RIGHT - OF - WAY PEST MANAGEMENT

Study Guide for Pesticide Application and Safety
Category 6

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Division of Plant Industry
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STUDY GUIDE FOR
RIGHT - OF - WAY PEST MANAGEMENT

Weed Control and Vegetative Management

The educational material in this study guide is provided to assist pesticide applicators in preparing for the Right-of-Way category examination. This guide does not include all of the information needed for the examination. Other topics that are covered on the examination include understanding and following pesticide label directions, emergency response, personal protective equipment (PPE), pesticide movement, mixing and handling pesticides, and additional application methods and equipment. Information on these and other topics can be found in the ***National Pesticide Applicator Certification Core Manual,*** published by the National Association of State Departments of Agriculture Research Foundation.

This book can be obtained from the Utah Department of Agriculture and Food (UDAF). Please contact your local UDAF Compliance Specialist or the state office in Salt Lake City. The UDAF telephone number is 1.801.538.7185 and the web site for the UDAF Division of Plant Industry is <http://ag.utah.gov/divisions/plant/pesticide/applicators.html>.

The organizations involved in the preparation of this study guide were the Utah Department of Transportation, the Utah Department of Agriculture and Food, and Utah State University Extension. This study guide was originally revised by the Utah Department of Transportation and then further revised and reformatted by Utah State University Extension personnel. Other contributors include the U.S. Department of Agriculture and the U.S. Environmental Protection Agency, Region VIII.

The material and recommendations presented in this study guide are based on information believed to be correct. No endorsement, guarantee, or warranty of any kind, expressed or implied is made with respect to the information contained herein. When working with pesticides, follow the directions provided on the product label.

INTEGRATED VEGETATION MANAGEMENT

FOR RIGHT – OF - WAYS

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I. INTRODUCTION

STUDY GUIDE

The right-of-way pesticide study guide provides basic information that applicators of pesticides need to meet the minimum federal and state standards for certification, recertification, and licensing. The standards are set by the U.S. Environmental Protection Agency (EPA) and the Utah Department of Agriculture and Food (UDAF) in line with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended and the Utah Pesticide Control Act.

Pesticide handlers who are licensed in the right-of-way category work for road transportation departments, utility companies, railroads, and pipelines. Maintaining vegetations in these right-of-ways is of crucial importance and involves controlling weeds, erosion, and overall growth for safety reasons.

Right-of-ways provide many important benefits including the transportation of people and products and the distribution of electrical power for homes and businesses. Unfortunately, right-of-ways also provide routes by which invasive plant species are introduced and established.
Construction of road and utility right-of-ways often requires the removal of vegetation. The bare ground that results is a good place for noxious weeds to flourish. Noxious and problem weeds impact food, recreation, wildlife, and water quality. Weeds cost the nation billions of dollars each year and right-of-way managers play a vital role in preventing and controlling noxious weeds.

PEST PERSPECTIVE

Humans depend on living things to provide the essentials for survival. Destructive pests make the efficient production of these necessities very difficult. Other pest organisms constitute a threat to the health and comfort of people. Such pests must be managed to protect desirable plants and animals.

Plants or animals may be identified as a pest if they appear in unwanted places or their numbers are too great. For example, a weed is a plant growing where it is not wanted. In this context, a corn plant in a lawn is a weed and a rose in a cornfield is a weed. Some animals have been domesticated and provide humans with food and fiber. Other animals provide recreation through human interaction, but if these animals are destructive or carry diseases then they are pests.

There are beneficial birds that eat destructive insects and many provide aesthetic enjoyment. Other birds, because of their population numbers and/or excessive noise, are regarded as public

nuisances. Some insects destroy crops or transmit diseases, while others pollinate plants or serve as parasites or predators of undesirable insects. In general, those plants or animals that conflict with the immediate or long term needs and desires of humans are regarded as pests.

PESTICIDES AND THE ENVIRONMENT

Chemical pesticides are commonly used to control pests. The goal of a pesticide application is to effectively manage the pest without threatening the safety of humans and the environment. Instances of inappropriate use or over application have resulted in the banning or limited availability of some pesticides. In some instances past mistakes have resulted in the development of better pesticides that are safer to use.

Using pesticides often means the difference between profit and loss. The use of pesticides has become almost indispensable to modern agriculture and to the consumers of agricultural products. Agricultural producers depend on pesticides for large scale production and consumers depend on these products being readily availability in the market.

There is no indication that pesticides will be eliminated and they continue to be the most effective defense against pests. It is important that researchers continue to investigate the effects of pesticides on humans and the environment. There are numerous well funded groups concerned about environmental protection that will continue to publicly resist the use and misuse of pesticides.

Where safety concerns occur relative to the use of a pesticide, the advantages must outweigh the disadvantages for a pesticide's continued use. Such decisions require objective evaluation. At present, the safest way to use a pesticide is to assure that applicators and handlers carefully adhere to label instructions and apply pesticides only when appropriate.

Concern about the environment has added considerable stimulus to the development of pest management techniques that reduce the need for pesticides. The challenge is to accomplish pesticide use reduction without lowering yields or quality. This goal has been accomplished in a few instances and there is reason to believe that further progress will be made.

Both the beneficial and harmful effects of pesticides are determined by how pesticides and the environment react to each other. To be effective a pesticide must normally penetrate the pest, move or be transported to the site of action, and there disrupt or alter a vital function of the pest. The manner in which the pesticide affects the vital function is called its mode of action. Penetration, transport, and mode of action involve interactions between the pesticide and the pest.

Interactions are also involved in the metabolism, accumulation, and elimination of pesticides by the pest, as well as in the biodegradation and biological magnification of pesticides. In addition, the ability of pesticides to kill or otherwise alter one pest, while not affecting another, and/or the pest's ability to develop a resistance to pesticides are dependent on differences in the interaction between pesticides and pests.

D*ichloro-****d****iphenyl-****t****richloroethane* or DDT as it is better known is one example of how pesticide perceptions have changed throughout the history of their use. DDT and other persistent chlorinated hydrocarbons formed the basis for much of today's public awareness and the legislative action that controls current pesticide use.

DDT was the most well known organic insecticide and most widely used chemical for the control of mosquitoes responsible for malaria, typhus, and other insect borne diseases. Today it is banned from use in the US. It is still manufactured and continues to be used to battle mosquitoes in other parts of the world.

Rachel Carson published the book *Silent Spring* in 1962. In her writings it was alleged that DDT harmed bird reproduction by thinning egg shells and caused cancer in humans. *Silent Spring* caused a huge public outcry which eventually resulted in DDT being banned for use in the US.

This was one of the most important events that led to the environmental movement.

DDT was subsequently banned from agricultural use in many countries by the 1970s. DDT, perhaps, more than any other pesticide in history, is responsible for saving hundreds of thousands of lives, but is perceived to be too hazardous for use in the environment. The controversy surrounding DDT continues as tissue analysis has found this pesticide to be present in humans from all parts of the world.

PESTICIDE MONITORING

Pesticides are monitored in the environment by the EPA, FDA, and USDA. The monitoring program includes fish, shellfish, wildlife, water, soil, food, and humans. In addition to the federal program, considerable monitoring is also done by state agencies, scientists from universities, and the chemical industry.

Extensive monitoring indicates that only a limited number of pesticides are generally found in environmental samples such as soil, water, air, and wildlife. However, articles written about pesticides in the environment often generalize about their occurrence, giving the false impression that all pesticides are involved.

Careful reading of these articles will usually reveal that they are based on studies involving DDT or another of the more persistent chlorinated hydrocarbon insecticides. The only samples that commonly contain pesticides are food crops that have been treated with these materials. These generally occur at levels below tolerance limits set by EPA. Pesticide monitoring studies must be interpreted carefully, especially when dealing with amounts in parts per billion or parts per trillion.

The use of gas liquid chromatography and mass spectrometry has made possible the detection of extremely small amounts of some chemicals. However, identification of these chemicals is by no means certain unless confirmatory techniques are employed. This may be very hard and perhaps impossible at such low levels unless large samples are used. Also, at these levels it may not be possible to rule out accidental contamination of the sample, either at the time of collection, during storage, or in the analytical process.

The importance of confirming the identity of pesticides was illustrated recently when two chlorinated hydrocarbon insecticides, dieldrin and heptachlor, were apparently discovered in soil that had been collected and sealed in jars between 1909 and 1911, long before these chemicals had even been synthesized. Efforts to confirm the identity of these chemicals proved they were not pesticides but apparently naturally occurring constituents of the soil.

There is also evidence that polychlorinated biphenyls (PCBs) have been erroneously reported as DDT in environmental samples. Apparently PCBs, which were used in a variety of products ranging from plastics to industrial coolants, are widespread in the environment and can easily be mistaken for DDT if proper analytical procedures are not followed.

PESTICIDES IN WATER

Pesticides may enter water in several ways, including fallout from the atmosphere, drift from nearby applications, and movement from treated land by means of soil particles or runoff water. They may also be applied directly to water, either purposely or accidentally. Although quantitative information on the importance of these sources of contamination is limited, it seems likely that treated soil is the principal factor involved.

Most pesticides found in the environment are often bound tightly to soil particles or organic matter in the soil and are not readily soluble in water. These particles can move long distances by wind and water, so it is not surprising that pesticides are sometimes found far removed from the site of application. Although agricultural lands contribute to pesticide contamination of water, some of this pollution originates from urban areas where pesticides are used in the home and garden.

Some of the contamination of the Great Lakes with DDT has been traced to city sewers. Pesticide contamination in the Red Cedar River in Michigan is reported to come mostly from waste water treatment plants, even though the

river runs through areas of extensive agricultural development.

The pesticides most often found in water were some of the chlorinated hydrocarbon insecticides including dieldrin, endrin, heptachlor, lindane, BHC, and chlordane. Herbicides such as atrazine, alachlor, prometon, and simazine are now the most common pesticides found in water.

PESTICIDES IN SOIL

Soils are important in determining what happens to a pesticide after application. Even though some pesticide volatilizes before reaching the soil or is intercepted by plants, a large portion eventually reaches the soil. As previously discussed, soil can serve as a reservoir from which pesticides may move to other areas by water or wind erosion.

Pesticides may also escape by evaporation from the soil surface into the atmosphere. Soil organisms may serve to transport pesticides from one area to another, usually because they serve as a food source for animals or birds.

The fact that soils and organisms in soils are largely responsible for the breakdown or inactivation of pesticides is of great importance. This neutralization of pesticides varies with soil type and climate and is in part the determining factor as to whether a particular pesticide should be used in a given area. Aside from purely environmental concerns, if a pesticide persists too long in soil, it may also damage future crops.

Most pesticides do not move readily in soil because they are bound to soil particles, especially clay and organic matter. Consequently, they are usually found in the top few inches of soil. In rare instances some have been found at depths of several feet.

PESTICIDES IN WILDLIFE

It is not surprising to learn that pesticides found in wildlife are generally the same ones found in soil and water. Wildlife consume the food derived directly or indirectly from soil and water. In some instances, pesticides will accumulate in wildlife at concentrations ranging up to thousands of times more than in soil and water. This process is biomagnification and is known to occur with persistent chemicals that are readily soluble in fat. One of the best examples is DDT.

Dieldrin and heptachlor have also been implicated in biomagnification as have some other chlorinated hydrocarbon insecticides. Some of the highest residues of the chlorinated hydrocarbon insecticides have been found in birds of prey such as hawks and eagles. Fish eating birds are especially likely to contain residues of these insecticides. As might be expected, the insecticides most commonly found are DDT and dieldrin. These chemicals have been associated with lowered reproduction in several species of these birds. In fact, this is the principal reason that the use of DDT and dieldrin were severely restricted in the United States and other countries of the world.

The presence of pesticides in seed eating birds is generally much less than in birds of prey, and to date, there is little reason to believe there has been any effect on their reproduction. Seed eating birds have been killed by direct application of pesticides and by eating food contaminated with pesticides. This is not a general occurrence and, so far as is known, has not caused population declines that would threaten the existence of a species of seed eating bird.

PESTICIDES IN FOOD

Pesticides in food are monitored and controlled by three federal agencies, the EPA, FDA, and USDA. State agencies are also involved in these activities.

EPA has the responsibility of establishing tolerances for pesticides in food. FDA monitors pesticides in foods that are prepared for the table. This is commonly referred to as a "market-basket" or "total-diet" studies.

FDA determines the amount of pesticides in foods shipped in interstate commerce. It has authority to seize shipments that contain pesticide residues above tolerance levels and to initiate legal proceedings against the shipper.

FDA examines foods for contaminants other than pesticides, including such things as rodent hair, fecal pellets, and insect parts. Tolerances are

established for these contaminants in food as well as pesticides. While consumers might be surprised to learn that a certain number of fecal pellets or insect legs are permitted in foods, perhaps they can take some comfort in knowing that current standards are much stricter than they were 20 or 30 years ago.

Pesticides have been largely responsible for these strict standards, and ironically, these standards are now a serious obstacle to the reduction of pesticide usage in certain situations. To the farmer, the use of pesticides may mean much more than simply increasing yield. If the quality of his crop is lowered by pest damage, he may not be able to market it at any price.

Every year, FDA determines the amount of pesticide chemicals in processed and raw agricultural products that are shipped interstate. This is a surveillance and regulatory program designed for the enforcement of tolerances set by EPA. Samples are collected throughout the year at producing, shipping, and destination points.

ENVIRONMENTAL CONCERNS

As we learn more about the behavior of pesticides in the environment, we find it necessary to devise more sensitive and discerning techniques to determine what their total impact will be. Invariably, man's innovations begin without a complete understanding of their consequences, such as the development of cars, airplanes, and the atomic bomb. Pesticides are no exception. The best we can do is to use all available knowledge, make allowances for unknown factors, and carefully estimate benefits and risks.

We will probably never be able to prove that any pesticide can be used without risk; proving a negative is generally impossible. But past experience and current EPA testing requirements give considerable assurance that risks will be minimal. During the past ten years, the time required to meet federal testing requirements has nearly doubled. There has also been a notable reduction in the appearance of new pesticides on the market and increased emphasis on finding ways to reduce the need for these chemicals.

The concern about the effects of pesticides on the environment is an extremely controversial issue debated by scientists, politicians, and the general public. One of the main reasons for this is that it’s very hard to prove that a chemical is or isn't harmful, especially when it is present in small amounts and its effects cannot be clearly demonstrated outside the laboratory.

INTERGRATED VEGETATION MANAGEMENT

In the early years of managing right-of-ways, most vegetation was controlled by mechanical means. Changing technology and the development of herbicides and biological controls offered additional methods for vegetative management. As the knowledge and understanding of pest management advanced the strategies of utilizing several methods of pest control at the right time to target specific pests became known as integrated pest management (IPM). As a specific component of IPM the phrase integrated vegetation management (IVM) was adopted.

