use proper pesticides or equipment for the job (NAC 555.400(2)).
- Failing to regularly check application equipment to make sure that it is functioning properly (NAC 555.400(4)).
- Failing to wear proper protective equipment (NAC 555.440).

If these precautions are not being followed, unnecessary risks are being taken and may result an enforcement action under state laws.

OTHER AREAS OF CONCERN

Nearly all parts of a weed control program involve some form of drainage. It is easy to recognize drainage ditches, but greenways, medians, turf plantings, landscapes, contour and overflow areas can be less obvious. Pesticide treatments should have minimal or no effect on these areas. Follow label directions and precautions where runoff water flows into sensitive areas or where the water is impounded for uses such as flood control, urban ponds, recreation, irrigation or livestock.

Sometimes problems are caused for a landowner without realizing it. Do not cross fields with heavy equipment when the ground is soft. Avoid crossing livestock lots without first cleaning the mud off of your equipment's tires. Communicable diseases, such as hog cholera, can be spread from one area to another by unwittingly tracking contaminated soil. If the death or injury of an animal is blamed on a pesticide application, a veterinarian should examine the animal. If investigation shows that compensation is justified, respond fairly and promptly.

Marijuana can be seen growing on utility rights-of-way in rural areas. Report it to the proper authorities. These areas should be bypassed until the marijuana has been destroyed. Use extreme caution in these areas.

Often, a landowner's questions concerning pesticide applications go unanswered or are not answered to the owner's satisfaction. This generally results in a formal complaint and polarized viewpoints. Landowners think the applicator is hiding something, and the crew supervisor may view the questions as a nuisance. A simple solution to this problem is to know the answer to the landowner's question before it is asked. A quick, direct response to the public's concerns facilitates better communication and a more enjoyable working environment. Be prepared to respond to commonly asked questions, such as:

- What are herbicides, and why are they used?
- Do herbicides affect birds?
- If my garden becomes contaminated, is it safe to eat the vegetables?
- Is it safe to eat wild berries from areas that have been sprayed?
- What kind of precautions are taken to make sure that pesticides don't get into groundwater supplies?
- Do herbicides and other pesticides pose any risk to me and my family?
- What happens if herbicides wash from the treated area into my pond; how does it affect the fish?
- If my cattle graze on treated rights-of-way, is the milk and meat safe to consume?

To answer these questions, an applicator will need to be knowledgeable in the physical, chemical and biological nature of the herbicide(s) being used. An applicator will need to be aware of the economic, social, esthetic and ecological costs and benefits of the application. The more complete the knowledge you have and the more quantitative your answers, the better informed the ultimate answers will be. Some answers may be simpler to answer, and some may be more of a challenge. However, the more you know about your application and the site of your application, the better off you will be to answer your customers questions. Remember, there are no text book answers to these questions; experience, knowledge, research and communication skills will aid in your abilities to facilitate an answer. Technical assistance from the chemical manufacture is only a telephone call away.

GLOSSARY

Absorption. The process by which an herbicide passes from the soil solution into plant root cells or from the leaf surface into the leaf cells.

Active ingredient. The chemical in a pesticide formulation primarily responsible for its activity against pests. It is identified on the ingredients statement of the product label.

Annual plant. A plant with a life cycle that is completed within one year.

Ballast. Material such as crushed rock, cinders or gravel that is placed both between and below railroad ties to make the track firm and lasting.

Berm. A shoulder along the edge of the ballast.

Biennial plant. A plant with a life cycle that is completed within two years, with seed production occurring during the second year.

Brush. Woody plants, such as brambles, shrubs and vines, that are less than 10 feet in height at maturity.

Calibration. Measurement of application equipment's delivery rate.

Cell membrane. Semi permeable wall that surrounds the inner portion of the cell.

Chloroplast. Organelles present in large numbers within plant cells that contain protein, lipids and pigments such as carotenoids and chlorophyll.

Contact herbicide. This causes localized injury to plant tissue wherever the plant and the herbicide have contact.

Cotyledon. A specialized seed leaf, one is found in monocots and two in seeds of dicots.

Cross-resistance. Type of resistance in which a pest or pest population is resistant to closely related pesticides.

Crown. That portion of a plant between the shoot and root regions that contains the meristems (buds) from which shoots arise.

Deciduous. Those plants that lose all their leaves during a portion of the year (usually winter).

Dicot. Plants that contain two cotyledons, such as broadleaf plants.

Enzyme. Proteins, formed in plant and animal cells or made synthetically, that act as organic catalysts in initiating or speeding up specific chemical reactions.

Erosion. The movement of soil particles by water or wind.

Evergreen. Plants that are always in leaf.

Fibrous root system. Type of system formed by lateral branching of the primary root, found in monocots (grasses).

