ORNAMENTAL AND TURF PEST MANAGEMENT

Study Guide for Pesticide Application and Safety
Category 3

Utah Department of Agriculture and Food
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STUDY GUIDE FOR ORNAMENTAL AND TURF PEST MANAGEMENT

The educational material in this study guide is provided to assist pesticide applicators in preparing for the Ornamental and Turf category examination. This guide does not include all of the information needed for the examination. Other topics that are covered on the examination include detailed information on understanding and following pesticide label directions, emergency response, personal protective equipment (PPE), pesticide movement in the environment, mixing and handling pesticides, and additional application methods and equipment. Information on some of 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.

The ***National Pesticide Applicator Certification Core Manual*** and numerous other references can be accessed on the Utah Department of Agriculture and Food (UDAF) web site. The UDAF web site is located at <http://www.ag.state.ut.us/plantind/pest_app.html>.

The organizations involved in the preparation of this study guide were the Utah Department of Agriculture and Food, and Utah State University Extension. 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 and the appropriate pesticide rules for Utah.

The individuals in Utah State University Extension that contributed to the 2011 updates, revision, and reformatting of this manual were F.R. Beard and H.M. Deer.

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I. INTRODUCTION

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STUDY GUIDE

The ornamental and turf 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.

Utah pesticide applicators who are licensed to apply restricted use pesticides in the ornamental and turf category includes those using pesticides to control pests in the maintenance and production of ornamental trees, shrubs, flowers and turf. This includes controlling pests on home foundations, sidewalks, driveways, and other similar locations.

Successful pest managers depend on several control strategies including prevention, early detection, correct diagnosis, and the appropriate selection and timing of pest treatments. Plant protection practices must include the implementation of cultural practices that promote plant health and limit plant susceptibility to injury from pests. Pest management must evaluate the economics and efficacy of pesticide treatments and strictly adhere to pesticide label directions. Applicators are ultimately responsible for any injuries or damages that occur as a result of pesticide treatments.

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 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 million or parts per billion.

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.

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 of 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

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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 ornamental and turf landscapes. 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 ornamental and turf landscapes.

GRASSES

Grasses are the most common plant species found on ornamental and turf landscapes. Grasses are classified as monocots, which are plants that have one seed leaf at germination. Grasses are an important plant for ornamental and turf landscapes 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. Ornamental and turf landscapes 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 ornamental and turf landscapes. Most shrub species are not considered weeds. Some of the common shrub species found on ornamental and turf landscapes in the western states are sagebrush and rabbitbrush. 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 ornamental and turf landscapes 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. 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 0.05 to 2 mm. Silt range in size from 0.002 to 0.05 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 ornamental and turf landscapes manager should have a working knowledge of the soil underlying and adjacent to ornamental and turf landscapes.


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III. ORNAMENTAL PEST MANAGEMENT

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ORNAMENTAL PLANT DISEASES

A disease is anything that interferes with normal plant function. It can be biotic or pathogenic (caused by living organisms) or it can be abiotic or nonpathogenic (caused by physiological disorders). Powdery mildew is a disease caused by a living organism. Iron deficiency is a disease caused by a physiological disorder. A disease is not a condition, it is a process. Infectious organisms, unfavorable weather, mechanical injuries, or chemical injuries cause abnormal plant growth.

NONPATHOGENIC DISEASES

Physiological disorders can be the result of unfavorable weather, mechanical damage, nutrient deficiencies, excess salts, or toxic chemicals and are not caused by pathogens. Most plant diseases are nonpathogenic. These causes do not grow in or move from diseased to healthy plants. Pesticides are not appropriate and will not cure noninfectious diseases.

PATHOGENIC DISEASES

Once an infectious disease starts, the process continues until the causal agent or host plant is removed or environmental conditions prevent its development. Pathogens that cause infectious diseases grow in plant tissue and disrupt normal physiological functions. When pathogenic organisms grow, they produce billions of spores that spread to other plants, causing disease outbreaks. Disease management reduces or delays epidemics enough to let plants thrive. Pesticides are designed to stop pathogen growth on or within host plants and to protect healthy plants. For many pathogens there is no pesticide treatment currently available.

INFECTIOUS DISEASE DEVELOPMENT

The three things an infectious diseases needs for development are the presence of parasite organism, an available susceptible host, and favorable environmental conditions. Pesticides can stop pathogen development, inhibit pathogen development, and reduce host susceptibility without changing the conditions that are favorable to the host.

Favorable conditions for one infectious disease may be unfavorable for another. For example, white mold can damage some annuals under hot, moist conditions, but is less damaging during cool, dry periods. In contrast, botrytis or gray mold occurs under moist conditions below 60 degrees F.

Moisture extremes affect disease development. Fungi and bacteria prefer wet conditions to enhance spore production and release. Rose rust prefers high humidity while leaf spot in aspen or fire blight in pears requires free moisture such as dripping dews or splashing rains to spread. Light, wind, pH, fertility, and soil type influence disease development.

Environmental influences are very important for disease development. For example, sudden temperature drops increase susceptibility to fungal cankers. Waterlogged soil increases root rots and moist conditions increase scab and leaf spot. Pathogens must complete developmental cycles with spore production, dispersal, infection and resting.

Some diseases spread slowly to new hosts while others spread rapidly in a single season. Slow spreading diseases produce spores or other inoculum during the growing season and disperse them at the season's end or the beginning of the next season. Diseases that spread rapidly disperse their inoculum almost continuously. Pathogens on a few plants produce large amounts of inoculum infecting many susceptible hosts.

Pathogenic diseases are caused by fungi, bacteria, viruses, nematodes, parasitic seed plants, mycoplasmas, and actinomycetes. Fungi, (plural of fungus) are responsible for most plant diseases. Pathogens get there nutrients from other organisms. The pathogens that get nutrients from dead plant materials are saprophytes and those who get nutrients from living plants are parasites. Most pathogens penetrate plant tissue mechanically or chemically.

DIAGNOSING DISEASES

Distribution of diseased plants within an area provides valuable information for diagnosis. In early stages, infectious diseases attack scattered plants or small clusters and rarely affect large areas. Problems that occur suddenly and affect different plants are more likely noninfectious diseases.

Diagnosing or distinguishing diseases by characteristic signs and symptoms is essential. Signs and symptoms usually show together in diseased plants. Signs appear in the form of identifiable pathogen structures that occur with diseases. They include fungal spores, spore-producing bodies, bacterial ooze, and parts of parasitic plants. A hand lens or microscope helps identify signs.

Symptoms appear in the form of plant disease reactions. Common disease symptoms include plant tissue that is dead, overdeveloped, or underdeveloped. Tissue death or necrotic symptoms come from degeneration and death of plant parts. Necrotic symptoms and their definitions are as follows:

- Scorch or burn: Sudden death and browning of large areas
- Streaks and stripes: Elongated, narrow, parallel necrotic lesions associated with leaf veins
- Net necrosis: Irregular interlocking necrotic lines
- Blight: Foliage or blossoms suddenly killed by pathogenic organisms
- Blast: Blighting or sudden death of buds, flowers or fruit
- Die back: Dying back from tips of twigs or branches
- Spot: Circular, dead areas on foliage
- Shot hole: Dropping out of necrotic tissue from foliage, leaving circular holes
- Pitting: Depressions of dead fleshy tissue under intact skin of fruits and tubers
- Mummification: Dried, wrinkled, rotted fruits that stay on the plant
- Rot: Decomposing dead tissue
- Canker: Sunken necrotic lesions on stems, tubers or roots
- Damping-off: Rot at the stem base so the plant falls over
- Leak: Soft rot in which juices leak out
- Bleeding: Chronic flow of sap (often fermented) from wounds

- Scald: Blanching of surface tissues, giving a pale or dirty brown color
- Gummosis: Viscous gum which oozes from wounds
- Resinosis: Abnormal exuding of resin

Tissue underdevelopment involves stunting, lack of chlorophyll, or incomplete development of plant parts. Their descriptions include:

- Chlorosis: Lack of chlorophyll or green color as in yellows or mosaics
- Etoliation: Spindly growth
- Abortion or atrophy: Halt in development of flowers and fruit
- Growth Suppression: Complete prevention of development of organs
- Dwarfing, rosetting, etc.: Stunting or tightly suppressed growth

Tissue overdevelopment involves galls, swellings, cell enlargement, or abnormal multiplication. Their descriptions include:

- Abnormal organs: Development of rudimentary or latent plant parts
- Premature growth: Development of shoots from normally dormant buds
- Tissue transformation: Transformation of tissues or organs
- Abnormal coloration: Atypical organ or tissue color development
- Gigantic growth: Tumor formation, callus, curl, scab, gall and root knots

ORNAMENTAL PLANT INSECTS AND RELATED PESTS

Insects thrive in deserts, rain forests, hot springs, snow, and caves. They are found in the air, soil, and water. Not all insects are pests and they are important because they pollinate plants and feed on other pests. Most insects cause no harm and relatively few eat human foods, destroy useful plants, are a nuisance to humans, or negatively affect human health.