There are many reasons to develop and implement an IVM program in the management of right-of-ways. Some of these reasons include:

Legal
State and federal laws require control of noxious weeds to help protect public and private lands from degrading impacts.

Quality
Improving vegetation programs reduce costs and the use of pesticides at the same time that it controls noxious and problem vegetation.

Cooperation
Working with other land managers improves weed control on public and private land.

Public Acceptance
When the public is educated about vegetation programs, the number of complaints and lawsuits usually is reduced.

Safety
Reducing and eliminating problem vegetation improves sight distance and maintains clear zones so roadside objects are visible to drivers.

Economics
IVM increases productivity and effectiveness and in turn reduces short and long term maintenance costs.

Efficiency
IVM contributes to the efficient use of equipment, personnel, and materials through the scheduling and priorities.

IVM programs strive to integrate chemical, biological, mechanical, and cultural weed control methods for optimum vegetation management.

PESTICIDES AND PESTS

Pesticides include a variety of chemical products designed for the management of pests. The term pesticide refers to products such as herbicides and insecticides that are used to kill or control harmful organisms such as weeds or insects. The following list includes numerous types pesticides and the pests they control.

Acaricide: mites and ticks
Adulticide: adult pests
Algicide: algae
Aphicide: aphids
Attractant: insects and vertebrates
Avicide: birds
Bactericide: bacteria
Defoliant: foliage removal
Desiccant: water removal from plant foliage
Disinfectant: microorganisms
Fumigant: insects, rodents, and weeds
Fungicide: fungi and other plant pathogens
Germicide: germs
Growth regulator: insects and plants
Herbicide: weeds
Hormone: insects and plants
Insecticide: insects
Larvicide: larval pests
Miticide: mites
Molluscicide: snails and slugs
Nematicide: nematodes
Ovicide: eggs
Pediculicide: lice
Pheromone: insects
Piscicide: fish
Predacide: predators
Repellent: insects and vertebrates
Rodenticide: rodents
Sanitizer: microorganisms
Silvicide: trees and woody vegetation
Slimicide: slime molds
Sterilant: microorganisms
Wood preservative: fungi and insects

PRECAUTIONARY STATEMENT

Pesticides offer both benefits and risks. Benefits can be maximized and risks minimized by reading and following the labeling. Pay close attention to the directions for use and the precautionary statements. The information on pesticide labels contains both instructions and limitations. Pesticide labels are legal documents and it is a violation of both federal and state laws to use a pesticide inconsistent with its labeling. The pesticide applicator is legally responsible for proper use. Read and follow the label instructions.

II. PLANT AND SOIL TYPES

PLANT TYPES BY LIFE CYCLE

The key to effective herbicide applications is applying the right herbicide to the properly identified target plant at the right time. Therefore an understanding of the life cycle of plants is critically important. The following are categories of plant life cycles.

ANNUALS
Annuals are plants that complete their life cycle in one growing season. The seed from an annual plant germinates, grows into a mature plant, and produces seeds in one growing season. Summer annuals and winter annuals are the two basic types of annuals.

Summer annuals germinate in the spring and complete their life by summer or fall. With winter annuals, the seed germinates in the fall and over winters as a seedling, then grows to maturity and produces seeds the next spring or summer. Russian thistle and puncture vine are examples of summer annuals. Cheatgrass and cereal rye are examples of winter annuals.

BIENNIALS
Biennials are plants that take two years, or two growing seasons, to complete their life cycle. In the first year, a biennial germinates, grows and stores food reserves without flowering or producing seeds. The second year, or second growing season, is when the plant develops mature flowers and produces seeds. Musk thistle and hounds tongue are examples of weedy biennials.

PERENNIALS
Perennials are plants that live from year to year. Some are short lived, while others can live for a very long time. Perennials die back to the ground each winter, but grow from the same roots the following year. Weedy perennial species generally have large underground root systems for storing food reserves. This is one of the reasons it is difficult to control perennial species. Examples of weedy species that are perennials are field bindweed, leafy spurge, and Russian knapweed.

Understanding the life cycle of a plant plays an important role when applying herbicides. The highest level of control for most annuals and many biennials is obtained when they are in the young seedling and rosette stages. For most perennial species the prebloom to bloom stage is the time when the plant is vulnerable to herbicides because this is the period when perennials are putting most of their energy into seed production.

PLANT TYPES BY FORM

There are many types of plants that grow on right-of-ways. Grasses, broadleaf's, shrubs and trees are some of the most common ones. It is important to properly identify the plant and employ the appropriate management strategy. The following are some of the common plant forms found on right-of-ways.

GRASSES
Grasses are the most common plant species found on right-of-ways. Grasses are classified as monocots, which are plants that have one seed

leaf at germination. Grasses are an important plant for right-of-way erosion control. Knowing that the problem plant is a grass is critical in selecting the appropriate herbicide for control. There are many species of grasses and most are very useful, but there are several species that are weeds. Two grasses that present special control problems are cheatgrass and medusahead rye.

BROADLEAFS

Broadleaf plants are generally dicots. These are plants that have two seed leaves at the time the seed germinates. Broadleaf plants make up a large part of the plants known as weeds. They also encompass many of the plants known as wildflowers. Right-of-way managers must know the difference between which species are weeds and which are not. Many weed species have very showy flowers. Dalmatian toadflax and purple loosestrife have attractive flowers, but they are a very invasive weed species.

Shrubs

Shrubs are woody plants with multiple stems and grow to a height of less than ten feet. There are many shrub species found on right-of-ways. Most shrub species are not considered weeds. Some of the common shrub species found on right-of-ways in the western states are sagebrush and rabbitbrush. Generally shrubs cause few problems, but they must be controlled if they block sight distance on roads, hide animals along thoroughfares, or cause snow drifting problems on roads. Knowing the shrub species and its growing habits is very beneficial when implementing a control method or selecting a herbicide.

TREES

Trees are plants that generally grow from a single trunk and are more than ten feet in height. There are many tree species found on right-of-ways and there are many reasons to control tree growth. Russian olives and Siberian elms are very invasive trees that can overtake and crowd out all other plants. Trees block sight distance on roads, grow into power lines, block signs, plug up drainages, and can also be a hazard to people and property. Although trees are one of the most loved plant species, they are also one of the biggest problems.

SOIL TYPES

An understanding of soil types and their interaction with herbicides is necessary for effective vegetation management. Some soil types will decrease or increase herbicide effectiveness. Soil types can influence how much herbicide must be used and how long it will last. Soil can affect the way that plant roots absorb the herbicide and how it moves through the soil.

The classification of soils is a complex operation that can be difficult to correctly categorize. To predict herbicide interactions several soil characteristics are typically necessary. One of the most important soil characteristics is soil texture. The three basic textures that soil can have are sand, silt, and/or clay. The textural names given to soils are based on the amount of each of the three soil parts. Soils highest in the percent of sand are sandy soils. Soils highest in the percent of silt are silts and those with the highest in clay are clay. Soil type identification depends on properly determining the size of the individual soil particles. Sand ranges in size from 2 to 0.05 mm. Silt range in size from 0.05 to 0.002 mm. Clay is less than 0.002 mm in size.

Classification of Soil Texture by Feel

- Sand, loamy sand: Feels gritty, but does not ribbon or smear on the hand.
- Sandy loam: Feels gritty and leaves a smear on the hand, but does not ribbon.
- Silt loam: Feels smooth and flour like, but does not ribbon.
- Sandy clay loam: Feels gritty and forms a ribbon that breaks into pieces.
- Sandy clay: Feels gritty and forms long pliable ribbons.

Soil Structure

Soil structure depends on how the various particles are grouped together into a stable collection by organic substances. There are several soil structure types such as granular, blocky, and platy. Soil structure directly influences the amount of water in the soil. Soil structure influences how much water the soil will hold and how fast water will move through the soil. In the case of soils that are mostly clay,

water does not infiltrate the soil at all. In contrast, water moves through sandy soils at a very fast rate. Soil structure affects how quickly a herbicide will move through the soil and can influence how much herbicide is necessary for an effective and safe application.

Organic Soil

Humus is the organic matter found in soil. It is usually not used in the classification of soil type. When organic matter is found in high levels in a soil it can dominate the soil properties. Soils can be classified as organic soils if they meet the following criteria.

1. The mineral content of the soil has no clay and the organic content is 20% or more.
2. The mineral content of the soil is between 0 and 50% clay and the organic content is between 20% and 30%.
3. The mineral content of the soil is 50% or more clay and the organic content is 30% or more.

Organic matter in the soil can hold water and herbicides very tight because of the amount of negative and positive charged ions. This can be good as the herbicide will be held in the soil and will not continue to move downward into the soil profile. When some herbicides, such as diuron, bind with the soil they will not move through the soil at all. Soil type, structure, and makeup impacts the effectiveness of herbicide applications. A right-of-way manager should have a working knowledge of the soil underlying and adjacent to right-of-ways.

III. WEED IDENTIFICATION AND CONTROL

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WEED PROBLEMS

A weed is a plant that is out of place or one that interferes with the management objectives of the area. Weeds are normally not valued by humans. They can be injurious to crops and are often considered to be unsightly. The unwanted vegetation growing on Utah's right-of-ways are generally classified nuisance weeds or noxious weeds.

Nuisance weeds include a variety of unwanted vegetation that is controlled depending on the purpose of the right-of-way. Noxious weeds are those plants that under state and/or federal law must be controlled or eradicated. Noxious weeds are plant species that cause a severe impact to agricultural crops or the natural environment. These types of weeds are often referred to as invasive species. Noxious weeds aggressively invade and take over croplands

and public lands such as forest service lands. These invasive plants also crowd out native plants that are used by wildlife.

Over time some noxious species will form dense monocultures that have little or no value to people or wildlife. Many species of noxious weeds increase the risk of fires. The impact to the nation from noxious weeds is estimated to be in the billions of dollars annually.

Nuisance weeds are plant species that cause problems in croplands or on right-of-ways. These plants create safety problems on right-of-ways and increase production costs on agricultural lands because they require herbicide applications and/or other control methods. Nuisance weeds have no legal requirement for control or eradication.

The Utah Department of Agriculture and Food (UDAF) officially designates and publishes a list of noxious weeds for the state of Utah, as per the authority vested in the Commissioner of Agriculture under Section 4-17-3 of the Utah Noxious Weed Act. UDAF maintains a list at: http://ag.utah.gov/plantind/nox_utah.html

LIST OF UTAH NOXIOUS WEEDS

Bermudagrass (c*ynodon dactylon variety dactylon*) Bermudagrass is not a noxious weed in Washington County of Utah and is not subject to provisions of the Utah Noxious Weed Act in that county.
Canada thistle (c*irsium arvense*)
Diffuse knapweed (c*entaurea diffusa*)
Dyer's woad *(isatis tinctoria L.)*
Field bindweed [Wild Morning Glory] *(Convolvulus arvensis)*
Hoary cress [White top] *(Cardaria drabe)*
Johnsongrass (see perennial sorghum below)
Leafy spurge (e*uphorbia esula*)
Medusahead (t*aeniatherum caput-medusae*)
Musk thistle (c*arduus nutans*)
Perennial pepperweed *(lepidium latifolium)*
Perennial sorghum [Johnsongrass] (s*orghum halepense L.* and s*orghum almum*) species plural, not limited to Johnsongrass
Purple loosestrife *(lythrum salicaria L.)*
Quackgrass *(agropyron repens)*
Russian knapweed *(centaurea repens)*
Scotch thistle [Cotton thistle] *(onopordum acanthium*)
Spotted knapweed (c*entaurea maculosa*)
Squarrose knapweed (c*entaurea squarrosa*)
Yellow starthistle (*centaurea solsitialis*)

A complete list of noxious weeds, noxious weed seeds, and restricted weed seeds are listed in Appendix 1 of this manual.

IDENTIFICATION AND CONTROL OF NOXIOUS WEEDS

The Utah Department of Transportation provided the following color pictures of noxious weeds commonly found on right–of-ways. A complete listing of such plants in various stages of growth and development can be found in texts such as the Weeds of the West and on numerous web sites that depict the stages of growth, and size with both foliage and flowering colors.

The black and white version of this publication does not adequately display the plant colors and details necessary for identification. The Internet version of this manual is available on line at: http://ag.utah.gov/plantind/sg_rightofway.pdf Please access the Internet version of this manual for color pictures of common noxious weeds found on Utah right-of-ways.

The proper identification of any pest is critical for the implementation of a successful pest management program. The size and location of Utah's many right-of-ways, combined with a thorough understanding of the diverse vegetation and soil types present, are necessary components of a management plan. The scheduling and budgeting of equipment, materials, and labor must also be considered in a successful management plan for right-of-ways.

The following noxious weeds are introduced and discussed in the same order as the list that appears above. A picture of the plant is provided, followed by a brief description. Herbicide recommendations and mechanical

control methods are discussed. Biological control measures for weeds are discussed at the end of this chapter.

BERMUDAGRASS

Bermudagrass is a perennial in the Poaceae or grass family. It has creeping rhizomes and usually it is easy to recognize because of its spike like branches, although, it can be confused with crabgrass. Crabgrass is an annual grass that looks much the same in general appearance. Bermudagrass is believed to have been introduced from Africa and it is a serious problem to agriculture. It has a low growing profile that results in few problems in right-of-ways; however, it will quickly spread to other lands and should be controlled to prevent that problem. Bermudagrass is classified as a noxious weed in all counties of Utah except Washington County.

Bermudagrass

Bermudagrass Control Methods

There are several herbicides that are good at controlling Bermudagrass. Unfortunately, most of the effective herbicides are nonselective and will harm other vegetation. Imazapyr works well in controlling Bermudagrass. Glyphosate, which now has many trade names, provides some control on Bermudagrass, but multiple treatments are required. Read and follow the label directions when handling and applying pesticides.

Bermudagrass has stolons and rhizomes that can root at the nodes. This makes mechanical control methods such as disking and harrowing of little to no effect and usually spreads the plant to new areas.

CANADA THISTLE

Canada thistle is a member of the sunflower family. It is a perennial plant that is usually less than three feet tall. It has purple flowers and starts blooming in July. Leaves and flower heads are covered with spines. The plant is a common weed and is found in most of the United States and Canada. It spreads from its roots as well as seeds.

Canada Thistle

Canada Thistle Control Methods

There are several herbicides that give good results on Canada thistle. Dicamba and mixes of 2,4-D amine and dicamba will give fair to good results. Clopyralid and picloram give excellent results. Canada thistle is often found in wetlands and when in such locations, 2,4-D and glyphosate with an aquatic label should be used.

Digging a single plant with a shovel works when the roots are removed from the soil. Disking and tilling does not work on Canada thistle because it spreads the roots and seeds.