Flash point. The minimum temperature at which a liquid pesticide gives off sufficient vapor in the surrounding air to form an ignitable mixture.

Formulation. The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Fungicide. Pesticide used for the control of fungal diseases.

Herbaceous weed. A vascular plant that does not develop woody tissue above ground.

Herbicide. Pesticide used for the control of undesirable vegetation.

Insecticide. Pesticide used for the control of insects.

Integrated management program. A system where at least two pest control strategies are used.

Lateral movement. Movement of a substance through soil, generally in a horizontal plane, from the original site of application.

Monocot. Plants that contain one cotyledon, such as grasses.

Non selective herbicide. An herbicide that is generally toxic to all plants. Some selective herbicides may become non selective if used at high rates.

Nontarget organism. Plant or animal species not intentionally treated by a pesticide.

Non target site. Area not intentionally treated with a pesticide.

Noxious weed. A weed specified by law as being especially undesirable, troublesome or difficult to control. Precise definition varies according to legal interpretations.

Perennial plant. A plant with a life cycle that lasts more than two years.

Pesticide resistance. The inherited ability of a pest to tolerate the toxic effects of a particular pesticide.

Photosynthesis. The biological production of organic substances, chiefly sugars, occurring in green plant cells in the presence of light.

Phytotoxicity. An effect that is injurious or lethal to plants.

Plant growth regulator. A substance that alters the normal growth and/or reproduction of a plant.

Post emergence. Application of an herbicide after emergence of the specified weed or crop.

Pre emergence. Application of an herbicide to the soil prior to emergence of the specified weed or crop.

Residual herbicide. An herbicide that persists in the soil and injures or kills plants for an extended period of time (several weeks to several months, depending on the herbicide).

Respiration. The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms.

Rhizome. A specialized horizontal stem that grows below ground or just at the soil surface.

Rights-of-way. An area involved in common transport.

Rodenticide. Pesticide used for the control of rodents.

Rosette. A circular cluster formed by basal leaves of certain broadleaf plants, particularly biennials.

Selective herbicide. A chemical that is more toxic to some plant species than to others.

Spray drift. Movement of airborne particles from the intended area of application.

Stolon. A specialized horizontal stem that grows above ground.

Surfactant. A surface-active agent that produces physical changes at the surface of liquids. Used in agricultural sprays as wetters, stickers, emulsifiers and penetrants.

Tap root. Type of root system, found in dicot plants, that has relatively little lateral branching.

Translocated herbicide. An herbicide that is absorbed and moved to other plant tissue.

Tuber. A short, thickened stem structure that develops below ground as a consequence of the swelling of a portion of a rhizome and subsequent accumulation of reserve materials.

Vapor pressure. Chemical property of a substance that describes its potential for conversion into a gaseous state.

Vaporization. Process by which a solid or liquid material is transformed into a gas.

Volatility. See vapor pressure.

Water solubility. Chemical property of a substance that describes its potential for dissolving in water.

Weed. A plant that grows out of place.

Woody plant. Perennials that have a thick, tough stem or a trunk covered with bark.

Appendix A

Control of Salt Cedar

Saltcedar Invasive Species Management

(Tamarix spp)

Saltcedar is a rapid growing non-native deciduous tree reaching a height of 20 feet at maturity. It has been recorded in 19 states in the United States. It is one of the most invasive, hard-to-control woody plants in the world. Introduced from Eurasia into the western United States in the early 1800s, this plant rapidly spreads along rivers, lakes and streams. Once established, it quickly out-competes desirable vegetation. Most important, saltcedar can utilize water from underground aquifers — up to 200 gallons per plant per day.

Control

The difficulty in control of this plant is its rapid resprouting after cutting and the buildup of salt in the soil under heavy plant densities. Systemic herbicides are one of the most effective methods to control infestations. Controlling saltcedar is not a one-time job; treated sites will still need to be checked for resprouts and seedlings after application, and follow-up treatments may be necessary in subsequent years for complete control. Once saltcedar is controlled, plants used in revegatation should include salt tolerant species to improve success of site restoration.

Saltcedar

A tank mix of Milestone® herbicide with Garlon® 4 Ultra/Remedy® Ultra or Garlon 3A specialty herbicides will control saltcedar without damage to monocot species (grasses). Additionally, the tank mix provides weed control to allow grasses to flourish. The desirable plants, left to grow and reproduce, become competitors with resprouts and seedlings of saltcedar decreasing the potential for re-invasion.