On the other hand there are many insects that are pests and some of these insects damage ornamental plants. Insects feed on and tunnel into leaves, roots, stems, seeds, and nuts. They can carry diseases and some suck the sap from leaves, stems, roots, fruits and flowers. Some insects damage, weaken, or kill plants, leaving unhealthy and/or unattractive ornamental plants. Some insects will continue causing damage after plants are harvested, stored, and processed.

COMMON INSECT CHARACTERISTICS

Understanding insect classifications, growth, development, and life cycles is necessary to for effective pest control and allow for applicator intervention at the most effective time. Insect control is most effective if they are treated during the most vulnerable point of their life cycle.

Insect Classification

All adult insects have three body segments that include the head, thorax, and abdomen. Insects have six, jointed legs extending from their thorax and insects are classified by mouth and wing structure.

Insect Mouth Parts

Insect mouths are adapted to perform piercing and sucking, chewing, sponging, and siphoning actions. A description of these actions and some examples of the insects with this types of mouth parts are listed below:

Piercing and sucking mouths have long slender tubes to force into plant or animal tissue to suck out fluids or blood. Stable flies, sucking lice, bed bugs, mosquitoes, true bugs, and aphids are examples of insects that pierce and suck.

Chewing mouths have toothed jaws to bite and tear. Beetles, caterpillars, grasshoppers, and ants are examples of chewing insects.

Sponging mouths have tubular tongue like structures and spongy tips to soak up liquids or soluble food. Insects may extrude digestive fluids onto the food before sponging. Houseflies, flesh flies, and blow flies are examples of sponging insects.

Siphoning mouths have a long tube for sucking nectar. Insects coil the siphon tube when not in use. Butterflies and moths are examples of siphoning insects.

Insect Wings
Some adult insects have no wings, while others have two or four. Wings vary in shape, size, thickness, and structure. Beetles have hard, shell like wings while grasshopper wings are leathery. Flies have forewings that are membranous and the wings of the true bug are part membranous and part hardened. Most insects have membranous hind wings. The wings of moths and butterflies are membranous but covered with scales.

Metamorphosis
Metamorphosis represents changes in shape, form, and size during life stages and can be either complete or incomplete. Insects that go through complete metamorphosis have four developmental stages. Insects with incomplete metamorphosis hatch from eggs and develop into wingless nymphs.

Eggs hatch into larvae (worms, caterpillars, grubs or maggots). Because of feeding habits, the insect larval stage is the most damaging to plants. When larvae change into the resting or pupae stage they do not eat. During the pupae stage they undergo a major transformation and emerge as mature winged adults that can lay eggs. Nymphs are smaller than and look like the adults, as they undergo small changes to develop into winged, mature adults.

PEST MANAGEMENT STRATEGIES

Management or control of insects and related pests is vital to growing plants in Utah, but many insects are beneficial and insecticide applications often kill insects indiscriminately. Pesticides should be applied when pests damage is reaching aesthetic or economic thresholds and integrated pest management (IPM) should be implemented to maximize the pest management strategy.

Signs of Insect and Mite Presence
Insect or mite pests may not be present or visible when damage is discovered. Signs of their presence will include the following:

- Silk shelters: usually do not enclose foliage. Caterpillars feed outside the shelter and use it for protection from predators, weather, etc.
- Web enclosed foliage: silk webs enclosing foliage with caterpillars feeding inside.
- Insect or mite remains: egg shells, shed skins, cocoons, frass, and trails of silk.
- Scale and aphid covering: most scales and some aphids excrete a protective waxy covering.
- Honeydew: sticky liquid sugar excreted by insects. Black, sooty mold may grow on honeydew.
- Sawdust, wood chips, and pitch balls: material on or below trunks from feeding by bark beetles, wood borers and shoot borers.

Natural Controls of Insects and Mites
Natural controls for some pests in Utah are:

- Spider mites: predatory mites, minute pirate bugs, ladybird beetles, predatory thrips
- Aphids: wasps, ladybird beetles, syrphid flies, lacewings
- Scale: wasps, ladybird beetles, lacewings
- Leaf beetles: wasps, fungal diseases, spiders, stink-bugs
- Bark beetles: fungal diseases, wasps
- Gall midges: wasps, predatory midges
- Tussock moths: wasps, virus diseases, tachinid flies, spiders
- Tip moths: wasps, tachinid flies
- Leafrollers: wasps, tachinid flies, spiders
- Leafminers: damsel bugs, stink bugs, wasps

Biological Controls
Bacillus thuringiensis (Bt) is a bacterial disease organism manufactured and sold as a “microbial insecticide” under trade names such as Dipel, Thuricide, and Javelin. Bt is considered nontoxic to humans, pets and wildlife. It is exempt from food crop tolerance standards and can be used up until harvest. Bt is highly specific and most formulations only affect leaf and needle feeding caterpillars. It is a stomach poison and insects must eat it. Predators and parasites and insect pollinators are not affected.

Thorough coverage is essential when using Bt. Insects may not die for two to three days, but they stop feeding within hours after eating treated foliage. Researchers are developing Bt strains effective against other pests such as elm leaf beetle.

Parasitic nematodes are biological insect controls. They invade and kill susceptible

insects. They need moist conditions and are most effective in controlling white grubs, billbugs, sod webworms, root weevils, and crown borers.

Mechanical Control
Mechanical controls reduce pests using devices that affect them directly or alter their physical environment. They include hand picking, trapping, and using screens, barriers, sticky bands, and shading devices. Using mechanical controls requires time and labor and typically is impractical on a large scale.

Pheromone traps use pheromones that have been identified for insects and many are produced synthetically as lures to trap insects. Insect pheromones used in traps are those produced by females to attract males. The traps monitor insect flights that vary at different locations and seasons. Trapped insects are correlated with egg laying and provide information to determine the proper timing of insecticide and other pest management strategies. Pheromone trapping is commonly used for lilac/ash borer, peach tree borer, codling moth, and gypsy moth.

Legal Control
Government entities can quarantine or restrict movement of potential pests into an area or use public resources to eradicate, prevent, or control pests. For example, gypsy moth or Japanese beetle control projects use public funds to prevent pest invasions and/or establishment.

Cultural Control
Growing practices reduce pest populations by creating unfavorable environments. These include favorable planting locations, trap crops, tillage, clean culture, timing and resistant varieties. Knowing pest life cycles is essential for effective cultural controls. Cultural controls change the environment during the vulnerable parts of pests' life cycle to kill them or slow their reproduction. Cultural methods are aimed more at prevention than cure.

Reproductive Control
Reproductive control reduces pests by physical treatments or substances that cause sterility, alter sexual behavior or otherwise disrupt normal reproduction.

Chemical Control
Using chemicals to reduce populations by poisoning, attracting, or repelling insects is the most common pest management tool. Insecticides are highly effective, economical, and offer quick control. When insect populations approach economic or aesthetic thresholds and natural controls are inadequate, insecticide applications are the best control option.

Insecticides can control multiple species of pests with a single application, which is both an advantage and disadvantage in ornamental ecosystems. Insecticides should be applied when pests are most vulnerable, usually when they are young. For example, bagworms should be controlled in late spring just after they hatch or scale insects should be controlled in the crawler stage before they develop waxy coverings.

Insecticides should be applied in the locations where pest spends most of its time. For example, the underside of leaves should be sprayed to control white flies.

Many insect and mite species go through multiple generations in a season. Unless the population is controlled in earlier generations, pests can increase to damaging levels as the season progresses. Most insecticides only last one to four weeks and must be reapplied to control later generations.

Oils for Insect and Mite Control
Pest control oils are specialty sprays with impurities that can damage plants. Oils suffocate insects and mites by clogging breathing spiracles or pores. Spray oils are often used as dormant oils to control scale, aphids, or mites that overwinter on woody plants.

Dormant oils should be applied on warm spring days before buds break and thorough coverage is essential for effective control. Oils are safe and easy for applicators to handle. They are effective on some hard to control pests such as scales and leaf curling aphids and they do not adversely affect predators and parasites.

Oils should be used cautiously because they can injure sensitive ornamental plants such as the

black walnut, some maples, Russian olive, junipers and redbud. Blue spruce will tolerate oil treatment, but these trees lose the waxy bloom which gives them their distinctive color.