DIFFUSE KNAPWEED

Diffuse knapweed is an annual or short-lived perennial. It has flowers that range in color from yellow to rose and is a member of the sunflower family. The bracts under the flower have yellow spines. Looking at the bracts is one of the best ways to tell the difference between the four noxious species of knapweeds. Diffuse knapweed blooms throughout most of the summer. Knapweeds are allelopathic, which means that they produce chemicals that reduce competition from other plants. This is one reason it is important to control these species.


Diffuse Knapweed

Diffuse Knapweed Control Methods

Several herbicides provide good to excellent control of diffuse knapweed. Good control is provided by 2,4-D formulations, but the control of diffuse knapweed usually requires several treatments. Picloram and clopyralid are the two best herbicides to use on diffuse knapweed. Both provide excellent control.

Mechanical control of diffuse knapweed can be done with disking or deep tilling. Both methods have to be done several times during the growing season to provide some control and will damage desirable vegetation. Herbicides are the most cost effective means of control.

DYER'S WOAD

Dyer's woad is a member of the mustard family. Its life cycle is interesting because it may act like an annual, biennial, or perennial plant. A small to medium sized plant, it has bright yellow flowers that bloom in early spring. The seeds turn to a dark brown or black color, making it easy to spot once the seeds have matured. Dyer's woad was introduced from Europe because the seeds are used to make dye.


Dyer's Woad

Dyer's Woad Control Methods

Some of the herbicides that work on Dyer's woad are 2,4-D and dicamba, or mixes of 2,4-D and dicamba. Three way mixes of 2,4-D amine and dicamba with metsulfuron or sulfometuron, give excellent results when applied from rosette to bloom stage.

Hand pulling is used to control Dyer's woad and this works well as long as the tap root is removed. Disking and tilling will work on Dyer's woad if done several times per growing season.

FIELD BINDWEED [WILD MORNING GLORY]

Field bindweed is a perennial plant that was introduced from Europe. The leaves of field bindweed have a distinct arrowhead shape. The flowers are trumpet shaped and are usually white or pink in color. This plant has deep a taproot which can reach depths of ten feet or more. It is also extremely adaptable and can be found in most of North America. Field bindweed is commonly called morning glory because it resembles morning glory flowers.


Field Bindweed [Wild Morning Glory]

Field Bindweed Control Methods

Herbicide applications are the best method for controlling field bindweed. Most formulations of 2,4-D produce good results. Dicamba is another herbicide that gives good control of field bindweed. There are many combinations of 2,4-D and other herbicides that give good results on field bindweed. Dicamba and 2,4-D or glyphosate and 2,4-D work well together. The 2,4-D and glyphosate mix is especially effective when applied after the first frost. Glyphosate translocates easily in plants. When applied after the first frost, the herbicide is

moved into the roots of the plant, giving control of the roots.

Some control of field bindweed can be accomplished with mechanical means. Disking or tilling removes the top growth and stops the plant from producing energy. However, disking and tilling have no effect on the roots of the plant, and field bindweed will resume growing from the roots.

HOARY CRESS [WHITE TOP]

Hoary cress is commonly called white top and is a member of the mustard family. It is a deep rooted perennial that reproduces from seed as well as the roots of the plant. It is a smaller plant that only reaches about two feet in height. This plant starts growing in early spring and it produces many white flowers are conspicuous in midsummer.

Hoary Cress [White Top]

Hoary Cress Control Methods

Several herbicides have shown good control on Hoary cress. Dicamba, or 2,4-D amine by themselves, or in combination, produce good results. Chlorsulfuron and metsulfuron also provides good control. Three way mixes of dicamba, 2,4-D and chlorsulfuron or metsulfuron are especially effective.

Disking or deep tilling provides some control on hoary cress. Mowing is also helpful if the plant is cut very short and often. Using multiple tillage operations is much more costly than herbicide applications.

JOHNSONGRASS

Johnsongrass is a perennial plant belonging to the Poaceae grass family. It is a large vigorous plant that grows up to eight feet tall. It has large rhizomes that reach one inch in diameter. Johnsongrass was introduced to the United States from the Mediterranean as a forage crop. It can cause problems for right-of-way managers because of its large size.

Johnsongrass

Johnsongrass Control Methods

Many herbicides provide effective control of Johnsongrass. Imazapyr is one that gives very good control of Johnsongrass, but is a nonselective herbicide. Glyphosate is also effective, but multiple applications may be necessary.

Johnsongrass is not effectively controlled with mechanical methods. Its large rhizomes are easily spread with disking and other tillage operations.

LEAFY SPURGE

Leafty spurge is a perennial plant that grows about three feet tall. Flowers are yellow in color and bloom in late spring to early summer. It spreads by seed and rootstock. Leafy spurge has a very large and deep rootstock. Roots have been measured up to twenty feet long. When the seed capsules dry out they can explode and shoot the seed several feet from the plant. Leafy spurge is a native of Eurasia. It is known to be toxic to livestock and is a serious problem in many western states.

Leafy spurge

Leafty Spurge Control Methods

Herbicides provide fair to good control on leafy spurge. Because of its large and deep root system it requires multiple applications to get it under control. Formulations of 2,4-D esters gives fair control, but they need to be applied several times. Dicamaba applied in spring or early summer gives fair to good control. Glyphosate offers some control of leafy spurge, but better results are achieved when mixed with 2,4-D. All herbicide treatments for leafy spurge requires more than one application. There are no mechanical control methods that offer good results on leafy spurge.

MEDUSAHEAD

Medusahead is a member of the Poaceae or grass family. It is a winter annual that germinates in the fall and overwinters as a seedling. This allows it to start growing very early in the spring. It is a very aggressive plant that displaces other vegetation. The long awns of the seed head often become twisted at maturity. Meduashead was introduced from Eurasia.

Medusahead

Medusahead Control Methods

Medusahead is hard to control, and most herbicides require several applications, combined with other methods. Glyphosate is a nonselective herbicide that offers good control if it is applied in the fall after the seeds have germinated and are in the seedling stage, or in the early spring. Pre-emergence herbicides provide good control if applied before germination takes place.

Disking and tilling can provide control of Medusahead if done during the seedling stage. Deep tillage that buries the seeds may stop germination. Burning to remove the thatch layer will improve effectiveness of pre-emergence herbicide applications.

MUSK THISTLE

Musk thistle is a member of the sunflower family. It is a large biennial plant that can grow up to six feet in height. It has a large purple or violet flower. The flowers are often bent over explaining why it is sometimes called a nodding thistle. It is native to Eurasia, it very invasive in the western states, and it spreads primarily by seeds.

Musk Thistle

Musk Thistle Control Methods

There are several herbicides that provide good to excellent control of Musk thistle. Formulations of 2,4-D amine mixed with dicamba give good results on rosettes and small plants. Metsulfuron works well on small plants. Once this species has reached a large size, other herbicides need to be used. Picloram offers fair results on larger plants, but follow up treatments are needed.

Disking and tilling give fair to good results on the plant when rosettes are present. Digging with a shovel works on small plants. Once this species has reached it full size, mechanical methods do not work.

PERENNIAL SORGHUM

See the section on Johnsongrass

PERENNIAL PEPPERWEED

Perennial pepperweed is a member of the mustard family and as its name implies, it is a perennial. Growing up to six feet in height, it spreads from seed and its large rootstocks. It blooms from early summer to fall, and has many clusters of white flowers during the period of bloom that gives rise to the common name tall white top. Perennial pepperweed is a native to Europe and Asia.

Perennial Pepperweed

Perennial Pepperweed Control Methods

This plants large rootstocks make its control very difficult. Metsulfuron and chlorsulfuron are two herbicides that provide good control of perennial pepperweed. Either of these herbicides should be applied when the plants are in bud up to the early bloom stage of growth because of their mode of action. Perennial pepperweed is often found in wet locations that require herbicides with appropriate aquatic labeling. Herbicides such as 2,4-D amine and glyphosate with aquatic labels provide good control, but may require multiple applications.

Perennial pepperweed has large underground rootstocks that prevent mechanical control methods from being effective. Digging to remove the plant and its root system can be an effective control method.

PURPLE LOOSESTRIFE

Purple loosestrife is a tall perennial plant with rhizomes. It grows up to eight feet in height with purple flowers at the top. The purple flowers extend six to eight inches above the stem and the plant begins blooming in the early summer. Purple loosestrife reproduces with seeds and rhizomes and is an extremely invasive weed on wetlands. It is believed to have been introduced to the US from Europe as an ornamental plant.

Purple Loosestrife

Purple Loosestrife Control Methods

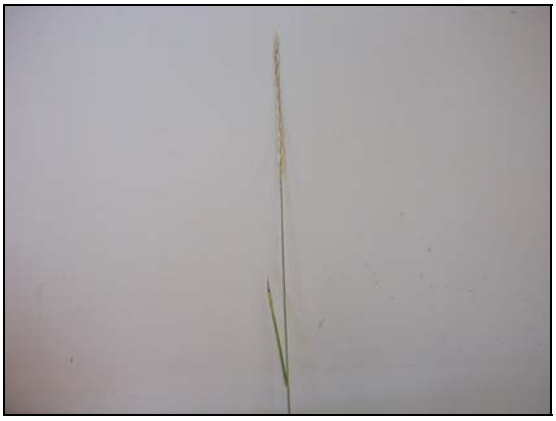
There are few herbicides that provide fair to good control of purple loosestrife. This plant is usually found in wetlands and wet sites where herbicides with aquatic labeling are required. Formulations of 2,4-D give fair control, but multiple applications are needed for control. Imazapyr and glyphosate provides good to excellent control of purple loosestrife.

Purple loosestrife is often found in wetlands which can restrict acceptable mechanical control methods. The United States Corps of Engineers must approve the use of mechanical control methods in some wetland areas. Harvesting the seed heads and hand cutting have been used in some places to control or stop the spread of this plant.

QUACKGRASS

Quackgrass is member of the grass family. It is a perennial plant that spreads by seed or with rhizomes. It has a long slender seed head. The leaf blades are wide, up to one half inch, and often have a constriction near the tip of the leaf. Quackgrass is native to the Mediterranean. Many grasses are hard to

identify and special care should be taken to accurately identify grass species.


Quackgrass

Quackgrass Control Methods

Glyphosate is one of the most effective herbicides for quackgrass. However glyphosate is a nonselective herbicide, so when sprayed as a broadcast application, it damages other plant species. Fluazifop is a slow acting herbicide that is also very effective in controlling quackgrass. Signs of fluazifop's control on quackgrass may not show for as long as two to three weeks.

There are no mechanical methods to control quackgrass. Disking or tilling only spreads the quackgrass rhizomes and increases the number of new plants.

RUSSIAN KNAPWEED

Russian knapweed is a member of the sunflower family. It is a perennial plant with deep roots and flowers of pinkish color that bloom from early to late summer. The bracts are pointed and the tips are white in color. Russian knapweed is also allelopathic, which means that its produces chemicals that reduce competition from other plants. Russian knapweed is from Eurasia, it is a very invasive weed, and it also causes chewing disease in horses.


Russian Knapweed

Russian Knapweed Control Methods

There are several herbicides that provide fair to excellent control of Russian knapweed. Formulations of 2,4-D offer fair control, but multiple treatments are usually required. Picloram and clopyralid are still the two best herbicides for use on Russian knapweed. Mixes of 2,4-D with picloram, or 2,4-D mixed with clopyralid provides excellent control on this plant species. Glyphosate can also provide good control of Russian knapweed, but it is a nonselective pesticide that damages nontarget vegetation.

Russian knapweed is a deep rooted perennial plant for which mechanical control methods have little or no effect.

Scotch Thistle [Cotton Thistle]

Scotch thistle is also a member of the sunflower family and native to Eurasia. Scotch thistle will grow up to eight or nine feet in height. It is a biennial with red flowers that start to bloom in June. Its large size and invasive nature make it a problem plant in many western states.


Scotch Thistle [Cotton Thistle]

Scotch Thistle Control Methods

There are several herbicides that provide fair to excellent control of Scotch thistle.

Formulations of 2,4-D amine mixed with dicamba provides fair to good control when in the plant is in the rosette stage. Metsulfuron and sulfometuron gives excellent control when applied to small Scotch thistle plants or during rosettes stages of growth. Clopyralid and picloram give excellent control from rosette growth stages up until the plant reaches two feet in height. This species is difficult to control once it matures.

Disking and tilling while in the rosette stage can give fair control of Scotch thistle. Digging up single plants also works. Its large size and spiny nature makes Scotch thistle difficult to handle.

SPOTTED KNAPWEED

Spotted knapweed is a member of the sunflower family and is a short-lived perennial plant. The flowers are usually pink in color and the bracts have dark spots on them. Spotted knapweed blooms from early summer to October and is believed to be allelopathic. Allelopathic means that its produces chemicals that reduce competition from other plants. This plant is native to Eurasia. It is believed it have been introduced with alfalfa.

Spotted knapweed

Spotted Knapweed Control Methods

Many of the common herbicides provide fair to excellent control of spotted knapweed. Formulations of 2,4-D mixed with dicamba will give fair to good control. The two best herbicides for knapweed are picloram and clopyralid. These two herbicides will provide good to excellent control of spotted knapweed. Picloram mixed with 2,4-D and clopyralid mixed with 2,4-D will also give very good control on this species.

Disking and tilling spotted knapweed produce good results. For these methods to work, the area must be disked or tilled several times during the growing season. Digging with a shovel or hand pulling works for small areas.

SQUARROSE KNAPWEED

Like other knapweeds, squarrose knapweed is a member of the sunflower family. This species is a long-lived perennial with a taproot. Its flowers are rose to pink in color. This species starts blooming in early to midsummer and the bracts are curved outward. This species is also a native of the Mediterranean. Like the rest of the knapweeds this species is also believed to be allelopathic. Allelopathic means that its produces chemicals that reduce competition from other plants.

Squarrose Knapweed

Squarrose Knapweed Control Methods

Herbicides: Many of the herbicides that give fair to excellent control on the other knapweeds also work for squarrose knapweed. Dicamba and 2,4-D provides fair to good control of squarrose knapweed. Picloram and clopyralid provides good to excellent control, and picloram or clopyralid mixed with 2,4-D also give good to excellent control.

Disking or tilling of squarrose knapweed have little value because of the large taproot. Hand pulling or digging with a shovel works as long as the taproot is removed.

YELLOW STAR THISTLE

Yellow star thistle is member of the sunflower family. It is a winter annual that grows approximately two feet tall and has bright yellow flowers with large thorns under them. It is made up mostly of stems and begins to bloom in early summer. Introduced from Europe, it is often found on roadsides and

waste areas. It is also known to cause chewing disease in horses.


Yellow star thistle

Yellow Star Thistle Control Methods
There are several herbicides that give fair to excellent control of yellow star thistle. Formulations of 2,4-D amine compounds applied in the rosette stage give fair to good results. Mixtures of 2,4-D amine with dicamba give excellent control from the rosette stage to prebloom. Clopyralid and picloram both give excellent results on yellow star thistle when applied before prebloom stage of growth.