Foliar Treatments to Resprouting Plants after Mowing or Cutting:

After cutting, mowing or shredding operations, saltcedar will resprout. Allow time for the plants to regrow and develop adequate leaf area for a foliar application. This may mean the application will need to be done the year after cutting or, at least, in the late summer after mowing the previous winter or early spring. Apply Milestone at 7 fluid ounces per acre plus Garlon 4 Ultra/Remedy Ultra at 3 quarts per acre with non-ionic surfactant at 0.25% v/v or methylated seed oil (MSO) at 1 quart/acre. This treatment will also control broadleaf weeds such as Canada thistle, musk thistle, Russian knapweed, and many others that may invade the area after cutting (see label for complete list of weeds).

Saltcedar

Foliar Treatments to Individual Trees (less than 6 feet in height):

Treatments can be made to small plants or to plants less than 6 feet in height. It is important to calibrate your equipment to determine the amount applied per acre, even with a backpack sprayer or a hose and gun from a main tank. Typically about 100 gallons per acre (GPA) are sprayed when “spraying to wet” without any runoff from the leaves. Mix 7 fluid ounces (0.055% v/v) of Milestone and 3 quarts (0.75% v/v) of Garlon 4 Ultra/Remedy Ultra in 100 gallons of water with 1 quart (0.25% v/v) of a non-ionic surfactant.

Selective treatment with no grass injury

Non-selective treatment with grass injury

Saltcedar regrowth after mowing

Cut Stump Application:

Cut stump treatments can be used any time of the year as long as the herbicide does not freeze when applied, and the tree is not frozen. When using Garlon 3A, cut stumps should be treated immediately (less than 1 hour) after cutting. When using Garlon 4 Ultra/ Remedy Ultra, applications can be made up to two weeks after cutting but before resprouting begins. Thoroughly spray the outer 2 inches of the top of the stump. Apply mixture in a continuous ring between the bark and the wood of the stump. If the bark is torn away from the stump, be sure to treat down the side to form a continuous ring around the bark since the coverage and uptake is essential for root kill.

Recommended herbicide rates and mixing guide for cut stump applications

Product	Rate	Amount of Product for 1 Gal Mix	Amount of Product for 3 Gal Mix
Garlon® 3A	50% v/v in water	2 qts	6 qts
Garlon 4 Ultra/ Remedy Ultra	50% v/v in oil	2 qts	6 qts
All spray solutions are mixed in water or basal oil as indicated.			

Spray the sides of the stump including the root collar area, and the outer portion of the cut surface (the cambium) until thoroughly wet but not to the point of runoff or so that puddling occurs at the crown or root collar.

Basal bark applications:

These treatments can be applied any time of the year, including winter months, except when the bark is wet, frozen, or frost is present on stems. Applications are easier from late fall to early spring when there is little foliage to intercept the spray. Another advantage to treatment at this time of year is that many desirable plants are dormant, and selectivity can be improved. For best results, herbicide applications should be avoided during rapid saltcedar growth in the spring.

A mixture of Garlon 4 Ultra/Remedy Ultra in an oil carrier is very effective for both basal bark and cut stump applications. An oil carrier ensures good coverage and herbicide absorption through the bark. The recommended concentration of Garlon 4 Ultra/Remedy Ultra is 25-30% (see chart below for specific recommendations).

Recommended herbicide rates and mixing guide for basal or cut stump applications

Product	Rate	Amount of Product for 1 Gal Mix	Amount of Product for 3 Gal Mix
Garlon 4 Ultra/ Remedy Ultra	25% v/v	1 qt	3 qts
Garlon 4 Ultra/ Remedy Ultra	30% v/v	1.3 qts	4 qts
All spray solutions are mixed with oil. Use oil carriers such as basal oils, diesel, kerosene, methylated seed oils or other oils with use directions for basal and cut stump applications. Materials used need to be registered for use on the type of site where the saltcedar occurs.			

Be sure to adjust the sprayer nozzle to deliver a narrow, cone-shaped spray. Spray the herbicide mixture lightly but evenly (similar to using spray paint) on the plant's stem or trunk from ground level up to 12-15 inches. Apply the mixture to all sides of every stem, but not to the extent that runoff and puddling occurs at the crown or root collar. Saltcedar with old, rough bark may require each stem to be treated higher up the stem (15-18 inches) than plants with smooth bark (12-15 inches). Use on stems up to but not greater than 6 inches in diameter. Larger stem diameter trees may require retreatment. If the tree has been cut, use this treatment mix and spray the sides of the stump including the root collar area, and the outer portion of the cut surface (the cambium) until thoroughly wet but not to the point of runoff or so that puddling occurs at the crown or root collar. This treatment is effective up to two weeks after cutting but before resprouting.

Label precautions apply to forage treated with Milestone and to manure from animals that have consumed treated forage within the last three days. Consult the label for full details.

Some states require an individual be licensed if involved in the recommendation, handling or application of any pesticide. Contact your local Extension ffice for information regarding licensing requirements.

Always read and follow label directions.