Soaps for Insect and Mite Control

Soaps are used as insecticides or miticides to control most small, soft bodied insects and mites like aphids, thrips, psyllids, and spider mites as well as larger insects like honey locust plant bugs and pear slugs. Insecticidal soaps have several advantages. They are safe and easy for applicators to mix and apply. The insecticidal activity of soaps is specific so most beneficial insects, parasites, and predators are not adversely affected. Likewise, birds, pets, and wildlife are not injured by treatments.

There are limitations to the effectiveness of of insecticidal soaps. Some plants are injured by soaps and because most soaps are not labeled for insecticide treatment, the safety of soap for specific plants may not be known. Also, soaps act as contact insecticides and have no residual activity. Soaps must be applied thoroughly over the entire area being treated. Soaps do not control pests like caterpillars and leaf beetles.

Also, pesticides used in agricultural applications such as farms and greenhouses must be labeled with the guidelines for agricultural use requirements and/or worker protection standards.

Slug and Snail Control

Slugs and snails are mollusks, not insects. They are active at night and chew holes in leaves or stems. Slug and snail damage can be confused with caterpillar injury. Caterpillars leave large droppings on plant foliage. Slugs leave shiny streaks of dried slime on plants and soil. Slugs chew completely through a leaf or stem. Caterpillars may leave part of the leaf veins and stems untouched.

Slugs have both male and female organs in the same body and may act as males and/or females as adults. Self fertilization is also possible. Slugs lay eggs in moist locations in clusters of 20 to 100. Mulch, boards, or rocks provide cool, moist conditions for hiding and egg laying. At 50 degrees F, eggs hatch in less than 10 days and mature in three months to a year. Slug offspring are smaller and lighter colored but resemble the adults. Slugs can be controlled with sanitation and molluscicides. Weeds and hiding places should be eliminated and irrigation modified to make conditions less favorable for slugs.

WOODY PLANT INSECTS AND RELATED PESTS

Many different insects and mites feed on woody plants. The greater the variety of plants in a landscape the more insect and mite species are present. This is not always a problem because having a wide variety of plants in a landscape will limits the number of plants damaged by insects that attack single or specific plant species. Landscape managers should know how to common insect and mite pests. Correct identification of a pest is the first step in a pest management program.

Some ornamental plants require frequent controls while others have few pest problems. The present of some insects and/or mites does not necessarily indicate that insecticide or miticides must be applied. In Utah, some pests thrive and cause trouble every year while other appears infrequently. Prior to selecting a insecticide treatment make sure that alternatives such as sanitation, pruning, and hand removal have been considered.

LEAF FEEDERS

Deciduous plants tolerate some defoliation without affecting tree vigor. Late season defoliation of deciduous trees and shrubs is less damaging because trees have produced and stored food necessary for growth. Leaf feeding defoliators include butterfly, moth, beetle, and sawfly larvae. Late season defoliation of evergreens is more damaging because evergreens store food in needles and leaves. Insect destruction of new annual growth is most damaging since it is responsible for the majority of plant growth. Many caterpillars feed on the foliage of trees and shrubs, but only a few are serious pests in Utah. Some form unsightly webs on branches, justifying their control. Most pest caterpillars in Utah have one generation per year. Leaf beetles do most of their damage during the immature larval stage.

WOOD BORERS

Wood boring insects are among the most damaging tree pests. Some wood borers attack living plants and others attack dead or severely stressed plants. There are three common groups of wood borers that cause damage. Long horned beetles, known as round headed borers, in the larval stage, make deep tunnels and structurally weaken infested trees. Metallic wood borers, known as flat headed borers, in the larval stage, tunnel under the bark and make galleries that girdle trees. Clear winged borers are moths with larvae that develop at the base of the tree.

Controlling borers is difficult as they are protected inside the tree. Trunk sprays may be made as a preventative measure if made before borers deposit eggs on the bark. Pheromone traps can be used to determine flight times of clear winged moths like the ash/lilac borer and peach tree borer. Since pheromone traps for wood boring beetles are not available, managers must carefully observe adults to time insecticide treatments. Metallic wood borers lay eggs in May, June, and July and long horned beetles lay eggs in July, August, and September.

An alternative to spraying is to locate and destroy borers with a sharp probe. This is a labor intensive activity. Managers should avoid making additional wounds. Heavily infested branches should be pruned out and destroyed before adults emerge. Many borers enter trees near wounds so pruning should be done to allow wounds to close rapidly. Healthy trees are less attractive to borers and they tolerate borer damage that does occur. Managers should use natural defenses and use cultural practices to promote vigorous plant growth to prevent borer infestations.

SHOOT BORERS

Tip moths and various beetles feed on the surface or insides of conifer shoots, causing abnormal growth and death. Treatments for shoot borers should occur during egg laying and hatching when the eggs or larvae are exposed on the bark.

PLANT GALLS

Galls are abnormal growths caused by insects, mites, diseases, and hormones. The unusual shapes and colors of galls cause concern but serious damage is rare. Gall formation varies seasonally due to natural controls. The gall making insects and mites produce galls during feeding and egg laying. Since only new growth is susceptible, most galls form in late spring as leaves develop. Most insecticide treatments are done to improve appearance. Time insecticide treatments to coincide with egg hatch and feeding. Treat insects that overwinter on plants prior to bud break in the spring.

TYPES OF VEGETATION

Grass and broadleaf weeds begin as seedlings, develop vegetatively, produce buds and flower, and reach maturity. Seedlings are similar for annual, biennial, and perennial weeds. While small and tender, they are easiest to kill with either mechanical or chemical controls.

MANAGEMENT OF ANNUAL AND BIENNIAL VEGETATIVE WEEDS

During vegetative growth, plants produce stems, leaves, and roots. During the mature stages of life weeds are more difficult to control than when they are seedlings. During vegetative growth, annual and biennial weeds are managed by cultivation, mowing, and the application of postemergent herbicides.

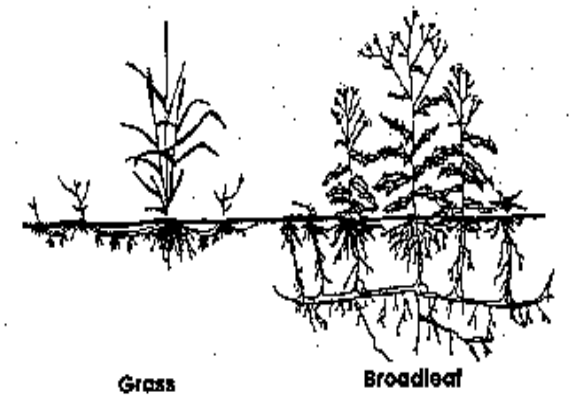
Vegetative Annuals and Biennials

Grass **Broadleaf**

MANAGEMENT OF WEEDS WITH BUDS AND FLOWERS

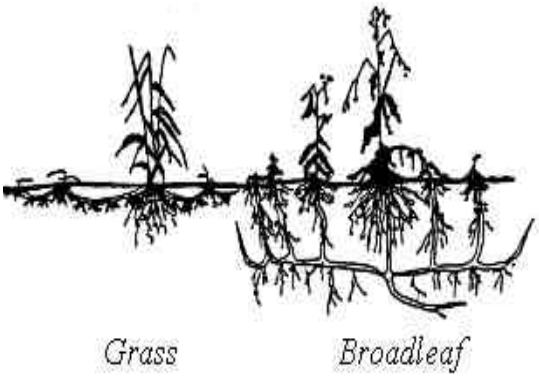
During the bud and flowering stage most of a plants energy is being used to produce flowers and seeds. Plants begin to store food in the roots during these stages and continue through maturity. Herbicide applications are more effective during the bud stage on some weeds and during the flowering stage on others.

Flowering Perennials



MANAGEMENT OF PERENNIAL WEEDS

Perennial plants live three years or longer and the portion of the plant above the ground dies at the end of the growing season. Underground roots and stems live through the winter and send up new growth in the spring. The growing points of perennial grass and creeping perennial grass buds are protected below the soil surface. When attempting to manage perennial weeds, these plants will regrow if herbicides do not reach and/or cultivation does not remove the growing parts.



MANAGEMENT OF WOODY PERENNIAL WEEDS

Woody plants go through the same growth stages as other perennials. They do not die back to the ground during the winter, but deciduous trees lose their foliage. Herbicide control of woody perennial weeds is most effective when the plants are young and exhibiting new growth. Woody perennials move nutrients from the foliage to their roots in the fall and many can be controlled with fall herbicide applications. Herbicide applications are most effective if treatments occur when leaves are still actively growing and before the first frost.

Many woody plants will sprout from wherever buds are found on the roots, trunks and limbs. Seedling broadleaf weeds have an exposed growing point at the top of the young plant and in leaf axils. Herbicides applications and/or cultivation control seedlings effectively. Established perennial broadleaf plants are hard to control because they have many buds on the roots, stems, and crown.