Disking and tilling offers some control of yellow star thistle. Such mechanical control methods should be done while the pant is in the rosette stage of growth. Digging up plants with a shovel works on small numbers of plants.

IDENTIFICATION AND CONTROL OF NUISANCE WEEDS

The Utah Department of Transportation provided the following color pictures of the nuisance weeds found on right–of-ways. The black and white version of this publication does not adequately display the plant colors and details necessary for identification. The Internet version of this Right-of-Way manual is located at: http://ag.utah.gov/plantind/sg_rightofway.pdf. Please access the online version of this manual for color pictures of common noxious weeds found on Utah's right-of-ways.

Many species of plants cause problems for managers of right-of-ways. Some of these plants cause safety problems, present obstacles to proper drainage, and/or interfere with power lines. Some of the nuisance species are native to Utah and some plants have been introduced. Nuisance plants on right-of-ways also include agricultural crops or ornamental species that interfere with management objectives. Some of the common nuisance weeds on Utah's right-of-ways include rabbitbrush, sagebrush, kochia, sunflower, Russian thistle, and Russian olive.

RABBITBRUSH

Rabbitbrush is a member of the sunflower family and has yellow flowers that bloom from late summer to early fall. It can grow to more than four feet in height and often forms dense stands that crowd out other plants. If not controlled, rabbitbrush can obscure guardrails and other road safety fixtures.


Rabbitbrush

Rabbitbrush Control Methods
Rabbitbrush is hard to control and more than one application of herbicide is required. Some 2,4-D ester formulations work well when applied at high end rates. Herbicides should be applied early in the spring, when the plants are actively growing. After a few weeks of growth these plants are difficult to control with 2,4-D types of herbicides. Picloram mixed with 2,4-D gives good control of rabbitbrush in the spring.

Mechanical control methods provide limited control of rabbitbrush. Mowing and burning will provide temporary control because the plant resprouts from the crown.

SAGEBRUSH

Sagebrush is a member of the sunflower family and a common plant in most western states. Sagebrush is a perennial plant that can reach over ten feet in height. It is a woody

shrub that blooms in late summer. Sagebrush can form dense stands and displace other plant species. The size and competitive nature of sagebrush make it a safety problem on right-of-ways.


Sagebrush

Sagebrush Control Methods

There are several herbicides that give good to excellent control on sagebrush species. Formulations of 2,4-D esters, some 2,4-D amines and dicamba herbicides work well. These herbicides applications should occur early to late spring when the plants are actively growing. Other herbicides like picloram or tebuthiuron can be used with good results.

Mowing and other methods of mechanical control work well on sagebrush. Machines that pull the sagebrush out of the ground, or cultural practices such as disking or tilling provide good control. Burning sagebrush has proven to be an effective means of control.

Kochia

Kochia is an annual plant belonging to the goosefoot family. It is native to Asia and was introduced as an ornamental plant. Kochia can reach heights of six feet or taller and is a prolific seed producer. Kochia can germinate with a minimal amount of rainfall, it can endure extreme temperatures and it is a strong competitor. Kochia can have many flushes throughout the spring, summer, and fall. It can grow large enough to hide guardrails and other roadside fixtures and create sight distance problems along roads.


Kochia

Kochia Control Methods

There are many herbicides that work well on kochia. Formulations of 2,4-D amine at high rates that will give good control as long as the plants are sprayed when they are about six inches in height. Dicamba can be used when the plant is larger. There are several formulations of 2,4-D that can be mixed with dicamba to offer very good control of kochia up to two feet in height. Pre-emergence herbicides offer excellent control, but they may need to be followed with 2,4-D or dicamba treatments for complete control. Kochia is one of the weed species noted for herbicide resistance. Herbicides should be rotated and new herbicides used when possible.

Tilling and disking works on young kochia plants. Hand pulling and digging is effective on small numbers of plants. Mowing helps to reduce the size of the plant and to reduce seed output, however the lower part of the plant remains and seeds are produced by the remaining stems.

Sunflower

Sunflowers are annual plants that are easily recognized by their large leaves and bright yellow flowers. They are a native plant species of the United States and are found in most right-of-ways. Common sunflowers can reach heights of up to ten feet. They are large in size and can form dense stands, making them a problem on right-of-ways. Sunflowers usually flower from July into September.


Sunflower

Sunflower Control Methods

Most of the commonly used herbicides give good to excellent control of sunflowers. Formulations of 2,4-D amines give good control when sunflowers are six to eight inches in height. Dicamba also offers good to excellent control for small plants. Mixes of 2,4-D and dicamba are also excellent. When sunflowers are over two feet in height, high-end application rates of these herbicides are required. Pre-emergent herbicides will give good control, but the timing of the application is important. Applications need to be timed with rainfall, so the pre-emergent is still active when the sunflowers start to germinate. Glyphosate provides good control of sunflowers, but damages other vegetation.

Mowing is very effective for controlling sunflowers. The plants must be mowed as short as possible before they can set seed. Digging or hand pulling will work on small patches of sunflowers. Disking and tilling will give good control, but may not be practical on right-of-ways.

RUSSIAN THISTLE

Russian thistle is an annual plant and a member of the goosefoot family. This species was introduced from Russia and is common on right-of-ways. It is a small bushy plant covered with stiff spines and the stems usually have purple stripes. Russian thistle is a prolific seed producer. Once mature the plants spread seeds as tumbleweeds. The dead plant skeletons pile up against fences causing sight distance problems and fire hazards.


Russian thistle

Russian Thistle Control Methods

Herbicides applications provide good to excellent control for Russian thistle. The 2,4-D amines and dicamba give good control if applied when the plants are less than six inches in size. Formulations of 2,4-D mixed with dicamba or glyphosate offer excellent control when applied to young growing plants.

Disking and tilling of young plants give good control of Russian thistle, but may not be practical on right-of-ways. Hand pulling and digging will work on small patches of plants. Mowing does not work on Russian thistle because of its small size.

RUSSIAN OLIVE

Russian olive is a member of the Oleaster family. It was introduced from Europe as an ornamental tree and as a food source for wildlife. It grows to approximately twenty-five feet in height with silver green leaves. It produces an aromatic smell and large numbers of tan colored olives. The branches of this tree have long thorns, making it difficult to handle. Russian olive trees can be very aggressive, infesting drainage areas and causing sight distance and access problems.


Russian olive

Russian Olive Control Methods

There are only a few herbicides that give good control of Russian olive trees. Most will take several treatments to get complete control especially if it is a large tree. Formulations of 2,4-D amine and esters at high-end rates provide good control. If 2,4-D esters are being used, apply only when temperatures are below 80 degrees Fahrenheit. Glyphosate products also give good control, but can cause off target damage. One of the best herbicides for Russian olive trees is imazapyr. When treatments of imazapyr are applied, spray just enough to wet the tree. Any herbicide that runs off can result in total vegetation kill on surrounding plants.

Once Russian olive trees reach maturity physical removal is the only effective control strategy. Stumps and roots must be dug up or treated with a herbicide to prevent regrowth. The most effective time to treat Russian olive stumps with herbicides is in the fall of the year after the tree is cut down. Glyphosate products are good for this kind of treatment, because they translocate to the roots of the plant.

BIOLOGICAL CONTROL OF WEEDS

Typical biological control methods include the introduction of an insect species or pathogen that damages an undesirable plant. Insect may feed on the leaves, stems, or seed heads of the target plant. Pathogens may disrupt the growth of the plant or make it more susceptible to injury. Such attacks either kill or weaken weeds so more desirable vegetation can grow. The insects and pathogens selected for biological control are host specific, meaning they damage specific species of plants.

Once biological control insects are released on target plant species, they spread to new plants. Insects can reproduce and pathogens maybe transported by insects movement between plants or by wind displacement. These methods of spread and relocation are especially advantageous if it is unsafe or difficult to treat the plants with herbicides. Biological controls continually damage the weeds through the growing seasons and reduce the amount of herbicides and other control methods that otherwise would be needed.

There are several limitations to the use of biological control. This weed control method can take up to five years for a reduction to occur and they are commonly plant specific and do not provide control for other weed species. Biological controls are available for a limited number of weed species, but as research advances additional controls will become available.

The following are a list of selected weeds found on Utah right-of-ways with lists of some of the biological controls that are available. These weeds include leafy spurge, purple loosestrife, yellow starthistle, musk thistle, Canada thistle, diffuse knapweed, Dyer's woad, field bindweed, dalmatian toadflax, and poison hemlock.

Biological Control for Leafy Spurge

Leafy spurge flea beetles:

There are five to six different species of beetles used on leafy spurge. Each species seems to prefer different environments. These beetles feed on the root hairs and young roots of spurge while they are developing. The adult insects feed on the foliage of spurge plants. Over a long period of time these beetles can reduce the number of leafy spurge plants.

Leafy spurge stem borer:
The larvae of beetles feed inside the stem, crown, and root of the plant. The adults feed on the leaves and stems.
Leafy spurge gall midge:
The larvae of this insect feed on the root tips of the spurge plant. The midge species can produce many generations per year.

Biological Control for Purple Loosestrife

Purple loosestrife leaf beetle:
The larvae and adults of this beetle feed on the leaves and new shoots of purple loosestrife plants. Once established, they can defoliate the entire plant.

Biological Control for Yellow Starthistle

Yellow starthistle weevil:
There are two species of weevil that feed on yellow starthistle. The larvae of both weevil species feed on the flower and seeds of the plant. The adults feed on the young buds of the plants.

Biological Control for Musk Thistle

Rosetta bedding weevil:
This insect feeds on the shoot tips and leaves of musk thistle while the plant is in the rosette stage.

Biological Control of Canada Thistle

Stemming weevil:
The young of the stemming weevil bore into the Canada thistle stem and feed on the tissue. Larvae of this species can also feed on the crown and root of the Canada thistle.
Tortoise beetle:
This insect's larvae and adults eat the leaves and stems of the Canada thistle plant. The adult beetles will feed all summer and can defoliate entire plants.

Biological Control of Diffuse Knapweed

Sulfur knapweed moth:
Larvae of this moth feed on the roots and crowns of diffuse knapweed.
Seedhead moth:
The seedhead moth lays eggs at the base of the flowers of diffuse knapweed. The larvae feed on florets and seeds of the plant.
Root-boring weevil:
These weevils feed on roots of diffuse knapweed and cause enough damage to kill the plant.

Biological Control of Dyer's Woad

Systemic rust:
Systemic rust infects Dyer's woad and the rust is specific to the woad. Once plants become infected they will turn yellow and do not produce seeds.

Biological Control of Field Bindweed

Bindweed gall mite:
The bindweed mite is almost microscopic in size. The bindweed mite causes galls in the field bindweed plant which cause the shoots to be stunted and misshaped.

Biological Control of Dalmatian Toadflax

Toadflax flower beetle:
The larvae and adult beetles feed on young tissue and reproductive parts of dalmatian toadflax causing reduced seed production.
Toadflax moth:
The larva of this insect feeds on the leaves and young shoots of the dalmatian toadflax.
Toadflax weevil:
This insect feeds primarily on reproductive parts and seeds of dalmatian toadflax causing a reduction in viable seed.

Biological Control of Poison Hemlock

Hemlock Moth:
The larva of this insect feeds on the leaves and flowers of poison hemlock. They can defoliate the entire plant. The hemlock moth feeds on the seeds, resulting in lower seed production.

IV. Right - Of - Way Pest Management

HERBICIDES USED FOR VEGETATIVE MANAGEMENT

Herbicides are the main tools in a vegetation management program for right-of-ways. Herbicides may be classified by chemical composition, whether they are selective or non-selective in the control of weeds, by their method of application or mode of action, and whether they are contact pesticides or translocated through the plant. The two chemical classifications of herbicides are inorganic and organic.

INORGANIC HERBICIDES

Most inorganic herbicides are salt compounds. Brine, a mixture of salt and ashes, has been used to kill vegetation for hundreds of years. Another inorganic herbicide is copper sulfate. It is a selective herbicide used to kill broadleaf weeds in grain fields. Sodium arsenite was used as an herbicide for most of the first part of the 20th century. Ammonium sulfamate can be used for brush control. Sodium chlorate is used as a bareground herbicide. The borates, other salt compounds, have also been used as bareground herbicides. Inorganic herbicides last for a long time in the soil and can cause environmental problems.

ORGANIC HERBICIDES

Organic herbicides are made from a large number of chemicals with over thirty classifications. Some of the most commonly used herbicides for vegetation management are described below.

Benzoic Acids

Dicamba is a benzoic acid used on broadleaf weeds. It is used as a contact herbicide (applied directly to the plant), but also has soil

residual properties. Residual means the herbicide will stay in the soil for several days and can be absorbed by the roots of the plants. Dicamba is classified as a growth hormone herbicide. The mode of action is to interfere with protein synthesis in the plant. Dicamba is commonly found mixed with 2,4-D and the resulting products have many different names. The mixture of dicamba and 2,4-D can be found in products used in agriculture, turf and ornamental, right-of-ways, and home products. Dicamba can be applied pre or post-emergence.

Phenoxys

The most common phenoxy herbicide is 2,4-D. It was first introduced in 1944, and has been the mainstay of broadleaf weed control for over fifty years. Classified as a hormone weed killer, it is highly selective for broadleaf weeds. Its mode of action is much like a growth hormone and it affects cellular division. Many companies manufacture 2,4-D. It can be found in products used by agriculture producres, right-of-way managers, homeowners, and many other people. It is classified as a selective contact herbicide and will persist in the soil for a short time. It is mostly used as a post emergent herbicide.

Phosphono Amino Acids

The best known herbicide of this type is glyphosate (Roundup). Herbicides in this class kill all types of plants including broadleaf plants and grasses. They are applied foliar to vegetation and translocated throughout the plant. Their mode of action seems to stop the production of amino acids in plants. This class of herbicide seems to work better on grasses than on broadleaf plants. Phosphono amino acid herbicides are nonselective foliar applied herbicides. They have no soil activity and are applied post emergent. Glyphosate can be found in many products used in almost every type of vegetation management.

Carboxylic Acids

Picloram is an example of this type of herbicide. These are hormone herbicides that are used as selective herbicides on broadleaf weeds and many brush species. They translocate easily in most plants. Their mode of action is much like phenoxy herbicides in that it acts like a natural plant hormones. Picloram will remain active for a long time in soil.

Carboxylic acids are herbicides that are applied pre or post emergent. They can be absorbed by plant foliage or by roots and have a long half life. Most of these herbicides are restricted use pesticides (RUP) and should be used only by certified and licensed applicators.

Ureas

Ureas are substitute compounds. Most of the urea type pesticides are nonselective and are usually applied to the soil as a pre-emergent herbicide. These herbicides also have post emergent uses and are used for foliar applications. This class of herbicide attaches to soil very firmly, persists for a long time, and is absorbed by the plant roots. Their mode of action is to inhibit photosynthesis. Some of the most commonly used ureas in right-of-ways are diuron or diuron and bromacil.