V01-000-162 (10/10) DAS 010-50638

Appendix B

Biological Control of Invasive Range Weeds in Nevada

SP 97-03

Biological Control of Invasive Range Weeds in Nevada

Robert C. Wilson
Tim Stevenson
Jeff B. Knight

OUTLAW WEEDS!

Nevada Project WEEDS

University of Nevada, Reno
Cooperative Extension

SP 97-03

BIOLOGICAL CONTROL of INVASIVE RANGE WEEDS in NEVADA

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Pershing County

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University of Nevada, Reno
Cooperative Extension

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BIOLOGICAL CONTROL of INVASIVE RANGE WEEDS in NEVADA

INTRODUCTION

Noxious weed encroachment is a serious threat to the ecological balance of Nevada's rangeland resource. Exotic, invasive, noxious weeds are plants that have the ability to outcompete a complex of native range plants. This results in extensive monocultures of the introduced species gradually displacing the diverse plant and animal communities native to the Great Basin. Replaced are the various plant associations and communities that support a diversity of animal species especially adapted to the Great Basin environment. The native plant and animal associations are not easily restored once disturbed.

All of our invasive plant species were introduced from Europe or Asia. They became widespread in various areas of the western United States because their native range had a similar environment. Some examples of this include: squarrose knapweed, native to southeastern Europe and Central Asia; yellow starthistle, native to southern Eurasia and the Mediterranean Basin; and saltcedar, native to central and southwestern Asia. In each of these examples, the plant is not a problem in its home range because of the natural suppression and stresses not introduced to this country along with the plant.

There are several tools being used to fight the spread of exotic noxious weeds in the Great Basin. Chemical control has proved effective on some species but may not be economically or ecologically effective in every instance. Cultural practices may be used with some annuals but perennials are often spread or benefited by disturbance. Prevention is always the preferred method of control but unintentional spread of seeds or plant parts on vehicles and animal movements is inevitable. Finally, biological control is a tool that has great promise of controlling the spread and impact of noxious weeds to our native rangelands.

UNDERSTANDING BIOLOGICAL CONTROL

Biological control is the intentional introduction of agents that incrementally stress the target species. When the noxious weed is stressed, it is less competitive with native plant communities. It must be remembered that biological control is not a tool to be used without other control measures. When the invasive weed population has become economically or ecologically uncontrollable with simpler measures, biocontrol should be considered.

Noxious weed encroachment is a serious threat to the ecological balance of Nevada's rangeland resource.

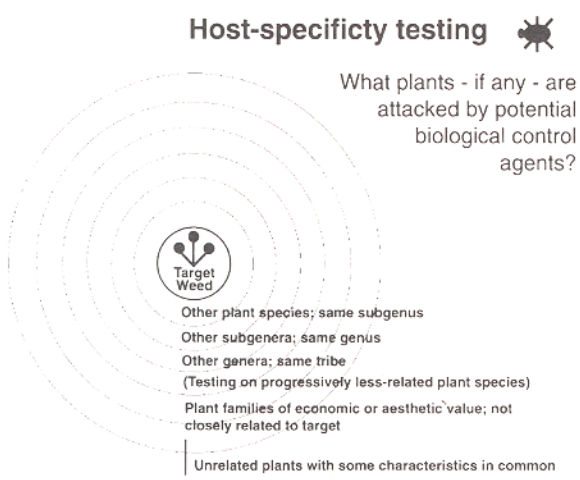
Large areas of weed species infestations are required for the biological agent to reproduce and survive. The target invasive plant species is never eradicated. Biological control agents leave a population of the invasive weed species where the control agent reproduces. Therefore, if eradication of the target species is the goal, biological control agents are not an appropriate tool. It is generally agreed by researchers that for

All of our invasive plant species were introduced from Europe or Asia.

most invasive plant species between seven and ten biological agents, each of which add stress to the target plant species, is necessary before sufficient stress is placed on a species so that it is no longer able to outcompete most other vegetation.

In the United States, the procedure for determining appropriate control agents is quite rigorous and expensive. Initially, public demand, or the well being of a particular industry, determines appropriate target weed species. At this point, other management tools have been deemed ineffective or uneconomical. Potential biological control agents are identified in the home ranges of the target weed. They undergo extensive testing overseas to determine their effectiveness at controlling the target species and to ascertain their potential for harm to an economically or environmentally important native species. These "starvation" tests prove that the potential biological control agent will starve to death rather than feed on plant species other than the target. Failure to pass this test eliminates the insect from importation into the United States. Figure 1 shows the process that must be undertaken before an exotic control agent can be introduced into this country.

Figure 1.



After passing "starvation" tests, the potential biological agent is imported into the United States for further testing. If the biological agent is an insect, usually the number imported is quite small. The agent must first be multiplied into sufficient numbers for experiments to be conducted.