ORNAMENTAL PLANT WEEDS

Most weeds can be placed into five convenient groups that include annual grasses, perennial grasses, annual broadleaf plants, perennial broadleaf plants, and woody plants. Woody plants are further divided into shrubs and trees. Shrubs have multiple stems and are less than ten feet tall, while trees are usually single stemmed and more than ten feet tall. Knowing the life cycle and classification is important for weed control.

Summer annuals grow from seeds that sprout in the spring, mature, and reproduce before dying in the winter. Common summer annuals are barnyard grass, puncture vine, Russian thistle, and pigweed.

Winter annuals germinate in fall or winter and flower, produce seed and die in the spring. Common winter annuals are annual bluegrass, chickweed, mustard, and wild oats.

Biennials require two years to complete their life cycles. These plants grow vegetatively without flowering the first year. In the second year the plants flower, produce seed, and die. Common biennials are musk thistle, mullein and hounds tongue.

Perennials live three years or longer. These plants flower and set seed without dying. Most die back in the winter but resume growth in the spring. Common perennials are quack grass, field bindweed, dandelion and plantain.

WEED CONTROL

Weed control does not always require herbicides and in some locations, any plant cover is better than bare ground.. Avoid using herbicides in areas with sensitive plants. Herbicides should be used with an understanding of the weeds, knowledge of how to protect nontarget species and the environment, and label requirements. Applicators are required by law to follow label directions and are responsible for the pesticides they apply.

BROADLEAF WEEDS

Postemergent herbicides selectively control annual, biennial, and perennial broadleaf weeds. Broadleaf herbicides are used alone or when mixed with other broadleaf herbicides. Spring and/or fall applications are used to control weeds and reduce damage to desirable plants. Spot treatments of herbicides are most effective for control of scattered or small numbers of weeds.

GRASS WEEDS

Pre-emergent herbicides are appropriate for treatments of annual grass infestations. Spot treatments on grass weeds with postemergent herbicides work well for local infestations.

HERBICIDE TYPES AND CHARACTERISTICS

There are a large variety of herbicides and because of the differences in their chemical makeup they exhibit numerous modes of action. Some of the most common herbicides are described in this manual.

INORGANIC HERBICIDES

Chemical compounds that do not contain carbon are inorganic. Inorganic compounds include products such as salt, copper sulfate, sulfuric acid and sodium chlorate. Herbicides with these compounds can be very persistent and can cause serious soil pollution problems. Many inorganic herbicides are registered as restricted use pesticides.

ORGANIC HERBICIDES

Organic herbicides include petroleum oils and synthetic organic formulations. Petroleum oils are refined from crude oil. Synthetic organic herbicides are made of carbon, hydrogen, and other elements.

SELECTIVE HERBICIDES

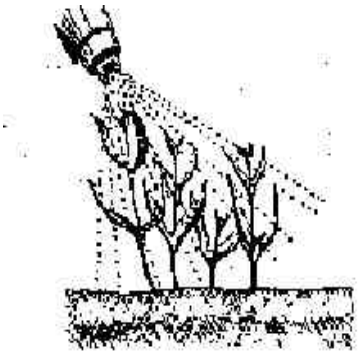
Selective herbicides injure some plants and do not injure other plants. These herbicides are totally selective and may damage desirable plants if misused or over applied. Broadleaf weed killers are commonly used on turf areas where the grass will grow, but weeds will die.

NONSELECTIVE HERBICIDES

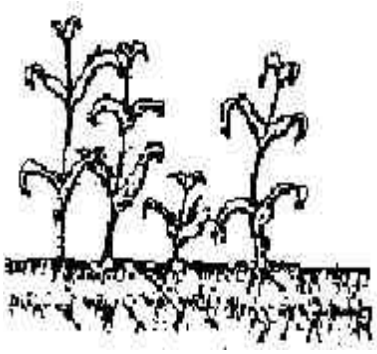
Nonselective herbicides are toxic to all plants. Nonselective herbicides are used to provide bare ground areas that reduce fire or safety hazards, protect structures from damage, eliminate pest breeding areas, improve visibility, and improve security. Nonselective herbicides can be soil, contact, or translocated products. Wind, water and soil erosion can move herbicides before they fix in the soil. Off target movement of herbicides can do damage to adjacent, desirable plants.

CONTACT HERBICIDES

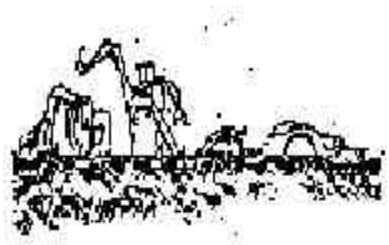
Contact herbicides cause localized injury to plant tissues. They should be applied when plants have leafed out. Complete herbicide coverage is necessary since only the treated parts of a plant are affected. In general, contact herbicides are nonselective and damage foliar parts of all plants. Some contact herbicides will run off of grasses with narrow vertical leaves, but easily adhere to broadleaf plants.



When a contact herbicide comes in contact with plant foliage the killing action starts.



Herbicide is taken into the plant leaves and interferes with growth. Plants curl, wither, and turn brown.



Some plants may regrow from roots. New weeds may also grow from seeds in the soil.

Contact herbicides are most effective when they are applied to actively growing foliage. Leaves absorb contact herbicides and most plants dieback very quickly. Plant growth is stopped at that point, but some plants will regrow from the roots which are not killed by contact herbicides. Also, weeds may grow from seeds in the soils.

TRANSLOCATED HERBICIDES

Translocated herbicides move within a plant from the point of contact to the site of action. Some translocated herbicides are applied to plant foliage and others are applied to the soil and move from the soil into emerging plant shoots or roots of existing plants.

The selectivity of translocated herbicides depends on differences in plant species biochemistry. Herbicides are translocated to the actively growing sites of a plant, causing the plant to die. The effectiveness of translocated herbicides on weed control depends on the chemistry of the active ingredients, application rates, rainfall after or during application, soil type, growing activity of the weeds, and the presence of dust of other materials on plant foliage that may interfere with herbicide contact.

PRE-EMERGENT HERBICIDES

Pre-emergent herbicides are applied to the soil before weeds emerge and are there when weeds emerge from seeds. These herbicides translocate as new shoots emerge from seeds.

POSTEMERGENT HERBICIDES

Postemergent herbicides are applied after weeds emerge from the soil. They are generally applied to foliage as contact or translocated herbicides.

GROWTH REGULATORS

Growth regulators control or modify plant processes without damaging the host or other plants. They are generally foliar applied and not persistent.

HERBICIDE CHARACTERISTICS

Many herbicide particles have positive or negative charges. Those without charges move through the soil quickly. Those with positive charges tend to tie up with negative charged soil particles.

Leaching is the movement of herbicides in water through soil due to chemical characteristics and soil factors. Herbicides vary from insoluble to completely soluble in water. The persistence of herbicides in the environment depends on chemical characteristics, application rates, soil texture, organic matter present, precipitation, temperature, and surface flow. Herbicides can remain concentrated at the surface, partially leach, or run off of the soil surface, allowing weeds to grow.

Plant Foliage Coatings

The species and physical characteristics of plant foliage affect herbicide absorption. Wax and cuticle formation affect the way herbicides penetrate leaf surfaces. Herbicide sprays can easily penetrate thin leaf cuticles, but these sprays will stand up in droplets on leaves with

thick waxy surfaces. Fine hair like structures on leaf surfaces will reduce spray absorption because the herbicide droplets will remain suspended above a leaf's surface. Herbicides provide more effective control when applied to young weeds because the foliage wax and leaf cuticles are thinner. Seedling weeds have fewer and shorter hairs and are more easily managed with herbicides.

Leaf Shape And Maturity

Leaf shape affects herbicide use. Herbicide sprays run off plants with narrow, vertical leaves. Broader leaves hold the spray. Use an adjuvant to increase retention. Plant development is another important consideration. Seedling weeds are easier to control than larger weeds.

Environmental Factors Affecting Herbicides

Soil applied herbicides require soil moisture in the form of precipitation or irrigation for the active ingredients to be taken up by plant roots.

Temperature directly effects plant growth rate and how well weeds will absorb or take up herbicides and translocate them within a weed. At low temperatures plants are not actively growing and do not readily take up herbicides. At very high temperatures herbicides can volatilize and move off target.

Foliar herbicides enter the leaf more easily and rapidly under conditions of high humidity. High humidity can make the leaf tender by thinning the wax and/or cuticle layers.

Depending on the type of herbicide treatment, precipitation can be beneficial or problematic. Precipitation on weeds soon after or during a foliar application can displace the herbicide and reduce effectiveness. Precipitation following a the application of a soil herbicide will activate the herbicide and move it into weed roots. Too much precipitation will move herbicides past the root zone and/or move surface herbicide applications down slope.