Uracils

Uracils contain the chemical bromacil. They can be used as a pre and post emergent herbicides. Bromacil controls most grasses and broadleaf plants. When used as a pre-emergent herbicide it must be applied early in the year and is moved into the root zone by moisture either from rainfall or irrigation. Bromacil also has a long half life and remains active in the soil for a long time. The mode of action for uracils is much like the ureas, they stop photosynthesis in plants. This class of herbicides should not be used in sandy soils or soils with low organic matter. The herbicide moves through these kinds of soil and causes off target damage.

Sulfonylureas

These are some of the newest herbicides for right-of-way use. Most of the herbicides in this class are used as pre and post emergent applications for broadleaf plants. Some can work on both grasses and broadleaf plants. They remain active in the soil for a moderate to very long time. These herbicides can have very low application rates and as little as one-quarter ounce per acre is effective. Their

mode of action is that of meristematic inhibitors, which means they stop amino acid biosynthesis and cell division at the root tips.

Bipyridyliums
This class of herbicides is not widely used in right-of-way programs, but they are used occasionally. They are contact herbicides that cause quick damage to plants. They act as desiccants which cause cell and chloroplast membranes to rupture. This usually occurs within hours of application. Plants show rapid wilting and tissue damage. Two of the common herbicides in this class are diquat and paraquat. They have no soil activity and are not translocated in the plant. They produce good results when used on annual plants. However, they are not as successful with perennials since they only destroy the tops of the plant, allowing plant regrowth.

Imidazolinones
These are another relatively new class of herbicides. These herbicides are applied as pre and post emergent herbicides. They are used on both grasses and broadleaf plants. Their soil activity ranges from moderate to long. Like sulfonylureas, they are meristematic inhibitors and stop amino acid biosynthesis. An example of this type of herbicide used on right-of-ways is imazapyr. It is used to control grasses, broadleaf plants, and trees.

Dinitroanilines
This class is used mainly as soil incorporated pre-emergent herbicides. They have little or no effect on established plants, but work well on germinating plants. They have very low water solubility that keeps them from moving in the soil. Their mode of action is to kill weed seed as they germinate. An example of this type of herbicide is pendimethalin which is commonly used on right-of-ways.

Cyclohexanediones
This class of herbicides is less commonly used on right-of-ways because they control annual and perennial grasses. Their mode of action is to interfere with plant growth by inhibiting auxins which are plant growth substances. These pesticides are selective post emergent herbicides and are only effective on grasses.

VEGETATION CONTROL ON RIGHT-OF-WAYS

The complete removal of vegetation is sometimes desirable and may be referred to as bare ground control, total vegetation removal, and/or sterilization. Total vegetation control is beneficial in numerous right-of-way applications, but the maintenance of such areas is sometimes problematic. Road right-of-ways have multiple structural features for thoroughfare safety and ease of maintenance.

Guardrails and crash cushions need to be clear of vegetation so they can easily be seen by drivers. Such structures must also delineate the edge of the road at night and during other times of low visibility. Some road departments maintain four or more feet of bare ground along road shoulders to clearly identify road edges and allow water to flow more quickly from the road surface.

Power companies that have power poles and other utility structures along right-of-ways prefer that access to such equipment is not obstructed by vegetation. Railroads maintain the right-of-ways adjacent to tracks so that they are clear of all vegetation and the tracks are easily visible. Railroad crossings are also maintained for complete removal of vegetation.

Complete removal of vegetation from soil surfaces also presents problems. Soil surfaces without vegetation are easily eroded and depending on the soil type, slope, rainfall, and/or water runoff, will require additional maintenance. Erosion along roadsides can result in damage to hard surfaces and the undermining of guardrails and other roadside fixtures.

In addition to erosion problems, total vegetation removal can also cause difficulty with herbicide applications and weed infestations. Herbicides applied to bare ground may easily move when water passes through or over the soil surface. Soil with much gravel or sand content will allow herbicides to move through the soil. Soil with high clay content might allow surface herbicides to move with water over the soil surface.

When herbicides are moved away from target application sites there is the possibility of unintended killing of nontarget vegetation. Further, weeds can easily invade the unprotected bare ground sites. Weed invasions will also occur as herbicides break down over time.

HERBICIDES FOR BAREGROUND APPLICATIONS

Following is a list of herbicides and combinations of herbicides that are most commonly used for total vegetation control.

Diuron and Imazapyr

Sahara is a combination of diuron and imazapyr. As a pre-emergent it can be applied in late fall or early spring. It can also be applied as a post emergent. Glyphosate can be added to improve the control of vegetation that has already grown. Application usually lasts for one season.

Diuron and Bromacil

Krovar is a combination of diuron and bromacil. It is usually applied in late fall or early spring. It works as a pre or post emergent application. Glyphosate can be added to control existing vegetation. Application usually lasts for one season.

Pendimethalin and Glyphosate

Pendulum is pendimethalin and it has no post emergent activity so it is mixed with glyphosate or another such herbicide to control existing vegetation. High rates of often are necessary for long term control.

Diuron and Glyphosate

Karmex is diuron and it can be mixed with glyphosate for bare ground control. Diuron will have little or no movement once it has bonded to the soil.

Prodiamine and Glyphosate

Endurance is prodiamine and is very similar in its mode of action to pendimethalin. Prodiamine needs to be used with another herbicide like glyphosate to control existing vegetation.

Sulfometuron-methyl

Oust is sulfometuron-methyl and is active on plants at very low rates. Sulfometuron-methyl can be mixed with glyphosate to control existing vegetation.

Imazapyr

Arsenal is imazapyr and will work as a bareground herbicide by itself. Adding glyphosate will speed up the control of existing vegetation.

MECHANICAL CONTROL OF VEGETATION

Mowing is the primary mechanical method used to control vegetation along right-of-ways. Mowing of vegetation improves visibility and extends sight distance. Mowing also reduces the height of vegetation that will burn in the event of a fire.

Certain species of plants, mainly annuals, are effectively controlled by mowing. Some of the taller grasses and tall plants such as sunflowers are controlled by mowing. Such plants may require repeated mowing for control during their growing seasons and a very short mower setting may be necessary to stop plant from producing seed. Some plant species are effectively controlled by mowing.

Mowing is less effective in the control of perennial plants, in part because right-of-way mowing is too infrequent to offer effective control of most perennial plants. The frequent mowing of right-of-ways is not a cost effective management strategy and many of the common weeds, specifically those classified as noxious weeds, have deep root systems that are not affected by mowing.

In some cases mowing does more to spread weeds than to control them. When heavy stands of weeds are mowed with rotary mowers, the seed heads are shattered and the seeds are spread to surrounding areas by the rotating blades.

Another way mowers spread weeds is that seed and plant matter adheres to the mower and or tractor and are transported to other locations. Many western states try to mow only once a season, usually in the fall after most plants have set seed.

Mowing may also cause problems with grasses that have been established to control erosion. Many of the native and introduced grasses along roadsides do not tolerate being cut short. When mowing damages the crown of some grasses, such as Bunch grasses, plant vigor is reduced and some grasses do not recover. If a plant's vigor is reduced it may no longer compete with weed species. Turf type grasses will recover if cut very short.

There are many ways to reduce the negative impact of mowing right-of-ways. The frequency of mowing operations can be reduced and the blade height can be set higher so will not damage preferred vegetation. To reduce the spread of plant parts and seeds, operators should not mow through weed patches. All plant materials should be removed from the mower and tractor equipment before moving to a new mowing site. In some cases it may be possible to apply herbicides so weed species are significantly reduced prior to mowing.

COMPETING WITH WEEDS

One of the best weed control methods on right-of-ways is to establish dense preferred vegetation that competes effectively with weeds. During construction activities and often following renovation projects, the existing vegetation on right-of-ways is disturbed and sometimes entirely removed.

Bare ground and areas with sparse vegetation are easily invaded by weeds. Revegetation of right-of-ways in a timely manner is critical for weed control. It is much easier to establish preferred vegetation on such sites than to reclaim an area after weed populations are thriving.

A revegetation plan should be developed prior to disturbance or removal of existing plants. The following guidelines should be considered when planning the revegetation of right-of-ways. Identify the plants, including the weeds present prior to disturbing the area. Similar plants maybe replanted and the growth of non native weeds will indicate invasion from an outside source.

Where appropriate, the elevation, slope, drainage routes, and other such features of the existing terrain should be noted. Necessary changes can be determined and problems associated with the original site can be corrected during the renovation process. Once the renovation begins, vegetation disturbance should be minimized and if a substantial amount of soil will be relocated, the topsoil should be stockpiled to allow for replacement.

Many factors influence the establishment of preferred vegetation on a disturbed site. If weeds are invading the site then weed control may be required before seeding. If the weeds on the site are a broadleaf species, then a selective broadleaf herbicide can be used to remove many of the weeds before planting begins. If the weeds are mainly grasses then a nonselective herbicide can be used for control.

After weed control, soil preparation is the next step. The degree of the slope will determine the method used to do the seeding. If a site has flat ground and steep slopes, then more than one method of seeding will be required. Flat surfaces can be tilled for planting. Steep slopes may require alternative seeding methods and smaller areas may even be seeded by hand.

Revegetation may be done with a grass seed mix appropriate for the location, soil type, and rainfall. Grass seed is typically a blend of several species that grow well under certain conditions. Good seed vigor is one trait needed in right-of-way plantings. In some cases broadleaf plants are planted or planted in conjunction with grasses.

Grass offers several advantages for right-of-way revegetation. Grass seed is economic to use and the shallow depth required for planting can be achieved by different planting methods. Grasses can be established faster than many other types of vegetation. Another advantage of using grasses is that a selective herbicide can be used to control broadleaf weeds.

After grasses are established and the weed species are under control, then broadleaf species can be over seeded on the site. Over time other species will naturally appear giving the area biodiversity. If these naturally occurring plants are appropriate for the site then they will also be good for the environment.

In flat areas several methods of seeding will work. Drill seeding works well on flat sites where the soil has been prepared. The grass seeds are drilled at a depth of one quarter to one half inch. This is the general planting depth for most grasses. Be sure of the recommended planting depth of the species selected, as there are types that need to be planted deeper than others.

The no till drill method is another successful way for seeding. This method is done with an implement towed behind a tractor. The implement cuts several shallow narrow furrows in untilled soil. Seed are uniformly dropped in the furrow and then rollers close the furrow. This method works very well on areas where more extensive tillage operations

are not appropriate or where existing vegetation will not be removed.

Another type of machine similar to a no till drill is an over seeder. This machine works well on roadsides and other sites that will not be tilled prior to seeding. The over seeder has tines on the front that lightly till the soil. Seed is dropped onto the tilled soil then rollers pack the soil around the seed. On sites where the no till drill or over seeder are used, an herbicide treatment may be necessary to remove weeds before the seeding takes place.

One of the easiest and most economical methods of seeding is broadcast seeding. Broadcast seeding can be done on flat ground or steep slopes. On large flat areas a tractor with a broadcast seeder attached to the three-point hitch can spread seed while dragging a mat or harrow behind it. This spreads the seed and incorporates the seed into the soil at the same time.

Broadcast seeding can be done on slopes as well. The slope can be hand prepared with rakes or other hand tools. For larger areas, a tracked vehicle such as dozer can "cat track" the soil surface. This operation leaves grooves in the soil that can be seeded with hand-held seed spreaders. The seed is then incorporated in the soil by hand with rakes or covered with a matting or hydro mulch.

Hydro seeding is usually done on slopes that are too steep for equipment. The most popular method of hydro seeding is to mix the seed and mulch together and spray it on the soil. This is the quickest method, but is less effective for sites that receive little rainfall.

The best method for hydro seeding arid sites is a two-step process. The soil needs to be raked, crusts on the soil need to be broken up and then the seed can be hand broadcast with a layer of mulch applied to cover the seed. Another two-step process with a hydro seeder is to mix the seed with a small amount of mulch applied to the area. Then a final amount of mulch is reapplied to cover the area.

There are many companies that produce products for mulch hydro seeding and erosion control. The hydro mulch selected and the application process utilized should be appropriate for the specific right-of-way location.

RECLAIMING WEED INFESTED SITES

Establishing desirable vegetation on a site covered in weeds can be difficult. It may take up to three years to reclaim locations heavily infested with invasive weeds. Such weeds actively spread and produce large amounts of seed allowing for continual regrowth. The following steps describe the typical procedure for reclaiming such sites.

Step One

Remove the existing weeds from the site. Usually treatment with a non-selective herbicide will kill the weeds. With some species, the site may need to be retreated several times during the growing season.

Step Two

Remove dead vegetation from the site. This can be done with tractor towed implements or if allowed by burning. In some cases hand labor maybe necessary.

Step Three

Prepare the soil for seeding and follow the revegetation plan. If using a seed mix, grasses are a good choice because treatments with selective herbicides will likely be needed to control the regrowth of broadleaf weeds. Use a seeding method that is appropriate for the location.

Step Four
Follow up on the site will be needed for several years. Selective herbicide treatments are usually necessary to control broadleaf weeds while grasses are being established. Low herbicide application rates are used to prevent damage to young grasses. Some areas will need to be reseeded and several years may be required for reclamation of such areas.

MANAGEMENT OF TREES

The management of trees is an important part of maintaining right-of-ways. Large trees with stronger trunks can be very dangerous. If a vehicle, traveling at a higher speed leaves the roadway and crashes into such trees, injury, death, and property damage can all occur. In addition to crash hazards, such trees can impair visibility, damage roadways, and interfere with drainage and snow removal from the road surface. During adverse weather conditions, tree parts can be deposited on roadways causing additional hazards. The following are descriptions of common tree management guidelines.

Tree Selection
One of the first criteria of tree management is appropriate tree selection. If trees are to be planted along right-of-ways, they should be selected by size first. A small tree should be selected so they do not present a safety hazard as they reach maturity. Trees along roadways should not obscure visibility. Trees near power pole should not interfere with access for power line maintenance or come in contact with the lines. Appropriate tree species should not invade clear zones or drainages.

Tree Pruning
The purpose of tree pruning is to keep tree limbs out of power lines, maintain visibility, and sight distances along right-of-ways. When pruning is done, the look and health of the tree should be a priority. Sign companies and roadside advertisers need the trees that block visibility to be either pruned or removed.

Tree Removal
Sometimes trees must be removed. If a tree presents a hazard, removal may be the only solution. Large trees may need to be removed by trained professionals and sometimes the tree stump must also be removed. Dead or dying trees are unappealing and will eventually present a problem. Such trees should be removed in a timely manner.

Tree Root Control
Tree roots along right-of-ways can cause damage to roadways, curbs, gutters, and sidewalks. If roots damage or displace concrete fixtures, the roots should be dug up and/or pruned back. Such maintenance activities are usually a short term solution. Aggressively removing or trimming a tree's roots may make a tree more likely to fall in windstorms and can weaken or kill the tree. There are fabrics that are impregnated with herbicides that interfere with root growth. Such materials can be used to control problem tree root growth.