Several crucial questions are then asked and tested. Will the insects react the same to the plant outside of its own environmental conditions? Will there be additional stress placed upon the target weed by the biological agent? Will the control agent reproduce or form important social structures in the new environment? How will the agent be dispersed? Will the agent populations survive predators in the new environment? In what specific environments is the biological agent effective? Only when these questions are answered positively, will the agent be released into the environment to fill its niche as part of the system.

The time it takes from the point of release until the agent is sufficiently established to impact the target species could take years, or even decades. There are many environmental factors that influence the action of a particular biological control agent. Also, frequently, more than one control agent is required to adequately stress widespread infestations of a particular plant species. For example, there are currently 14 control agents for spotted knapweed cleared for release now in the United States. Even

Establishment of biological agents takes a substantial period of time.

with that number of biological agents the range of encroachment by spotted knapweed is still increasing, but at a slower pace.

Biological control agents have numerous advantages and disadvantages when compared to other management methods. Once biological agents are in place, they are usually self-perpetuating in conjunction with the available food supply. Therefore, once established the long-term control cost is minimal. Biological agents have a searching ability to locate their hosts and it is unlikely that the target species will develop a resistance to the control agent. Control can be quite effective once biological agents place sufficient stress to limit the competitive vigor of the target organism. Finally, chemical use may not be permitted in many places. Biological control can be one of the tools used to control noxious weeds in environmentally sensitive areas.

Some disadvantages of using biological control include the need for a large infestation before the control agent can survive and reproduce. Also, since the invasive weed and its control agent have become part of the overall plant community, the target species will never be completely eradicated. The object is to reduce the density of the weed to some economic or biological threshold. A measure of control, between 0%-90%, can be expected according to the experiences of past biocontrol research around the country.

BIOLOGICAL CONTROL AGENTS

Table 1 is a list of invasive weed species that threaten Nevada, the biological agents which have been approved for release in the U.S., and those which have been introduced into Nevada by the spring of 1996:

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
musk thistle , nodding thistle (*Carduus nutans*) originated in southern Europe and western Asia	(*Cheilosia corydon*) thistle crown fly, A fly from Italy whose larvae feeds inside of the root crown	1990	1996 WP[1] Co.
	(*Rhinocyllus conicus*) thistle head weevil. A European weevil which feeds upon the seed heads	1969	1994 Wa Co. 1996 La Co.
	(*Psylliodes chalcomera*) Italian flea beetle feeds upon the growing tips of buds and stems	quarantine	
	(*Trichosirocalus horridus*) thistle crown weevil. An Italian weevil which feeds upon the rosette shoot tip	1974	
	(*Puccinia carduorum*) musk thistle rust. Turkish rust which reduces seed set	1987	
spotted knapweed (*Centaurea maculosa*) native of central Europe	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies. Two different European fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant	1973 and 1988	1995 WP Co. 1995 WP Co.
	(*Agapeta zoegana*) sulphur knapweed moth, a Yugoslavian moth that mines within the root.	1984	1995 WP Co.
	(*Cyphocleonis achates*) knapweed root weevil, larvae of an Asian weevil that feeds within the root crown	1988	1996 WP Co.
	(*Metzneria paucipunctella*) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed	1976	
	(*Bangasternus fausti*) broad-nosed seed head weevil. A		

[1] County abbreviations: WP – White Pine County, Wa - Washoe County, La – Lander County, El – Elko County, Hu – Humbolt County, Li – Lincoln County, Cl – Clark County, and Ly – Lyon County.