Hot, dry winds cause plant surface openings to close, leaf surfaces to thicken, and wax layers to harden. These changes to weed foliage will result in a reduction of herbicide penetration.

Tree

Shrub

IV. TURF PEST MANAGEMENT

TOPIC **PAGE**

TURF MAINTENANCE

Utah's turf industry includes parks, home lawns, sod farms, institutional and industrial grounds, golf courses, athletic fields, roadsides, and cemeteries. Home lawns make up the largest segment of the industry. Grass is used for beauty and recreation, erosion control, and utility purposes. Attractive turf needs proper management to provide good color and density and freedom from weeds, insects, and diseases.

Proper turf management requires the appropriate grass, mowing, watering, fertilizing, and thatch control. Pesticides are not a substitutes for good cultural practices and will not correct for problems with watering, fertilization, mowing height and frequency, thatch accumulation, poor soil, or poor species choice.

Utah's harsh climate makes the growing of consistent high quality turf difficult. Extreme, unpredictable moisture, humidity, soils, sun, and wind stress turf. Utah's variable climate allows for the growing both cool and warm season grasses in the state. This means that landscape managers must be able to identify pests and properly care for a variety of turf grasses. Some turf problems are specific to the species and the wrong grass in the wrong location can create problems that even superior management strategies will not overcome.

PREVENTIVE MAINTENANCE

Grasses, like all plants, require optimal amounts of light, moisture, and nutrients. They are also subject to pests. Not all lawns are affected by the same pests. Some areas of a lawn are more prone to damage and not all lawns need the same cultural intensity. Turf care depends on grass species, desired quality, intended use, time, effort, and money available.

There are numerous cultural practices that help to reduce or prevent pests and aid plant recovery. Examples of good cultural practices include:

- Select species or cultivars adapted to the site and the intended use.
- Ensure there is good soil conditions, including adequate surface and subsurface drainage.
- Establish turf correctly.
- Water properly. The longer grass is wet, the greater the possibility for disease problems. Apply enough water at one time to provide adequate moisture for a week and wet the soil six to eight inches deep.

- Remove thatch that is more than one-half inch deep. Thatch is a tight layer of living and dead stems and grass roots that develops between the leaves and soil surface. Too much thatch keeps water from penetrating the soil, prevents deep rooting and makes some pest problems worse. Thatch is often an ailment of intensive turf care. Grasses differ in their inclination to develop thatch.
- Mow upright grasses, such as bluegrass and fescues to 2½ inches or higher in the summer. Creeping grasses such as bent, Bermuda and zoysia can be mowed to one-half inch or less.
- Mow often enough that no more than one-fourth to one-third of the leaf surface is removed at a time. Mow the lawn in the fall until grass stops growing.
- Aerate compacted areas using equipment with hollow tines to remove soil cores that leave a hole or cavity in the soil.
- Fertilize according to recommendations based on soil analysis. Recommendations vary with species and use. Do not over fertilize to promote fast, lush growth.
- Implement pest management programs based on local growing conditions and grass species.

TURF PESTS

Common turf pests include weeds, insects, and diseases. Rodents also damage turf, but less frequently. When diagnosing turf pest problems there are several considerations.

- Correctly identify the grass species involved.
- Determine what is causing the problem.
- Determine if management practices, soil modification, and/or pesticides will control the pest.
- Review cultural practices to help the turf recover.
- Review pesticide labels for appropriate species, sites, and pests.

Poor management practices are a common cause and/or contribute to turf pest damage. Incorrect watering, mowing, or fertilization weakens turf making it more prone to pests. Turf damage varies, depending on species, developmental stages, and cultural practices. Injuries range from minor, temporary turf discoloration from slime mold to death from billbugs. Golf courses, sod farms, parks, and recreational facilities face significant repair and replacement costs and potential income loss.

Pesticides have traditionally been favored pest control methods because of their long residual, broad spectrum effects, and labor saving features. Concern about the effects of pesticides on man and the environment requires a re-evaluation of this approach. The pest tolerance level varies with the situation. Species, growth stage, use, environmental conditions, and management intensity dictate acceptable levels.

Homeowners may tolerate some weeds that a golf superintendent would not on a green or tee. Vigorous, healthy turf can tolerate some pests where weak turf cannot. Good pest management combines the best available methods of prevention and care. The best methods for protecting turf from pests are:

- Turf Selection: plant cultivars resistant to pests.
- Cultural Practices: proper mowing, aeration, watering and fertilizing practices.
- Pest Management: utilize integrated pest management techniques including proper use of pesticides.

Proper management and regular evaluation are important to prevent pests from reaching unacceptable levels. Some species and varieties of resistant turf will reduce pest damage.

Chemical and cultural methods can be preventive or curative. No grass does well in every situation. Blending or mixing suitable grasses helps turf under various conditions. Use good cultural practices to produce turf that tolerates pests and reduces or eliminates the need for chemical controls.

When a turf pest is identified and the predetermined threshold is reached, all possible controls must be weighed to determine the benefits and risks and cost effectiveness must be considered. Use the safest, most efficient and economical selective controls possible. Pesticide

controls require knowledge of the pests, knowledge of the turf species, and an understanding of correct pesticide usage.

TURF DISEASE

Poor quality turf is often caused by environmental and cultural conditions. Fertilizers and pesticides can injure turf if applied at a rate that is too high or too low. Micronutrient deficiencies also cause poor turf growth and good quality soil is essential for a healthy lawn. Good soil that is properly prepared will minimize future problems and allows water and air to penetrate and promote root growth. Soil should be aerated regularly to allow air penetration.

Lawns may also require maintenance due to the impacts of animals such as pets and rodents. In Utah, turf diseases are best controlled by cultural practices, not fungicides. Preventive fungicide use is sometimes warranted when turf has a history of disease. Fungicide applications should be timed according to the fungus life cycle and weather conditions. Routine fungicide use to prevent disease outbreaks is expensive and potentially harmful.

A more detailed discussion of plant diseases appears in **Chapter III** of this manual under the section titled **Ornamental Plant Diseases.**

TURF INSECTS

Insects and related arthropods commonly inhabit lawns in large numbers but few cause serious damage. Good management is the best defense against harmful pests. Healthy, unstressed grass can produce new roots and leaves, making it resistant to pests that feed on the plant. Grass that is weak or stressed is more easily damaged by pest infestations.

Insects that damage lawns are classified as above ground or below ground pests according to their feeding damage. Above ground pests feed on grass blades and stems. Included in this group are sod webworms, armyworms and cutworms. Foliage applied insecticides kill these insects as they crawl around or feed on the grass. Underground pests including white grubs and billbugs that feed on grass roots. The insecticides for these pests are applied to the grass and watered into the soil where the insects live.

PERIODIC INSPECTION

Periodic inspections are important to identify pest infestations and to initate control measure in a timely manner. Grass blades and stems should be inspected for above ground insects by sprinkling a mixture of one quart of water and one tablespoon of powdered detergent over four square feet of turf. A teaspoon of pyrethrum insecticide can be mixed with the water in place of the detergent. This causes the above ground insects to the surface within ten minutes. The insects can then be collected and counted to determine the level of infestation. Several areas of a lawn should be sampled to get an average number of insects.

To inspect for what appears to be subsurface insect damage, pull up a handful of grass. If the turf pulls up easily, the roots are damaged. If the grass will not come up or breaks off, look for other causes. To check for root feeding insects, cut a square section of sod on three sides, to a depth of four inches. Roll the cut section of sod back and shake the soil off the roots to look for the pests. Turf damage can occur from problems such as fertilizer burn, diseases, improper mowing, drought, dog urine spots, and pesticide damage which can also resemble insect damage.

IDENTIFICATION

The proper identification of insect pests is essential for proper control. Some insects benefit turf by preying on pests or feeding on decaying organic matter. Others insects are temporary and are not harmful or beneficial. Leafhoppers and clover mites are examples of insects that occasionally inhabit lawns but cause no damage.

PRESCRIPTION

When insect pests are present the management options should be evaluated. If insecticides are needed, the active ingredients must be

appropriate for the insects, the turf, and the location. Insecticide label directions provide detailed information for application rates, timing, and use requirements.

APPLICATION

When insecticides are used, apply them at the proper rate at the time when the pests are most vulnerable. Some pests may require repeated applications because the insects multiple generations during a single growing season. Do not exceed the annual application rate when making multiple applications.

EVALUATION OF TREATMENT

Did the insecticide work? It may take two to three days to control above ground insects and two to four weeks for soil insects. If the application did not work, determine why.

IDENTIFICATION OF TURF INSECTS

The following descriptions assist in identifying the insect pests that are found in turf.