HERBICIDE CONTROL OF WOODY VEGETATION
Trees and other tree like species, such as shrubs and woody plants, can cause problems on right-of-ways. Some plant species that are cut off at ground level will resprout from the stump or roots. Herbicide control of woody vegetation is often very effective and economical. Controlling small trees with herbicides is cheaper than using saws and labor to cut down and remove large trees. The following herbicide treatment applications are effective in managing trees.

Foliage Sprays

Foliage sprays with herbicides can be done in the spring once the leaves are full. Such applications should be done with low pressure or low volume spray equipment. Tree foliage should be sprayed until the leaves are wet. Some of the herbicides used for foliage sprays are 2,4-D amine, dicamba, glyphosate, triclopyr, and picloram. If nonselective herbicides are used to spray trees, the dripping herbicide will damage other vegetation.

Soil Applications

Herbicides that have good soil activity can be used to treat trees in this manner. Herbicides that come in the form of pellets can be spread around the tree base. Moisture moves the herbicide into the soil where it is taken in by the tree roots. Some of the best herbicides for this type of treatment are dicamba, imazapyr, and picloram. Care must be taken to keep herbicides away from the root zone of preferred vegetation.

Basal Bark Treatments

Basal bark sprays are treatments of herbicides applied to the lower trunks of the trees. Oil soluble herbicides are mixed with materials such as diesel oil or kerosene. This type of herbicide application can be made any time of the year. Basal bark treatments are a good choice for tree species that typically resprout.

Frill Applications

In frill treatments a hatchet is used to peel the bark back exposing the cambium tissue. Herbicides are then applied to the exposed cambium tissue. Herbicides with good translocation work well with this method. Imazapyr and glyphosate are good choices for this method of treatment. These methods work well where only some trees need to be removed and others left. There is also a device know as the Hypo-Hatchet that will inject the herbicide at the same time the frill is being made.

Stump Treatments

Many trees that need to be removed will need to have the remaining stump treated with herbicides to stop resprouting. After the tree is cut down the cut surface needs to be treated within one to two hours. The best method is to treat the cut surface right after cutting the tree. The herbicide can be applied to the surface or cuts can be made into the trunk and filled with the herbicide. This kind of treatment can be used in spring, summer, or fall. Some of the best results occur in the fall when the trees are moving food stores into the roots. The herbicide is moved into the roots with the food.

WETLAND HERBICIDE APPLICATIONS

Road departments and others that manage right-of-ways will sometimes have to spray weeds in wetland areas. When road construction moves into a wetland area, any of the wetland that is destroyed must be replaced. These man made wetlands are like any other disturbed site. One of the first plants to show up is usually a weed. Invasive or noxious weeds still need to be controlled. This means that herbicides will need to be applied on wetland areas.

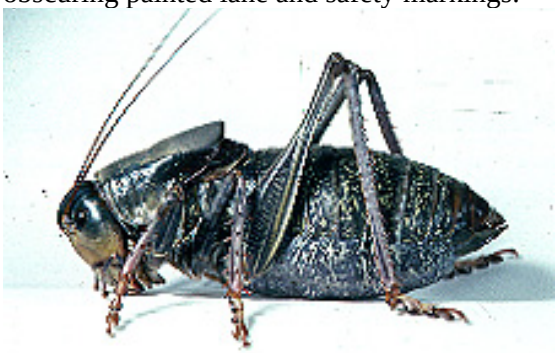
Where possible, hand pulling or digging with a shovel to remove weeds can be done to protect the wetland area. This labor intensive process has limited applications and often will not work on noxious weed species. To treat weeds in a wetland, a pesticide applicator must be certified and licensed in aquatic pest control. The procedure for controlling weeds with herbicides in wetland areas is similar to other pesticide application guidelines.

Identify the weed species on the site that will be treated with herbicides. Determine if the herbicides will come in contact with water. If

water will move off the application site, determine what vegetation will be encountered by the water's movement. Select the best herbicide for the site and weed species to be treated. Read the pesticide label and follow all of the requirements for safe application. Make sure the herbicide is labeled for aquatic application sites.

MORMON CRICKET PROBLEMS

Mormon crickets are insects native to the western United States. These insects negatively impact crop production in many states. Some years Mormon cricket infestations reach levels where there are millions per square mile. They also cause damage to vegetation on right- of-ways and their dead bodies cover roadways. As drivers run over the thousands of crickets on the road, a slick mess accumulates on the road surface, obscuring painted lane and safety markings.



Mormon crickets must be managed on right-of-ways for several reasons. Road surfaces must remain clean for safe travel and these insects must be controlled to reduce their damage to preferred roadside vegetation and the surrounding vegetative and crop areas. A common method used to control Mormon crickets is with poison bait. Baits are products such as oatmeal laced with insecticides. Such baits should be used carefully because they can be hazardous to wildlife, specifically birds.

There are several insecticides used for large scale control of Mormon crickets. Included are acephate, carbaryl, diflubenzuron, and malathion. These insecticides are available in liquid formulations for aerial applications or as granules. They can be purchased in granules or premixed with bait. The most effective method for right-of-way baiting is to spread the mixture along the roadside in front of moving crickets. This reduces the cricket numbers and helps keep them off roadways.

V. Equipment Operation and Pesticide Safety

EQUIPMENT OPERATION

Pesticide application equipment must be properly operated and the application rate must be correctly calibrated for safe and effective herbicide applications. Under application and over application of pesticides are common causes of pest control failures. Application equipment should be calibrated at the start of each season and then periodically checked for accuracy. Recalibration will be necessary when pesticide types are changed or when equipment operation varies. Although pesticide equipment is calibrated in a variety of different ways, the calibration of spray equipment typically involves the measurements of nozzle flow rate and equipment travel speed. Manufacturers provide detailed instructions for the operation, maintenance, and calibration of equipment. These guidelines, in conjunction with the pesticide label instructions should be the primary guides for safe equipment operation.

NOZZLE FLOW RATE

Nozzle flow rate is critical to the accurate application of pesticides. Nozzle flow rate depends on the following variables.

1. Nozzle type and size: Different nozzles can provide different flow rates and/or patterns when operated at the same pressure. Manufacturers provide detailed information related to the performance of each nozzle size and type when operated with certain liquid materials and at various operation pressures.
2. Pressure: Flow rate is related to pressure. As pressure in pounds per square inch increases, flow rate increases. As pressure decreases, flow rate decreases. Small adjustments in flow rate are achieved with changes in pressure. Larger changes in flow rate require a change in the travel speed and/or replacement of nozzle size and type.
3. Nozzle wear: As a nozzle wears, orifice size slowly increases. The result is an increased flow rate from the worn nozzle and a reduction in pressure for other nozzles on the same system. In instances where abrasive chemicals are sprayed, excessive nozzle wear may occur within a few days. In a multi-nozzle system, if the flow rate of any one nozzle differs more than 10 percent from the average of all the nozzles, then that nozzle should be replaced.
4. Blocked passages: Debris can block screens and orifices, reduce flow rates, and/or alter spray patterns. Frequently, a visual inspection of spray patterns will detect a blockage. Passages, screens, and orifices should be cleaned periodically and visual inspections made regularly.
5. Flow properties of the carrier: Nozzle flow rates provided by manufacturers normally reflect an application rate based on water as the carrier. In situations where carriers heavier or lighter than water are used, the flow rate changes. Some manufacturers provide charts showing alternative nozzle selections and/or pressure settings for liquids such as petroleum based products with densities different from water.

EQUIPMENT TRAVEL SPEED

Knowing the actual speed of spray equipment is essential. Errors in travel speed are a common cause of pesticide misapplications. Modern on board global positioning equipment and radar speed sensors have greatly improved the accuracy for application equipment. Small inaccuracies in travel speed can result in excessive under or over applications of pesticides.

To accurately determine travel speed the equipment must travel over a predetermined distance under actual application conditions. Measurements for this test are more accurate with a longer distance such as 300 feet rather than a shorter distance such as 50 feet. While traveling at operating speed, multiple trips are made and the time for each is recorded. Times are then averaged to calculate approximate travel speed. Throttle and/or gear settings are then adjusted to achieve correct travel speed. Chapter VIII of this manual has formulas to assist with equipment calibration. Both travel speed, in miles per hour, and application rate, in gallons per minute, may need to be adjusted to fine tune the spray application rates.

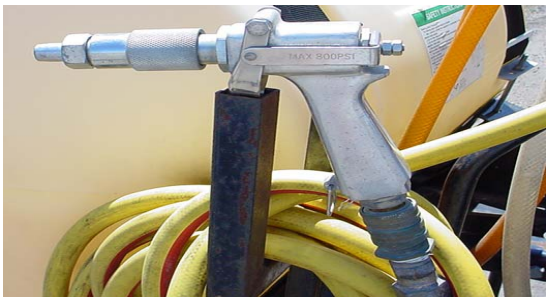
In general, spray applications are calibrated by measuring the volume of liquid delivered during one minute of time and the determination of how much area can be sprayed during one minute of operation. Typical application rates are gallons per acre or ounces per 1000 square feet.

HAND HELD SPRAYERS

When calibrating a hand held sprayer, the volume of water sprayed is collected in a container for a given period of time. Collection times such as 15, 20, 30, or 60 seconds are used and the calculations are done to determine ounces or gallons per minute.

The hand held spray gun is then used to spray water over a predetermined area such as 100, 500, or 1000 square feet. This test will provide the time required to spray a known area. The values are then used to calculate gallons per acre or ounces per 1000 square feet.

The common formulas used to calculate calibration values are listed in Chapter VIII of this manual. In addition to equipment calibration, the proper dilution of the concentrated pesticide formulation is also necessary to achieve correct application rates.

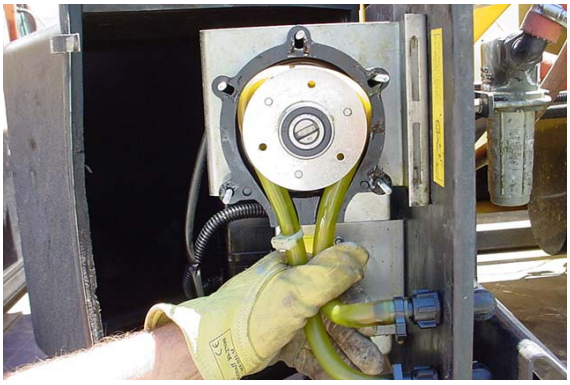


INJECTION PUMP SPRAYERS

It is common for liquid pesticides to be diluted with water in large tanks and then for that mixture to be sprayed. This type of dilution relies on predetermined information such as total area to be sprayed and how much time is required to complete a spray application. This type of tank mixing is sometime problematic. If estimates are incorrect or conditions change, then too little mixture may have been prepared or excessive mixture may remain after spraying is complete.

Injection pump sprayers mix the pesticide and water or other carrier at the point of release rather than in the storage tank. This allows accurate pesticide applications without having to transport or store large quantities of diluted pesticide mixtures. The concentrated pesticide is injected into a flowing stream of water or other carriers just prior to being sprayed from the nozzle.

When this improved technology is combined with modern satellite technology, detailed measurement, tracking, and mapping of spray applications are possible. The calibration of injector pumps involves holding a flexible tube against a set of rollers so that the equipment can be adjusted for accurate injection of concentrated pesticide into a stream of water or other carrier.



The calibration of such equipment is similar for different manufacturers, but each set of calibration guidelines should be followed in detail to assure accurate application rates. When calibrating equipment, the equipment should be clean and no pesticide should be released in a manner that will present a hazard to humans or the environment.

PESTICIDE SAFETY

The majority of pesticides are poisons that were manufactured to kill unwanted organisms. They should be stored, handled, and applied with care. Pesticides with a restricted use pesticide (RUP) designation present a particular hazard to humans and/or the environment and can only be used by certified and licensed pesticide applicators.

Pesticide toxicity values are a measure of the harmful effects on animals and are indicative of how humans may react when exposed to the product. The toxicity values are not the only hazardous factor associated with exposure to pesticides. A pesticide's active ingredients may be extremely toxic but the pesticide formulation may present very little hazard due to dilution, low volatility, specialized packaging, or restricted handling criteria.

A pesticide with a low toxicity may be quite hazardous because of the high volatility, prolonged or frequent exposure by applicators, a tendency to be mishandled, and/or a high concentration of active ingredients. In general, herbicides and fungicides are less toxic than insecticides or rodenticides. Pesticides with higher acute oral LD50 values are less toxic than pesticides with lower LD50 values. The LD50 value represents the quantity of active ingredient required to kill one half of the test animal population. The pesticide label is the best source of information for determining how to safely handle pesticides.

When mixing, loading, or applying pesticides, applicators can be exposed through oral, dermal, occular, or respiratory routes. Oral exposure occurs when pesticide is swallowed. Spray droplets, mists, splashes, ruptured hoses, and accidental drinking or eating are examples of how this can happen. Under normal operating conditions this is considered the least likely route of exposure.

It has been determined that for pesticide applicators, the extent to which dermal exposure occurs is much greater than respiratory exposure. However, a dermally deposited pesticide is outside of the body which allows for cleaning and removal. A respiratory dose is inside the body and cannot be readily removed.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

The protective clothing worn when mixing, loading, or applying pesticides provides a barrier between the pesticide and the human body. Respirators and gas masks protect against oral and respiratory exposure by covering the nose and mouth and by filtering inhaled air. Gloves, boots, hats, and body coverings protect against dermal exposure. Glasses, goggles, and face shields protect the eyes.

Respirators can be half face (cover nose and mouth) or full face (cover nose, mouth and eyes). Gas masks are full face and generally have replaceable filter cartridges. Pesticide users need cartridges specifically made for pesticides. Cloth masks or dust masks are not recommended, as they provide no protection against vapors. Full face respirators provide both respiratory and eye protection and are needed when irritating or highly toxic fumes and/or vapors are a concern.

Body coverings can be made of cotton, blended fabric, vinyl, neoprene, rubber, or lightweight synthetic garments. Almost any body covering provides some protection. Conventional work clothes, usually of cotton or blended fabric, provide protection when mixing, loading, or applying dry or dilute field concentrations of pesticides. They are not recommended during mixing and loading of liquid concentrates or liquid spray applications where contact is likely to occur.

Vinyl, neoprene, or rubber garments provide adequate protection if kept free of chemical contamination, but under hot and/or humid conditions they can be very uncomfortable and can lead to heat exhaustion or hyperthermia. Lightweight synthetic garments can provide

adequate protection if used in conjunction with a liquid proof apron during mixing and loading. These garments can have added coatings for additional protection when spraying more toxic pesticides.

Important points to keep in mind are that applicators often begin spray operations wearing minimal protective clothing and then add more at a later point thus covering the contaminated skin or garments; this may increase dermal absorption of the pesticide that is under the added protective clothing. Secondly, hot weather may increase the rate of dermal absorption when spray applicators tend to use less protective clothing.