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	Greek weevil that feeds upon the seed head (*Chaetorellia acrolophi*) knapweed peacock fly, a European fly that feeds upon the seed head (*Larinus minutus*) lesser knapweed flower weevil and the blunt knapweed flower weevil (*L. obtusus*) Greek weevils that feeds upon the seed head (*Pelochrista medullana*) brown-winged root moth, a Romanian moth that feeds upon the root (*Pterolonche inspersa*) grey-winged root moth, a European moth that feeds upon the root (*Sphenoptera jogoslavica*) bronze knapweed root-borer, a Greek beetle that feeds within the root (*Terellia virens*) green clearwing fly, an Austrian teph fly that feeds within the seed head (*Aceria centaureae*) knapweed blister mite, a Greek blister mite which produces leaf galls (*Sclerotinia sclerotiorum*) a fungus on the crown of the plant	1990 1993 1992 1984 1986 1981 1993 not released native	
russian knapweed, Turkestan thistle (*Centaurea repens*) native to the southern Ukraine, southeast Ruyssian, Iran, Kazakhstan & Mongolia	(*Subanquina picridis*) Russian knapweed gall, a Turkish nematode that bores into the leaves and stems (*Alternaria* sp.) a fungus of the leaves and stem (*Puccinia acroptili*) a fungus of the leaves (*Sclerotinia sclerotiorum*) a fungus on the crown of the plant	1984 unknown unknown native	
squarrose knapweed (*Centaurea virgata* ssp *squarrosa*) native to central Asia and the Middle East	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies, Two different fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant. (*Pterolonche inspersa*) a European moth that feeds on the root (*Bangasternus fausti*) broad-nosed seed head weevil. A Greek weevil that feeds upon the seed head	1988 1990 1993	
diffuse knapweed, tumble knapweed (*Centaurea diffusa*) native from southern Europe to northcentral Ukraine.	(*Urophora affinis* and *U. quadrifasciata*) knapweed gall flies, Two different fly species which lay their eggs inside of the flower bud. The plant then forms a gall around the egg to isolate it from the plant. (*Aceria centaureau*) a mite that forces the plant to form galls on the leaves (*Agapeta zoegana*) sulphur knapweed moth, a Yugoslavian moth that mines within the root. (*Bangasternus fausti*) broad-nosed seed head weevil. A Greek weevil thatfeeds upon the seed head (*Subanquina picridis*) a Turkish nematode that bores into the leaves and stems (*Larinus minutus*) lesser knapweed flower weevil and the blunt knapweed flower weevil (*L. obtusus*) Greek seed head feeding weevils (*Metzneria paucipunctella*) spotted knapweed seed head moth, a yellow Swiss moth that feeds upon the seed (*Pelochrista medullana*) brown-winged root moth, a Romanian moth that feeds upon the root (*Pterolonche inspersa*) grey-winged root moth, a European moth that feeds upon the root (*Puccinia jaceae*) a fungus that works on the leaves of the plant (*Sclerotinia sclerotiorum*) a fungus on the crown of the	1973 and 1988 quarantine 1984 1990 1984 1992 1975 1984 1986 unknown	1993 Wa Co. 1993 Wa Co. 1993 Wa Co.

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	plant	native	
	(*Sphenoptera jogoslavica*) bronze knapweed root-borer, a Greek beetle that feeds within the root	1981	1995 Wa Co.
	(*Terellia virens*) green clearwing fly, an Austrian teph fly that feeds within the seed head	1993	
	(*Aceria centaureae*) knapweed blister mite, a Greek blister mite which produces leaf galls	not released	
	(*Chaetorellia acrolophi*) knapweed peacock fly, a European fly that feeds upon the seed head	1993	
yellow starthistle, St. Barnaby's thistle (*Centaurea solstitalis*) native of southern Europe	yellow starthistle bud weevil (*Bangasternus orientalis*) a Greek seed head feeding weevil	1985	None
	yellow starthistle peacock fly (*Chaetorellia australis*) a Greek seed head fly	1988	
	yellow starthistle hairy weevil (*Eustenopus villosus*)) a Greek weevil that feeds on early bud stages of the seed head	1990	
	yellow starthistle flower weevil (*Larinus curtus*)) a Greek seed head feeding weevil	1992	
	yellow starthistle gall fly (*Urophora sirunaseva*) a Greek fly which feeds in the developing seeds	1984	
	knapweed blister mite (*Aceria centaureae*) a Greek blister mite which produces leaf galls	not released	
rush skeletonweed (*Chondrilla juncea*)* Native of qestern Europe and north Africa	skeletonweed gall midge (*Cystiphora schmidti*) A Greek stem and leaf feeding gall midge	1975	
	skeletonweed gall mite (*Eriophyes chondrillae*) An Italian gall mite which feeds upon the axillary and terminal buds	1977	
	rush skeletonweed rust (*Puccinia chondrillina*) An Italian rust of the entire plant	1976	
leafy spurge (*Euphoria escula*) a native of western asia	minute spurge flea beetle (*Aphthona abdominalis*)	1993	
	brown dot leafy spurge flea beetle (*A. Cyparissiae*)	1987	1991 El Co.
	black leafy spurge flea beetle (*A. Czwalinae*)	1987	
	brown-legged leafy spurge flea beetle (*A. Lacertosa*)	1992	1994 Hu Co.
	copper leafy spurge flea beetle (*A. Flava*)	1993	
	black dot leafy spurge flea beetle (*A. Nigriscutis*)	1989	
	(*A. chinchihi*), (*A. venustula*), and (*A. seriata*) Different European or Asian flea beetles that feed upon the leaves and roots.	not released, not released & quarantine	
	(*Chamaesphecia crassicornis*), (*C. empiformis*, (*C. tenthrediniformis*), (*C. astatiformis*), and Hungarian clearwing moth (*C. hungarica*) Yugoslavian moths that feed upon the roots	quarantine, quarantine, unknown, 1975 & 1993 1991	
	(*Dasineura* sp. *nr. capsulae*) an Italian fly that feeds upon the shoot tips	1966	
	leafy spurge hawkmoth (*Hyles euphorbiae*) a European moth that feeds upon the leaves and flowers	1982	
	red-headed leafy spurge stem borer (*Oberea erythrocephala*) a European beetle that feeds upon the stems and roots	quarantine	
	(*Oxicesta geographica*) a Russian moth that feeds in the leaves and flowers	quarantine	
	(*Simyra dentinosa*) a moth that feeds in the leaves and flowers	1986	1994 El Co.
	leafy spurge tip gall midge (*Spurgia esulae*) an Italian fly that feeds upon the shoot tips	not released not released	