Insects Feeding On Roots or Crowns

A. Larvae white, usually C-shaped, with brown heads, six short legs near head region .....**White grubs**

B. Larvae white, usually C-shaped, with brown heads, no legs, usually 3/8" long or less… **Billbug grubs**

C. Larvae tan or orange, six legs on forward part of body, smooth, slender body, and usually hard and shiny....**Wireworms**

Insects Feeding On Leaves and Stems

A. Larvae up to 5/16" long, gray with definite small spots from which hairs grow.....**Sod webworms**

B. Snout beetles, black and a body length of about 3/8".....**Bluegrass billbug**

C. Caterpillars usually brown and about 1” in length with six true legs on forward part of body, fleshy pro-legs on abdomen and distinct head capsules .....**Armyworms and cutworms**

1. Row of small yellow or white dots down center of back....**Variegated cutworm**
2. Dark colored granulated skin....**Black cutworm**
3. Yellow lengthwise stripes on entire body ....**Bronze cutworm**
4. Greenish color with distinct stripes on side of body.....**Armyworm**
5. Greenish or black with stripes on side of body, head with a white inverted Y on frontal portion..... **Fall armyworm**
6. None of the above...**Unidentified cutworm**

D. Small green or brown insects, 3/16" long, very active that jumps or flies when molested ....**Leafhopper**

E. Small green soft bodied, nonmobile insects, about 1/16" long found on leaves or stems....**Aphids**

F. Small greenish gray insects about 3/16" long, very active, commonly found running on ground in dry areas and usually occur in large numbers....**False chinchbugs**

Arthropods (Usually Do Not Injure Turf)

A. Small, about 1/8" wide, spiral shells .....**Snail**

B. Dark brown, wormlike, hard shelled creatures that usually coil when molested, have four legs on each segment.....**Millipedes**

C. Gray colored, soft bodied arthropods having 14 legs, usually in wet locations.....**Sowbugs**

D. Description same as above, but usually roll into small balls when molested.....**Pillbug**

E. Eight legs, various colors, usually brown, very active, up to 1" body length.....**Spiders**

F. Large black and yellow wasps, burrowing into soil.....**Cicada killers**

G. Small brown or red insects commonly concentrated near small soil mounds, may damage grass near mounds..... **Ants**

A more detailed discussion of landscape insects appears in **Chapter III** of this manual under the section titled **Ornamental Plant Insects and Related Pests.**

TURF WEEDS

Weeds in turf are prevented and controlled by mechanical, cultural, and herbicide applications. The best way to control weeds in turf is to have healthy, dense, vigorously growing grass. The best turf management practices are those that produce thick turf and discourage weeds. Killing weeds with herbicides is effective, but good growing conditions for grass are necessary for attractive turf.

Every cubic foot of topsoil has thousands of weed seeds that geminate when air, light, moisture, and temperature are favorable. This creates enormous numbers of potential weed problems in lawns. Many weeds cannot tolerate mowing and competition from grass. Weed numbers and density will decrease significantly after a season of good lawn care practices.

Weeds will invade unhealthy lawns and/or appear where grass stands are thin. Persistent weeds are troublesome and make a lawn look unattractive. The acceptable number of weeds in turf varies with grass type, growth stages, use, and environmental conditions. Pest managers maintain turf to support the function and environmental conditions for each particular location. In many cases a few weeds are acceptable, but most commercial turf and lawncare operations need the appearance to be that of a weed free landscape.

Few herbicides are safe on newly planted turf. Some pre-emergent herbicides will adversely affect grass germination later in the season. Some grasses are prone to herbicide injury and perennial grass weeds are hard to control in turf. Soil fumigants and nonselective herbicides will also kill desirable grasses.

A more detailed discussion of landscape weeds appears in **Chapter III** of this manual under the section titled **Ornamental Plant Weeds**.

Also in **Chapter III** of this manual is a detailed descriptions of herbicides under the section titled **Herbicide Types and Characteristics**.

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Plant Pest Diagnostic Laboratory
http://utahpests.usu.edu/uppdl/

V. Integrated Pest Management

TOPIC **PAGE**

PEST CONTROL TECHNIQUES

Integrated pest management (IPM) recognizes a variety of pest control techniques. IPM considers social, environmental, and monetary costs. Interest in IPM methods is often based on a desire to limit pesticide uses. However, pesticides are commonly included in any organized plan that involves comprehensive IPM techniques.

Pests can develop damaging levels in the same areas year after year. Early treatment can controls pests before they cause extensive damage. In situations where pest problems occur irregularly, applicators should schedule pesticide treatments to coincide with economic and/or aesthetic thresholds are reached. These thresholds are used to determine if controls are needed and when to use them. The **economic threshold** is the point when damage justifies the control costs. When pests cause damage, decide whether to initiate control measures or accept some loss. The **aesthetic threshold** is the point when pests cause unacceptable visible damage to ornamental plants.

Most landscape IPM programs:

- Stress plant health to reduce pest losses. Healthy, vigorous plants tolerate or avoid pests. Never use pesticides to compensate for cultural problems.
- Use sanitation, cultural controls and pesticides coordinated with natural plant healing or biological controls.
- Monitor pest problems to make sound management decisions. This detects pest population increases or declines allowing treatments to target needed areas. Monitoring gives proper pest control timing.
- IPM techniques manage pests at acceptable levels rather than eliminate them. Pests are tolerable if injury levels remains below where control costs exceed threatened damage. In ornamentals, the pest damage level is often obscured by aesthetic considerations.
- Help clients recognize that plant health requirements are separate from artificial aesthetic requirements. Injury levels are often so low there is no reason to control pests.
- Give priority to reducing environmental injury. Environmental management costs are important considerations.
- Avoid IPM incompatible “insurance” applications. Use preventive applications only if pest injury is predictable and where options do not exist after infestations occur (for example, borers or bark beetles on high-risk trees).

PEST CONTROL SOLUTIONS

Plant pest infestations are similar to human illness. A successful pest management strategy follows a set of established protocols. The steps are as follow:

1. Examine the site and organisms and check the for normal and/or healthy plants. If a plant shows signs of poor health or appears abnormal, look for possible causes.

2. Identify and assess potential problems, their causes, and severity. All organisms found on plants are not pests. Some are incidental, others are beneficial. Some pests cause little damage in the beginning, but can become serious problems.

3. Determine a control prescription based on examination identification and assessment. Choose preventive, curative, or no action. Take no action if infestations are not serious, when curative action causes more harm than the infestation, or when curative timing is not appropriate. Take action when pests are vulnerable.

PEST MANAGEMENT STEPS

Integrated pest management (IPM) relies on a variety of chemical and nonchemical controls to manage pests and minimize pest damage. The goal is to prevent pests from reaching economically or aesthetically damaging levels. IPM offers an effective pest control strategy that can reduce some of the negative effects of pesticides. Many successful IPM programs require less energy input and are site specific.

An IPM approach to pest management involves five steps. The steps are:

1. Identify the pest and understand its biology,
2. Monitor the pest to be managed,
3. Develop a sound pest management goal,
4. Implement an IPM program, and
5. Record and evaluate results.

A pest management program must begin with proper identification of the pest. If a problem is improperly identified, the prescription for control is likely to fail. Successful pest management programs require an understanding of a pest's life cycle, behavior, and the environmental conditions or factors that favor its development. The significance of the damage caused by the pest must also be determined. Some pests cause little or no damage, while others cause serious damage and they require immediate control.

The key to a successful IPM program is to monitor pest populations and the resulting damage or losses. The procedures for pest monitoring vary with the pest and the situation.

An IPM program should keep pest damage at an economically acceptable level. Pest prevention and suppression techniques are more common that total eradication. Multiple control strategies are integrated and where appropriate, pesticides are used. Other, nonchemical methods may provide longer and more permanent control of a pest than pesticides and the costs and benefits of all tactics must be considered.

Select the IPM methods that are the most effective at controlling pests and the least harmful to people and the environment. When possible, IPM programs rely on several strategies to control pests and minimize pest damage.

It is important to evaluate the results of control efforts. Consider how well all strategies worked and their impact on the environment before implementing them again.

IPM STRATEGIES

Planting resistance varieties: Plant resistant plants that have been developed through breeding, selection, and genetic engineering. These plants are selected and planted, and although total immunity is rare, these resistant varieties allow growth in spite of pests.

Sanitation: Pests are controlled by removing or eliminating the food, shelter, and/or other conditions that favor the pest's development.

Mechanical or physical control: Use insect screens, machines, and/or other methods to control pests, eliminate their access, and/or alter their environment.