Foot protection is always important when working with pesticides, especially when mixing and loading liquid concentrates and when walking through sprayed areas. Boots and shoes made of leather or canvas are not recommended when working with liquid pesticides as they absorb the liquids and hold them against the foot. They are difficult to decontaminate, and the continual wetting and drying causes cracking which makes pesticide penetration to the foot even easier.

Rubber boots are best for working with organophosphate insecticides while all waterproof boots are generally adequate for other pesticides. Boots should be worn with the pant legs on the outside to prevent pesticides from entering the top of the boot. Boots should be unlined for easy cleaning.

Gloves are helpful during all pesticide operations, but especially during mixing and loading of liquid concentrates. Canvas, cloth, or leather gloves should not be used for liquid operations for the same reasons as with canvas or leather boots. Lightweight plastic and rubber gloves provide some protection, but heavyweight waterproof gloves are recommended. Gloves should be unlined and have a cuff or anti-drip line so liquids do not run down the arm. Rubber gloves are recommended for organophosphate insecticides. Rubber or plastic gloves are suitable for most other pesticides.

Head protection should always be worn when working with pesticides especially during liquid spray operations. Billed caps provide some protection but not to the lower head, neck, and ear areas. Additionally, they absorb pesticides and are difficult to decontaminate.

Plastic hard hats with wide brims and nonabsorbing liners are better. However, because of air circulation space over the head, they are not adequate protection when working with highly toxic mists and dusts.

Southwester style hats (those with a wide slanting brim longer in back than in front) are most often recommended. Generally they have brims that protect the front, side, and back of the head and neck. A front brim is very beneficial protection against downward drift to the face. Waterproof hoods provide little face protection unless they have front brims.

Eye protection is important during mixing and loading operations with all pesticides especially liquids or where irritating fumes or vapors may be present. Full face respirators are recommended for eye protection against highly toxic pesticides. Face shields provide protection against pesticide splash but not dusts, mists, fumes, or vapors. Cup goggles will seal out splashes, mists, dusts, fumes, and vapors. Single lens goggles with hooded or baffled ports protect against splashes, mists, and dusts but not fumes or vapors.

All protective clothing must be kept clean and be decontaminated after use. Failure to do this can make exposure more severe than if no protective clothing were used. Contaminated protective clothing holds the pesticide against the skin frequently under hot moist conditions which can lead to increased rates of absorption.

Wash protective clothing in detergent and water and air dry preferably exposed to sunlight. Check the condition of protective clothing periodically and replace torn or perforated items. Change respirator cartridges as recommended by the manufacturer or whenever chemical odors are detected during use or when breathing becomes difficult because of filter plugging. Always have spare cartridges available. Wash the face piece, with the filters removed, in detergent and water, rinse thoroughly, and dry in a well ventilated area. Do not use alcohol or solvents to clean the face piece.

PESTICIDE LABEL

The information on the pesticide label is legal documentation of the requirements for handling and application of the product. The label information must be followed whenever the product is being handled or applied. The pesticide label contains information about the types of Personal Protective Equipment (PPE) needed for each pesticide.

The label also contains information on the formulation, EPA registration number, active ingredients and hazard statements. The hazard statement is the toxicity rating of the pesticide. Pesticide labels also include signal words such as danger, warning, or caution.

Danger

Labels that have "danger" on the label belong to group 1 pesticides. These are usually the most toxic of the pesticides, and will often have danger, poison, and/or the skull and cross bones on the label.

Warning

Pesticides that have "warning" on the label belong to group 2 and are moderately toxic. The label will have a hazard warning such as it causes burns, it is irritating to skin and eyes, or it is harmful if swallowed.

Caution

Labels with the signal word "caution" on the label belong to group 3 pesticides and generally the least toxic. These pesticides will have hazard warnings like it causes eye irritation or it is harmful if swallowed.

PESTICIDE CONTAINER DISPOSAL

Disposal of empty pesticide containers should be done according to the instructions on the pesticide label. Containers that are to be triple rinsed should also be damaged to prevent reuse. After triple rinsing they should be destroyed by crushing or puncturing. After containers have been properly triple rinsed, they can be disposed of with other refuse. When pesticide containers are burned, the smoke can be dangerous. Empty containers from 2,4-D and other growth regulating materials should not be burned.

Triple Rinsing

1. Empty the container into the spray tank. Let it drain 30 seconds.
2. Fill the container one-fifth to one-fourth full of water.
3. Replace the closure and rotate the container for about 30 seconds. Invert the container so the rinse reaches all the inside surfaces.
4. Drain the rinse water from the container into the tank. Let the container drain for 30 seconds.
5. Repeat steps 2 through 4 two more times for a total of three rinses.

PESTICIDE SPILLS

A pesticide spill can pose a serious threat to people and the environment. There are several actions that need to be taken when there is a pesticide spill. A common strategy to handle spills is referred to as the three "Cs" for pesticide spills. The first step is to control the spill. Stop the leak and prevent any further release of the pesticide. The second step is to contain the spill. Use a safe procedure to prevent the spilled pesticide from moving away from the spill sight. This is very important if off target movement will threaten people or present a greater contamination hazard for the environment. Spill kits and other containment strategies are the best option to achieve step two, The third and sometimes the most difficult step is to clean up the spill. Small spills on surfaces such as concrete or asphalt are easily handled with a spill kit or containment material followed by a soap and water cleaning. Larger spills and spills on materials that allow pesticide penetration or rapid off target movement present greater problems. In instances where public right-of-ways are involved, a large spill will involve public authorities and more elaborate mitigation strategies.

SUMMARY

Knowledge and experience with integrated vegetation management (IVM) programs and a thorough understanding of plants, soils, and pesticides are important for right-of-way managers. Picking the right herbicide for the target species and knowing how that herbicide will react with the soil and terrain in critical. Properly identifying the pest, selecting the appropriate control strategy, and timing the control operations for optimum outcomes

results in a more effective and economical program. Setting threshold limits for response to problem species and prioritizing annual goals is important. Managing equipment and labor with the proper selection of mechanical, biological, chemical, and cultural management options are necessary. As are the follow up and adjustment management decisions based on successes and failures of ongoing right-of-way management decisions.

VI. WORKER PROTECTION STANDARD

The U.S. Environmental Protection Agency's Worker Protection Standard (WPS), as revised in 1992, must be complied with when pesticides are used on agricultural establishments, including farms, forests, nurseries, and greenhouses, for the commercial or research production of agricultural plants. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these instructions include owners or operators of agricultural establishments and owners or operators of commercial businesses that are hired to apply pesticides on the agricultural establishment or to perform crop-advising tasks on such establishments. Family members who work on an agricultural or commercial pesticide establishment are considered employees in some situations.

WPS requirements for employers include:

- **Displaying information** about pesticide safety, emergency procedures, and recent pesticide applications on agricultural sites.
- **Training** workers and handlers about pesticide safety.
- Helping employees get **medical assistance** in case of a pesticide related emergency.
- Providing **decontamination sites** to wash pesticide residues off hands and body.
- Compliance with **restricted entry intervals** (REI)– the time after a pesticide application when workers may not enter the area.
- **Notifying** workers through posted and/or oral warnings about areas where pesticide applications are taking place and areas where REI are in effect.
- Allowing only **trained and equipped workers** to be present during a pesticide application.
- Providing **personal protective equipment** (PPE) for pesticide handlers and also for workers who enter pesticide treated areas before expiration of the REI.
- **Protecting pesticide handlers** by giving them safety instructions about the correct use of pesticide application equipment and PPE and monitoring workers and handlers in hazardous situations.

One of the provisions of the WPS is the requirement that employers provide handlers and workers with ample water, soap, and single use towels for washing and decontamination from pesticides and that emergency transportation be made available in the event of a pesticide poisoning or injury. The WPS also establishes REI and the requirements for PPE. PPE requirements are specified for all pesticides used on farms and in forests, greenhouses, and nurseries. Some pesticide products already carried REI and PPE directions. This rule raised the level of protection and requirements for all pesticide products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training. Handlers must have easy access to pesticide label safety information and a listing of treatment sites must be centrally located at the agricultural facility. Handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

References: ***The Worker Protection Standard for Agricultural Pesticides–How to Comply: What Employers Need to Know***. Web site <www.usda.gov/oce/oce/labor-affairs/wpspage.htm>.

VII. PROTECTING GROUNDWATER AND ENDANGERED SPECIES

INTRODUCTION

Federal and state efforts to protect groundwater and endangered species have resulted in special requirements and restrictions for pesticide handlers and applicators. Pesticides that are incorrectly or accidentally released into the environment can pose a threat to groundwater and endangered species. Whether pesticides are applied indoors or outdoors, in an urban area or in a rural area, the endangered species and groundwater must be protected and state and federal agencies rigidly enforce this requirement.

The need for special action by the pesticide handler/applicator depends on site location. Groundwater contamination is of special concern in release sites where groundwater is close to the surface or where the soil type or the geology allows contaminants to reach groundwater easily. In the case of endangered species, special action is normally required in locations where the species currently live or in locations where species are being reintroduced. The product labeling is the best source to determine if pesticide use is subject to groundwater or endangered species limitations.

The U.S. Environmental Protection Agency (EPA) establishes the specific limitations or instructions for pesticide users in locations where groundwater or endangered species are most at risk. These limitations and instructions may be too detailed for inclusion in pesticide labeling. In such cases the labeling will direct the applicator or handler to another source for instructions and restrictions. The legal responsibility for following instructions that are distributed separately is the same as it is for instructions that appear on the pesticide labeling.

PROTECTING

GROUNDWATER

Groundwater is water located beneath the earth's surface. Many people think that groundwater occurs in vast underground lakes, rivers, or streams. Usually, however, it is located in rock and soil. It moves very slowly through irregular spaces within otherwise solid rock or seeps between particles of sand, clay, and gravel. An exception is in limestone areas, where groundwater may flow through large underground channels or caverns. Surface water may move several feet in a second or a minute. Groundwater may move only a few feet in a month or a year. If the groundwater is capable of providing significant quantities of water to a well or spring, it is called an aquifer. Pesticide contamination of aquifers is very troubling, because these are sources of drinking, washing, and irrigation water.

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination. Formulation of the Utah Groundwater and Pesticide State Management Plan is a cooperative effort between federal, state, private agencies, producers, and user groups. It provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement, and implementation of groundwater strategies.

Utah recognizes that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of life, enhance outdoor activities, and give relief from annoying pests. The EPA has authorized the Utah Department of Agriculture and Food (UDAF) to enforce the protection of groundwater from pesticides.

The UDAF, in concert with cooperating agencies and entities, demands strict compliance with all pesticide labels, handling procedures, and usage to protect groundwater in the state.

Prevention of groundwater contamination is important, because once the water is polluted, it is very difficult and costly to correct the damage and in some instances impossible. City and urban areas contribute to pollution because water runoff can contain pesticides. Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers or water tables. Sandy soils allow more pollution to move than clay or organic soils, because clays and organic matter adsorb many of the contaminants. For more information about what groundwater is and where it comes from, read the study manual ***Applying Pesticides Correctly: A Guide for Private and Commercial Applicators.***

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establishes a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, the EPA can continue to register the pesticide. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that is not degraded or broken down and carry it to the groundwater via leaching.

There are many factors that influence the amount of pesticide contamination that can get into groundwater. The major factors are the soil type, soil moisture, persistence in soil, placement of the pesticide, frequency of application, pesticide concentration and formulation, pesticide water solubility, and precipitation. Each of these factors will influence the amount of pesticide that can penetrate the soil surface, leave the root zone, and percolate into groundwater.

Although some pesticides may have a high adsorption quality, when they are applied to sandy soil, they may still migrate to the water table because there are few clay particles or little organic matter to bind them. The management and use of pesticides is up to the individual applicator and/or landowner as to whether safe practices are used. Groundwater is a very valuable resource and it must be protected from pesticide contamination.

PROTECTING ENDANGERED SPECIES

The Federal Endangered Species Act lists the three classifications as endangered, threatened, and experimental. Endangered has the highest level of protection. The phrase “endangered species” is used when referring to these classifications. This Act was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. A portion of this Act requires EPA to ensure that these species are protected from pesticides.

EPA’s goal is to remove or reduce the threat to endangered species that pesticides pose. Achieving this goal is a portion of the larger continuing effort to protect species at risk. Normally these restrictions apply to the habitat or range currently occupied by the species at risk. Occasionally the restrictions apply where endangered species are being reintroduced into a habitat previously occupied.

Habitats are the areas of land, water, and air space that an endangered species needs for survival. Such areas include breeding sites, sources of food, cover, and shelter, and the surrounding territory that provides space for normal population growth and behavior.

Utah's endangered species plan is a cooperative effort between federal, state, private agencies, producers, and user groups. This plan provides agency direction for regulations, enforcement, management policies, and implementation of threatened and endangered species protection strategies.

EPA launched a major project known as Endangered Species Labeling (ESL). The goal is to remove or reduce the threat to endangered species from pesticides. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESL program is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The FWS reports to EPA concerning endangered species. EPA and FWS work cooperatively to ensure that there is consistency in the pesticide restriction information provided to agencies and pesticide users.

The UDAF acts under the direction and authority of EPA to carry out the ESL project as it relates to the use of pesticides in Utah. Utah's web sites with maps designating the habitat boundaries and listings of endangered plants and wildlife is: www.utahcdc.usu.edu .