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
	(*Oncochila simples*) an Italian bug causes defoliation (*Pegomya curticornis*) an Austrian fly that forms galls which cause wilting and death of shoots (*Pegomya euphorbiae*) a Yugoslavian fly that burrows into the stems	not released	
sulfur cinquefoil (*Potentilla recta*) is from the Mediterranean region*	None	None	None
common crupina (*Crupina vulgaris*)* a Mediterranian plant	None	None	None
scotch thistle (*Onopordum acanthium*) a Mediterranian thistle	(*Trichosirocalus horridus*) weevil (*Larinus latus*) a seed head weevil (*Tephritis postica*) a seed head fly (*Lixus cardui*) a stem-boring weevil (*Tettigometra* sp.) planthoppers	1995 experimental experimental experimental experimental	None
houndstongue (*Cynoglossum officinale*)*	None	None	None
hoary cress/whitetop (*Cardaria* ssp.)	None	None	None
perennial pepperweed, tall whitetop (*Lepidium latifolium*)	None	None	None
St. Johnswort, goatweed (*Hypericum perforatum*) native to western Europe, north Africa, and southern Asia	klamath weed beetles (*Chrysolina hyperici* and *C. quadrigemina*) multicolored European beetles that feeds upon the leaves and flowers of the plant. St. Johnswort borer (*Agrilus hyperici*) a French beetle that feeds upon the roots St. Johnswort inchworm (*Aplocera plagiata*) a French moth that feeds on the roots and flowers klamath weed midge (*Zeuxidiplosis giardi*) a French fly whose larve feed on the leaves	1945 & 1946 1945 & 1946 1950 1989 1950	1955 Wa Co. 1955 Wa Co. 1965 Wa Co.
purple lythrum, purple loosestrife (*Lythrum salicaria*) Native of Europe and north Africa	golden loosestrife beetle (*Galerucella calmariensis* and *G. pusilla*) German beetles that feeds upon the flower buds loosestrife root weevil (*Hylobius transversovittatus*) a German weevil that live within the roots and feed upon the foliage blunt loosestrife seed weevil (*Nanophyes brevis*) and the loosestrife seed weevil (*N. marmoratus*) European weevils that reduces seed production	1992 & 1992 1992 quarantine & 1994	None
Eurasian watermilfoil (*Myriophyllum spicatum*)	weevil (*Euhychiopsis lecontei*) and (*E. albertanus*) Feed on stem and leaves. May be native to North America moth (*Acentria nivea*) reduces apical meristem development milfoil midge (*Cricotopus myriophilli*) caddisfly (*Triaenodes tarda*) cuts leaflets weevil (*Phytobius leucogaster*) European moth (*Parapoynx stratiotata*)	1927? unknown	None
medusahead rye (*Taeniatherum caput-medusae*)	None	None	None
dalmation toadflax (*Linaria genistifolia* ssp. *dalmatica*) native of the Mediterranian	toadflax moth (*Calophasia lunula*) a European defoliating moth stem boring weevil (*Mecinus janthinus*) a Yugoslavian	1968 pending	1978 Li Co.

* No documented infestions of this plant species within Nevada, but potentially a problem plant species.

Table 1. List of invasive weed species threatening Nevada and available potential biological control agents.

Target Plant Species	Potential Biological Control agents	Year introduced into the U.S.	Year introduced into Nevada by County
region	weevil root-boring moth (*Eteobalea intermediella*) a Mediterranean root boring moth toadflax flower-feeding beetle (*Brachypterolus pulicarius*) a European ovary feeding beetle root-galling weevil (*Gymnetron linariae*) German weevil	pending 1919 not released	
yellow toadflax (*Linaria vulgaris*) native to Eurasia	toadflax flower-feeding beetle (*Brachypterolus pulicarius*) a European ovary feeding beetle toadflax capsule weevil (*Gymnaetron antirrhini*) and (*G. netum*) Eurasian seed capsule feeding weevils toadflax moth (*Calophasia lunula*) a European defoliating moth root-boring moth (*Eteobalea serratella*) Yugoslavian root-boring moth root-galling weevil (*Gymnetron linariae*) German weevil	1919 1909 1968 not released not released	None
saltcedar, tamarisk (*Tamarix ramosissima*) a native of Chine and eastern Asia	(*Diorhabda elongata*)	1996	1996
downey brome (*Bromus tectorum*), a native of Eurasia	None	None	None

There are additional biological agents that have been released in Nevada on weed pests which are not considered "invasive" (capable of dominating plant biodiversity) in the Great Basin. Table 2 lists those weed pests and the biological agents that have been released on them.