Cultural Controls: Healthy plants tolerate injuries better than stressed plants. Plant the right plant in the right location, alter the

environment, modify plant conditions, or influence pest behavior to suppress or prevent infestations. This makes pests less likely to survive, grow, or reproduce. Vary planting or harvest times and use good irrigation and fertilizing practices. Space plants and avoid excessive watering to suppress crown and stem rot. Use drip or surface irrigation to avoid spreading diseases. Plant cool season crops early to avoid root rot in warm soils.

Natural Controls: Pathogenic or nonpathogenic controls eliminate most pest problems. In a balanced ecosystem, natural enemies control pests. Pest outbreaks occur when natural controls fail. Typical nonpathogenic controls are things such as high winds, rain, extreme heat, or freezing temperatures. Cold, wet weather helps control insects. Natural pest enemies are effective in most ecosystems. Predators, parasites and diseases are important pest controls. Environmental factors that diminish their effectiveness include dust, unfavorable weather, biological competitors, drift of pesticides from adjoining areas, or pesticide use on a crop.

Biological Controls: These are parasites, predators, or pathogenic organisms that feed on or damage pests. They are introduced by people rather than occurring naturally. Biological control advantages include permanence, safety and economy. Once established, they are relatively safe without hazardous toxicity or environmental pollution.

Biological controls are not suitable for all pests. Parasites or predators need time to develop a large enough population to control pests. This can take too long to save an endangered crop. It is challenge to find parasites or predators to introduce.

Eliminating secondary parasites of beneficial parasites, protecting beneficials from insecticides and determining whether continuous releases are needed are other challenges. Introducing biological controls in small isolated landscapes is usually not effective.

Utah State University
Cooperative Extension Service
http://utahpests.usu.edu/ipm/

USU Landscape IPM Pest Advisories provide periodic updates on current insect and disease occurences, biology, and treatment recommendations for Utah.

USU Turf IPM Advisories will provide periodic updates on current insect and disease sightings and treatment recommendations.

Integrated Pest Management is used to suppress pest populations while minimizing costs and environmental degradation.

VI. PROPER PESTICIDE USE

TOPIC **PAGE**

PESTICIDE SAFETY

The majority of pesticides are poisons that are 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 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.

On the other hand, 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. 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.

PESTICIDE LIMITATIONS

Pesticides are very effective at controlling pests, but there are negative aspects to using pesticides. These limitations include the following:

- Develops pest strains resistant to pesticides.
- Temporary controls pests and repeated treatments are often necessary.
- Pesticide residues are found in and/or harvested crops.
- Pesticide treatments can result in outbreaks of secondary pests resulting from the destruction of their natural enemies.
- Undesirable damage to nontarget organisms such as beneficial parasites and predators, fish, birds or other wildlife, pollinators, man, domestic animals, and other plants.
- Acute and chronic hazards to humans from contact with pesticides.
- Specific hazards, formulations concerns, and equipment needs that are required by the label for safe handling of pesticides.

PESTICIDE APPLICATIONS

Mixtures of two or more pesticides are used to perform multiple pest control actions with a single application. Pesticides are sometimes combined with fertilizers to control pests and promote plant growth with one application. There are drawbacks to such products because pesticides and fertilizers are frequently not needed at the same place time.

When mixing pesticides together and/or with fertilizers an applicator must be sure the chemicals are compatible and that the application of the mixture does not injure non-target species. In some cases when a new combination of products is being used, a small mixture should be applied to a small area to determine the effectiveness and potential problems.

SYSTEMIC PESTICIDES

Systemic pesticides are absorbed into and move throughout plants. Systemic action allows pesticides to control pests like fungi that grow inside plants, leaf-curling aphids, tip moths, and leaf mining insects. Soil applied systemic insecticides are picked up by roots and translocated in the plant xylem to actively growing tissues for the control of leaf or needle feeding insects. Soil applied insecticides do not usually control scales and borers that feed on the phloem of woody plant tissues.

Many of the soil applied systemic insecticides are highly toxic, restricted use pesticides. These products are most effective on actively growing trees and are best at controlling pest before the outbreaks are serious. Some systemic pesticides are injected into tree trunks or plants and should be done sparingly because of the wounds in the plants.

SPRAY ADJUVANTS

Adjuvants are included in or added to pesticides for improved spray performance and better target coverage. These additives control the pH of the pesticide mixture, prevent pesticide hydrolysis, improve coverage, increase retention, and/or improve pesticide performance. These products include buffering agents, surfactants, and stickers and are described below.

Buffering agents are used to counteract Utah's high pH soil and water that increase pesticide breakdown rates. For example, carbaryl (Sevin) hydrolyzes ten times faster in water with a pH of 8.0 than when the water's pH is neutral at 7.0. Premature pesticide breakdown can reduce the effectiveness of a pesticides or increase injury to nontarget species if a spray mixtures is held for several hours before use.

Surfactants or surface active agents improve spray deposition and surface coverage. Treating waxy or hairy leaf surfaces is difficult without surfactants. Injury increases if some surfactants are used on sensitive plants.

Stickers add sticking agents to improve foliage adherence in situations where rain or irrigation might wash pesticides off the target plant.

SOIL FUMIGANTS

Soil fumigation is used before planting to treat persistent soil organisms. Since fumigation is

costly, it is used on high value crops or where more than one disease, nematode insect, and/or weed must be controlled. Almost all fumigants are restricted use pesticides that require special skills licenses. Soil fumigant use is less common in Utah and inexperienced applicators should contact a fumigation specialist for appropriate fumigant selection and applications.

Fumigation Considerations:

- Tilth: Fumigants are volatile toxins that diffuse through soil. Cultivate soils to the desired control depth.
- Organic Matter: Fumigants are actively absorbed by organic matter. Excess debris reduces effectiveness.
- Moisture Content: Excess moisture blocks fumigant movement, but most need moisture for best results. Ideal soil is moist enough for seeding but not saturated.
- Temperature: Fumigants are most efficient at soil temperatures of 50 to 85 degrees F.
- Waiting Periods: Fumigants are highly toxic. Depending on soil and chemical type, fumigated sites must be aerated for days or weeks before seeding.

SEED TREATMENTS

Germinating seeds are highly susceptible to damping off infections that destroy seeds and kill young, emerging stems. Chemical treatments protect germinating seeds and young seedlings. Most seed-treatment chemicals act only on the seed surface and nearby soil. Some systemic chemicals penetrate to kill pathogens within the seed and developing seedlings. Pathogens, such as verticillium and fusarium wilt pathogens, are soil-borne. They spread in contaminated soil, cuttings, transplants, tubers, roots and bulbs. Once in the soil, they live for years even without host plants and are almost impossible to eradicate.

PESTICIDE PHYTOTOXICITY

Pesticide applications that cause plant injuries are phytotoxic. Phytotoxicity creates abnormal growth, leaf drop, discolored, curled, and/or spotted leaves. Severe phytotoxicity kills plants. Phytoxicity causes can be obvious or subtle and mimic insect damage, plant diseases, and poor growing conditions such as insufficient moisture and improper fertilization.

Some herbicides may leave residues in spray tanks even after cleaning that injure desirable plants. It is recommended that separate sprayer equipment is used for herbicide applications. Phytotoxicity is more severe with certain plants, pesticide drift, pesticide persistence beyond the intended control period, and/or improper application rates or techniques. Factors that contribute to pesticide phytotoxicity include:

- High air temperatures during and immediately after pesticide applications
- Pesticide drift
- Excessive pesticide application rates
- Too little water in the pesticide mixture.
- Uneven pesticide distribution.
- Mixing fertilizers with pesticides.
- Wettable powder formulations are less likely to injure plants than EC formulations because they are not dissolved in oil.
- Using stickers, spreaders, and wetting agents in pesticide mixtures.
- Different plant variety and species in the area being treated.
- Pesticide mixture incompatibility such as when oils, copper, or sulfur compounds are included.

PESTICIDE PERSISTENCE

Residual activity varies greatly among pesticides. Persistence is directly related to application rate, soil texture, temperature, moisture, and other factors. Applicators must be familiar with pesticide persistence of products where adjacent areas may be affected, where treated soil is used to grow other plants, or where humans and pets frequent the area.

Successful pest control requires knowing the persistence period before making applications. For example, herbicides used for pre-emergent weed control in turf may persist for 60 to 90 days, and postemergent herbicides last from one day to several weeks.

MINIMIZING PESTICIDE HAZARDS

Ornamental and turf pesticides are often applied near humans, pets, and other domestic animals. Applicators must be alert to and are legally responsible for the potential hazards of nontarget species coming in contact with pesticide. The following are items to be considered by pesticide applicators.