VIII. CALIBRATION INFORMATION

Conversion:
Units

One acre = 43,560 square feet Example: ½ acre = 21,780 square feet
One mile = 5,280 feet Example: ¼ mile = 1320 feet
One gallon = 128 fluid ounces Example: ½ gallon = 64 fluid ounces
One quart = 2 pints = 4 cups = 32 fluid ounces Example: 2 quarts = 64 fluid ounces
One pint = 2 cups = 16 fluid ounces Example: ½ pint = 1 cup = 8 fluid ounces
One tablespoon = 3 teaspoons = 0.5 fluid ounces Example: 2 tablespoons = 1 fluid ounce
One pound = 16 ounces Example: ¼ pound = 4 ounces
One gallon = 231 cubic inches Example: 2 gallons = 462 cubic inches

Weights

1 ounce = 28.35 grams
16 ounces = 1 pound = 453.59 grams
1 gallon water = 8.34 pounds = 3.785 liters = 3.78 kilograms

Liquid Measures

1 fluid ounce = 2 tablespoons = 29.573 milliliters
16 fluid ounces = 1 pint = 0.473 liters
2 pints = 1 quart = 0.946 liters
8 pints = 4 quarts = 1 gallon = 3.785 liters

Lengths

1 foot = 30.48 centimeters
3 feet = 1 yard = 0.9144 meters
16 1/2 feet = 1 rod = 5.029 meters
5280 feet = 320 rods = 1 mile = 1.6 kilometers

Areas

1 square foot = 929.03 square centimeters
9 square feet = 1 square yard = 0.836 square meters
43560 square feet = 160 square rods = 1 acre = 0.405 hectares

Speeds

1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

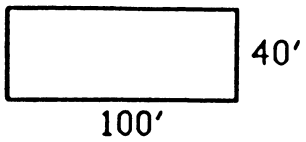
Volumes

27 cubic feet = 1 cubic yard = 0.765 cubic meters
1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

Area and Volume Calculations:

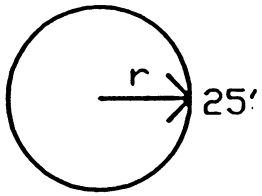
Area of Rectangular or Square Shapes

The area of a rectangle is found by multiplying the length (L) times the width (W).
(Length) x (Width) = Area
Example: (100 feet) x (40 feet) = 4000 square feet



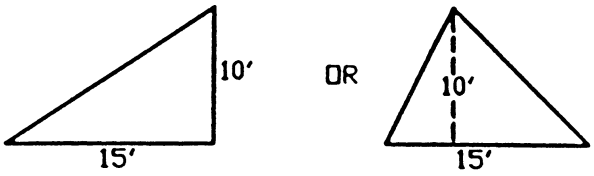
Area of Circles

The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.
(radius) x (radius) x (3.14) = Area
Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet



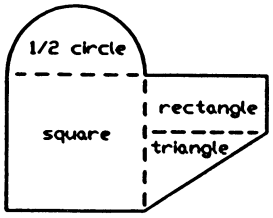
Area of Triangular Shapes

To find the area of a triangle, multiply ½ times the width of the triangle's base, times the height of the triangle.
(½) x (base width) x (height) = Area
Example: (½) x (15 feet) x (10 feet) = 75 square feet

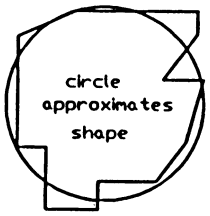


Area of Irregular Shapes

Irregularly shaped sites can often be reduced to a combination of rectangles, circles, and triangles. Calculate the area of each shape and add the values together to obtain the total area.
Example: Calculate the area of the rectangle, triangle, square, and one-half of a circle.



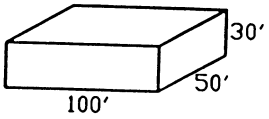
Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.
Example: Approximate the area by calculating the area of a similarly sized circle.



Volume of Cube and Box Shapes

The volume of a cube or box is found by multiplying the length, times the width, times the height.
(Length) x (Width) x (Height) = Volume

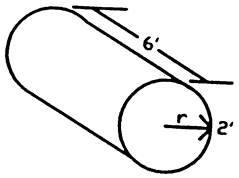
Example: (100 feet) x (50 feet) x (30 feet) = 150,000 cubic feet



Volume of Cylindrical Shapes

The volume of a cylinder is found by calculating the area of the round end (see formula for circle) and multiplying this area times the length or height.

Example: (radius) x (radius) x (3.14) = Area of Circle
(Area of Circle) x (Length) = Volume of Cylinder
(2 feet) x (2 feet) x (3.14) x (6 feet) = 75.36 cubic feet



Sprayer Calibration Formulas:

To Calculate Travel Speed in Miles Per Hour

The travel speed of a sprayer is determined by measuring the time (seconds) required to travel a know distance (such as 200 feet). Insert the values in the following formula to determine the miles per hour.

$$\frac{\text{Distance in Feet x 60}}{\text{Time in Seconds x 88}} = \text{Miles Per Hour}$$

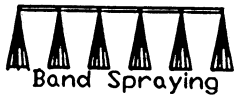
Example: $\frac{\text{(200 feet) x (60)}}{\text{(30 seconds) x (88)}} = \frac{12{,}000}{2640} = 4.55 \text{ mph}$

To Calculate the Gallons Per Minute Applied During Broadcast Spraying

The application rate in gallons per minute (GPM) for each nozzle is calculated by multiplying the gallons per acre (GPA), times the miles per hour (MPH), times the nozzle spacing in inches (W); then dividing the answer by 5940. For small adjustments in GPM sprayed, operating pressure is changed. For large adjustments in GPM sprayed, travel speed (miles per hour) is changed or nozzle size is changed.

$$\frac{\text{GPA x MPH x W}}{5940} = \text{GPM}$$

Example: $\frac{\text{(12 GPA) x (4.5 MPH) x (24”)}}{5940} = \frac{1296}{5940} = 0.22 \text{ GPM}$



To Calculate the Gallons Per Minute Applied During Band Spraying

Broadcast spraying applies chemicals to the entire area. Band spraying reduces the amount of area and chemicals sprayed per acre. To use the above formulas for band sprayer applications, use the band width (measured in inches) rather than nozzle spacing for the “W” value.

Pesticide Mixing:

Terminology

The ***active ingredients*** of a pesticide are the chemicals in a formulation that control the target pests. The ***formulation*** is the pesticide product as sold, usually a mixture of concentrated active ingredients and an inert material. Restricted use pesticides are purchased in formulations requiring ***dilution prior to application***. Formulations are diluted with inert substances such as water. The ***percentage of active ingredients*** in a pesticide formulation directly affects dilution and application rates. Given two pesticides, A = 50% active ingredients, B = 100% active ingredients; twice as much pesticide A formulation is required to equal pesticide B formulation.

To Determine the Total Amount of Pesticide Formulation Required Per Tank

To calculate the total amount of pesticide formulation needed per spray tank, multiply the recommended dilution, ounces/pints/cups/teaspoons/tablespoons/etc. of pesticide per gallon of liquid, times the total number of gallons to be mixed in the sprayer. A full or partial tank of pesticide spray may be mixed.

(Dilution Per Gallon) x (Number of Gallons Mixed) = Required Amount of Pesticide Formulation

Example: (3 ounces per gallon) x (75 gallons) = 225 ounces

Note: 1 gallon = 128 ounces; through unit conversion 225 ounces = 1.76 gallons

To Calculate the Amount of Pesticide Formulation Sprayed Per Acre

The calculate the total amount of pesticide formulation sprayed per acre is determined by multiplying the quantity of formulation (ounces/pounds/pints/cups/teaspoons/tablespoons/etc.) mixed per gallon of water, times the number of gallons sprayed per acre.

(Quantity of Formulation Per Gallon) x (Gallons Sprayed Per Acre) = Formulation Sprayed Per Acre

Example: (1/2 pound per gallon) x (12 gallons per acre) = 6 pounds per acre

To Calculate the Amount of Active Ingredients Sprayed Per Acre

The total amount of active ingredients (AI) applied per acre, multiply the amount (pounds, gallons, ounces, etc) of pesticide formulation required per acre, times the percentage of active ingredients in the formulation (100%, 75%, 50%, 25%, etc.), and divide the value by 100.

$$\frac{\text{(Amount of Formulation Required Per Acre) x (Percentage of AI)}}{100} = \text{Active Ingredients Per Acre}$$

Example: $\frac{\text{(4 pounds formulation sprayed per acre) x (75\% AI)}}{100}$ = 3 pounds of AI sprayed per acre

Note: 75 % = 0.75

To Calculate the Gallons of Pesticide Mixture Sprayed Per Acre

The total amount of pesticide mixture sprayed per acre is determined by dividing the number of gallons sprayed by the number of acres sprayed.

$$\frac{\text{Gallons Sprayed}}{\text{Acres Sprayed}} = \text{Gallons Sprayed Per Acre}$$

Example: $\frac{\text{200 Gallons Sprayed}}{\text{10 Acres Sprayed}}$ = 20 gallons of pesticide mixture sprayed per acre

Appendix 1. Utah Noxious Weeds

Updated October 2008

The following weeds are officially designated and published as noxious for the State of Utah, as per the authority vested in the Commissioner of Agriculture under Section 4-17-3, Utah Noxious Weed Act:

Bermudagrass*****	*Cynodon dactylon*
Black henbane	*Hyoscyamus niger*
Canada thistle	*Cirsium arvense*
Dalmatian toadflax	*Linaria dalmatica*
Diffuse knapweed	*Centaurea diffusa*
Dyers woad	*Isatis tinctoria L.*
Field bindweed (Wild Morning Glory)	*Convolvulus arvensis*
Hoary cress	*Cardaria Spp.*
Houndstongue	*Cynoglossum officinale*
Johnsongrass	*Sorghum halepense*
Leafy spurge	*Euphorbia esula*
Medusahead	*Taeniatherum caput-medusae*
Musk thistle	*Carduus nutans*
Ox-Eye daisy	*Chrysanthemum leucanthemum*
Perennial pepperweed	*Lepidium latifolium*
Perennial sorghum	*Sorghum halepense L. & Sorghum almum*
Poison hemlock	*Conium maculatum*
Purple loosestrife	*Lythrum salicaria L.*
Quackgrass	*Agropyron repens*
Russian knapweed	*Centaurea repens*
Saltcedar	*Tamarix ramosissima*
Scotch thistle	*Onopordum acanthium*
Spotted knapweed	*Centaurea maculosa*
Squarrose knapweed	*Centaurea squarrosa*
St. John’s wort	*Hypericum perforatum*
Sulfur cinquefoil	*Potentilla recta*
Yellow starthistle	*Centaurea solstitialis*
Yellow toadflax	*Linaria vulgaris*

*****Bermudagrass is not a noxious weed in Washington County and is subject to provisions of the Utah Noxious Weed Act within the boundaries of that county.

See additional noxious weeds by Counties in Utah on the next page.

Noxious Weeds Declared By Utah Counties

October 2008

County	Weeds
Beaver	Bull thistle
Cache	Goatsrue, Puncturevine
Carbon	Russian olive
Davis	Yellow nutsedge, Buffalobur
Duchesne	Russian olive
Iron	Western whorled milkweed
Juab	Blue flowering lettuce
Millard	Buffalobur
Morgan	Puncturevine, Burdock
San Juan	Silverleaf nightshade, Buffalobur, Whorled milkweed, Jointed goatgrass, Camelthorn
Sanpete	Velvetleaf
Sevier	Russian olive
Tooele	Jointed goatgrass
Uintah	Russian olive
Washington	Poison milkweed, Silverleaf nightshade
Wayne	Russian olive
Weber	Puncturevine

GLOSSARY OF TERMS

A

ACTIVE INGREDIENT - The chemical(s) in a pesticide responsible for killing, poisoning, or repelling the pest.

ANTICOAGULANT - A chemical that prevents normal blood clotting.
ANTIDOTE - A treatment to counteract the effects of poisoning.
APPLICATION - The process of spreading something on or over the surface of objects or materials.
ATTRACTANT - A substance or device that will lure pests to a trap or poison bait.

B

BACTERIA - Microscopic organisms, some of which are capable of producing diseases in plants and animals.
BAIT - A food or other substance used to attract a pest to a pesticide or trap.
BIOLOGICAL CONTROL - Control of pests by means of predators, parasites, disease-producing organisms or competitive microorganisms.

C

CONCENTRATION - The amount of active material in a given volume of diluent.

CONTACT REPELLENT - A compound that the pest must make contact with for the substance to repel pest.

CONTAMINATION - The presence of an unwanted substance in or on plants, animals, soil, water, air, or structures.

CULTURAL CONTROL - A pest control method that includes changing sanitation and/or work practices.

D

DECONTAMINATE - To remove or break down a chemical from a surface or substance.

DERMAL TOXICITY - Injury when absorbed through the skin.
DIAGNOSIS - The identification of the nature or cause of problem or fault.
DOSE OR DOSAGE - Amount or rate of chemical applied to a given area or target.

E

ECOSYSTEM - The physical and biotic factors that allow infestation by pests.
ECTOPARASITE - A parasite that lives on the outside of its host.
ENDANGERED SPECIES - Legally classified as a species in danger of extinction.
ENDOPARASITE - A parasite that lives inside its host.
ERADICATION - Pest management strategy that attempts to eliminate all members of a pest species.
EVALUATION - To examine or investigate for the purpose of judging the value, extent, or success.
EXPOSE - To be subjected to or come in contact with a material.
EXPOSURE ROUTE - The dermal, oral, or inhalation (respiratory) route by which a substance may enter an organism.

F

FORMULATION - Pesticide as prepared by the manufacturer.

FUMIGANT - Pesticide that controls by giving off fumes.

G

GROUNDWATER - Water sources located beneath the soil surface from which water is obtained.

H

HARBORAGE - A site that shelters and provides the food and water required for a particular organism to survive.
HOST - Plant or animal that is invaded by a parasite and from which the parasite gets its nutrients.

I

INERT INGREDIENT - In a pesticide formulation it is an inactive material without pesticidal activity.

INSPECTION - A critical examination an evaluation aimed at forming a judgment or determination.
INTEGRATED PEST MANAGEMENT (IPM) - A planned pest control program in which various techniques are used to keep pests from causing economic, health related, or aesthetic injury.

L

LEACHING - Process by which some pesticides move through the soil.

N

NONLETHAL – Not capable of causing death.

NONTARGET ORGANISM - Any plant or animal other than the intended target of a pesticide application.

P

PARASITE - An organism that lives on or in a living host and that gets all or part of its nutrients from the host.
PATHOGEN - Any organism capable of causing disease.
PERCOLATE - To pass slowly through a material or spread throughout a place.
PERSISTENCE - To have a continued or prolonged effect after treatment.
POLLUTION - The act of polluting or contaminating the environment with harmful chemicals or waste products.
PRECIPITATION - The formation of a suspension of an insoluble compound by mixing two solutions.
PRESCRIPTION - A proven formula for the control of pests.
PREVENTION - An action that makes it impossible or very difficult for an unwanted activity to happen.
PHYTOTOXICITY - Injury to plants by a chemical.
PREDATOR - An animal that attacks, kills, and feeds on other animals.

R

RATE OF APPLICATION - The amount of pesticide applied, usually measured as per acre, per 1,000 square feet, per linear foot, or per cubic foot.
RE-ENTRY INTERVAL - The length of time following an application of a pesticide when entry into the areas is restricted.

REPELLENT - A compound that keeps pests away.

RISK - A probability of an adverse effect in a given situation.

RODENTICIDE - A pesticide used to control rodents.

S

SIGNAL WORDS - Required word(s) that appear on every pesticide label to denote the relative acute toxicity of the product.
SOLUBILITY - The extent to which one substance is able to dissolve in another.
SURFACE WATER - Water on the earth's surface in rivers, lakes, ponds, streams, etc.

T

TARGET - The plants, animals, structures, areas, or pests at which the pesticide or other control method is directed.
TOXIC - Poisonous to living organisms.
TOXICITY - The degree or extent to which a chemical or substance is poisonous.

V

VECTOR - An animal that can carry and transmit a pathogen.

W

WATER TABLE - The upper level of the water saturated zone in the ground.