Table 2. Other weed species of interest and some available potential biological control agents

Target Plant Species	Potential Biological Control Agents	Year introduced into the U.S.	Year introduced into Nevada
puncturevine (*Tribulus terrestris*) introduced from Eurasia or African	puncturevine seed weevil (*Microlarinus lareynii*) an Italian weevil which feeds upon developing seeds puncturevine stem weevil (Microlarinus lypriformis) an Italian weevil which mines the stems and roots	1961 1961	1961 Cl Co. 1963 Li Co.
poison hemlock (*Conium maculatum*) a Eurasian and African plant	defoliating hemlock moth (*Agonopterix alstroemeriana*) a European moth that feeds all over the plant	1973	unknown
Russian thistle (*Salsola kali*)	(*Coliaphora* sp.) the larvae feed on the plant		1970 Wa & Ly Co.
Canada thistle (*Cirsium arvense*) a native of Europe, Asia and Africa	Canada thistle stem weevil (*Ceutorhynchus litura*) a German weevil Canada thistle bud weevil (*Larinus planus*) a European weevil thistle stem gall fly (*Urophora cardui*) a central European fly	1972 unknown 1977	1977 El Co.

Biological control is an evolving science. In order for it to be a useful tool in the effort to control invasive plant species additional knowledge is needed of the target plant and biological agents within Nevada. Because the Great Basin environment is frequently quite different than the environment of much of the surrounding states, frequently both the target plant and the biological agents react differently in those states environments.

To help make biological control efforts more effective within Nevada, there are a few things that still need understood. Scientists, state regulatory agencies, biological professionals, land management agencies, and the general public need to understand the opportunities and limitations of biological weed control projects. Other control efforts need strengthening in order to minimize the need for eventual movement to biological control as a last resort. A scientific method of selecting the best potential biological agents for the Great Basin needs to be developed. Research dollars need to be committed for development of biological agents on target plant pests peculiar to Nevada. Again, Nevada's high desert environment is different so systems used in other states may not work in our Great Basin. In addition, a system of release tracking, rearing, monitoring, redistribution, and effectiveness has started with the Division of Agriculture, but needs strengthening, within this state.

By implementing these steps, biological control agents can be an effective additional tool in the effort to keep invasive plant species from dominating the rangeland landscapes of Nevada.

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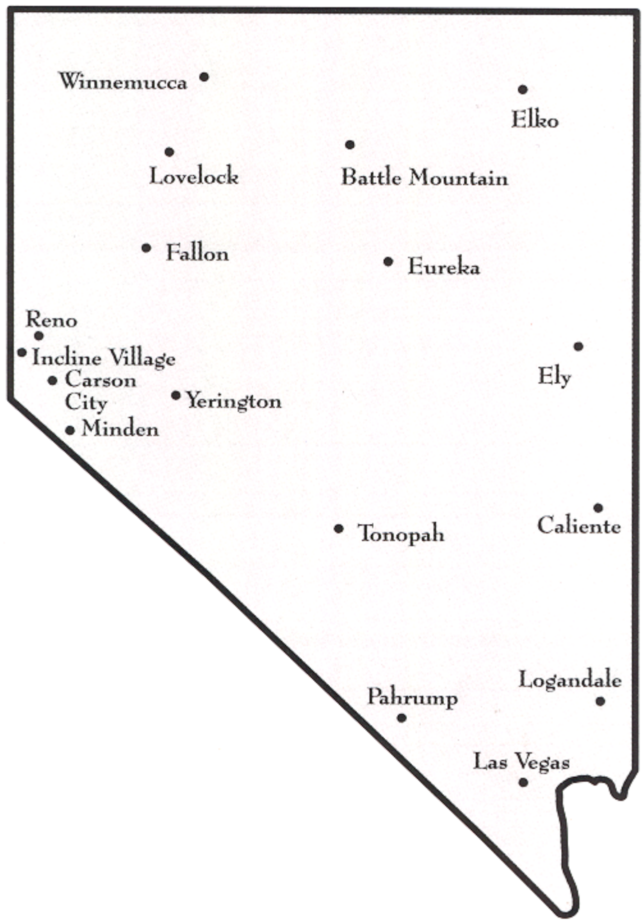

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