- Confirm that the correct site, location, or address is being treated.
- Do not spray or treat if children, pets, or other sensitive species are in the area or adjacent to the area being sprayed.
- Remove items such as toys, pet dishes, clothing, and bird feeders.
- Avoid spraying lawn furniture, standing water, and birdbaths.
- Close house windows.
- Observe label restrictions for fruits and vegetables.
- Sweep or rinse away all pesticide spray puddles.
- Secure containers and sprayers before moving.
- Keep herbicides away from desirable plants.
- Residues of herbicides are very hard to wash out and tiny quantities left in a sprayer can damage susceptible plants.

PERSONAL SAFETY

Personal safety is important for applicators and those who come in contact with the pesticides. Carelessly handled pesticides endanger the user, other nontarget species, and the environment. To avoid problems, pesticide handlers should read and follow the labels directions and carefully follow application guidelines.

VII. 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 treatments site 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>**.**

VIII. 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 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.

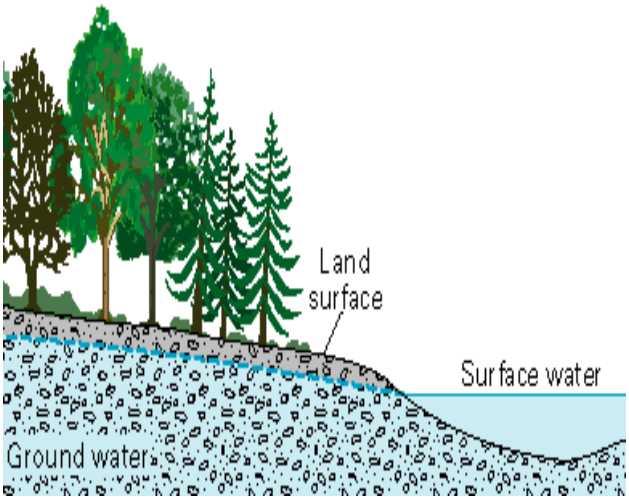
EPA's goal is to remove or reduce the threat to endangered species that pesticides pose. Achieving this goal is a portion of the larger continuing effort to protect species at risk. Normally these restrictions apply to the habitat or range currently occupied by the species at risk. Occasionally the restrictions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

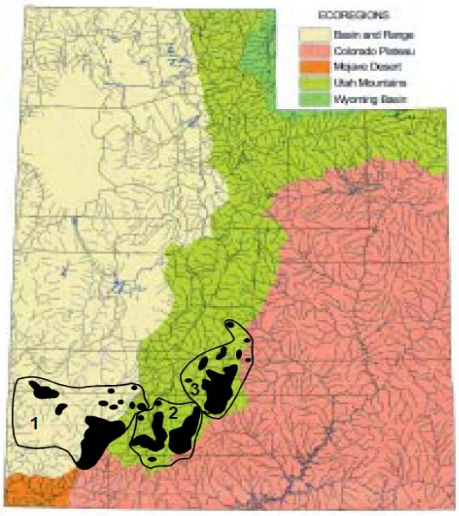
Utah's endangered species plan is a cooperative effort between federal, state, private agencies, producers, and user groups. This plan provides agency direction for regulations, enforcement, management policies, and implementation of threatened and endangered species protection strategies.

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



http://www.water.utah.gov/groundwater/default.asp
Utah Groundwater Information
Utah Division of Water Resources



1. West Desert 2. Paunsaugunt 3. Awapa Plateau

Present and past distribution of the Utah prairie dog.

http://wildlife.utah.gov/habitat/pdf/endgspec.pdf
Endangered and Threatened Animals of Utah

IX. 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

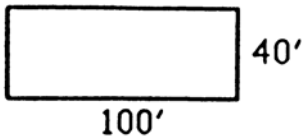
1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

Volumes

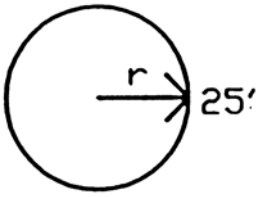
27 cubic feet = 1 cubic yard = 0.765 cubic meters
1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

Area and Volume Calculations:

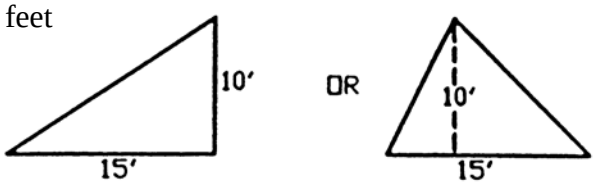
Area of Rectangular or Square Shapes
The area of a rectangle is found by multiplying the length (L) times the width (W).
(Length) x (Width) = Area
Example: (100 feet) x (40 feet) = 4000 square feet



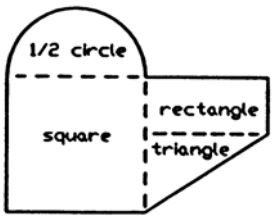
Area of Circles
The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.
(radius) x (radius) x (3.14) = Area
Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet



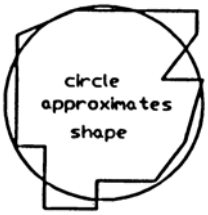
Area of Triangular Shapes
To find the area of a triangle, multiply ½ times the width of the triangle's base, times the height of the triangle.
(½) x (base width) x (height) = Area
Example: (½) x (15 feet) x (10 feet) = 75 square feet



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.

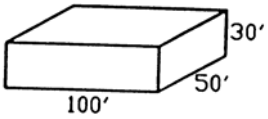


Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.
Example: Approximate the area by calculating the area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



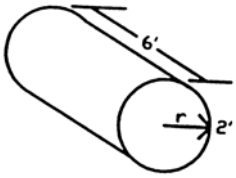
Volume of Cube and Box Shapes
The volume of a cube or box is found by multiplying the length, times the width, times the height.
(Length) x (Width) x (Height) = Volume

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.

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

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

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.

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

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

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

To calculate 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 calculate 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

X. UTAH PLANT PEST DIAGNOSTIC LABORATORY

The Utah Plant Pest Diagnostic Laboratory (UPPDL) at Utah State University in Logan, Utah provides assistance with pest identification. Many of the local County Extension Offices can provide assistance with pest identification and the pest species can be submitted. In some instances digital photographs can be submitted, but for the more difficult and/or small pest species, and actual specimen will need to be mailed to the laboratory. Please access the laboratory's web site for detailed instruction.

UPPDL is the only lab of its kind in Utah that identifies and provides management recommendations for pest problems. With more than 20 years of experience, it employs two diagnosticians (arthropod and plant disease) to identify a variety of plant pests for the citizens of Utah. The UPPDL also has three Extension Specialists to supplement the diagnosticians for customized management information.

Types of pests identified include:
- Plant diseases (fungi, bacteria, viruses, nutrient and physiological stresses, herbicide injury).
- Arthropods (insects, spiders, mites, ticks) from plant and urban environments.

Clientele includes USU Extension personnel, agricultural and horticultural producers, homeowners, state and federal agencies, health-care providers, and others.

In addition to plant pest biology and life cycles, The OPPDL also provides the following services:
- Recommendations for pest management, including IPM and reduced risk alternatives.
- Recommendations for legal and effective pesticide use.
- Develops and maintains plant pest identification databases.
- Develops in-service training and presentations for workshops and conferences.

Directions for submitting an arthropod sample:
http://utahpests.usu.edu/uppdl/files/uploads/submission-instructions-insect.pdf

Directions for submitting a plant disease sample:
http://utahpests.usu.edu/uppdl/files/uploads/Plant_Instructions.pdf

The fees for pest identification services are posted on the web site and updates occur regularly.

UTAH PESTS WEB SITE

http://utahpests.usu.edu/

Utah's diverse landscape supports thousands of insects and plant pathogens. The **UTAH PESTS** web site is the Internet portal for learning more about pests, their beneficial counterparts, and how Utah State University Extension personnel provide a greater understanding of these organisms in the world. This site contains links to the following topics of detailed information.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is used to suppress pest populations while minimizing costs and environmental degradation. The Utah IPM pest advisories provide weekly or seasonal pest information for tree fruit, small fruits, and vegetables, landscapes, and turf. Advisories are delivered by email to subscribers or found on the web site.

PLANT DISEASES

Effective disease control depends primarily on early, accurate identification of the disease and the causal agents. In most cases, it is too late to control a disease on a plant once the disease appears. However, timely control measures can prevent the disease from spreading to other plants.

INSECTS AND THEIR RELATIVES

Insects are among the most adaptable group of animals on earth. They thrive in many environments including deserts, rain forests, hot springs, snow, and in caves. There are more insects than all the other plants and animals combined. Fortunately, less than 1% of all known insects are considered pests that cause economical loss or are of medical importance. Insects are highly important because they serve multiple functions in the ecology of the earth. They are efficient pollinators, macrodecomposers and biological control agents. Most insects are also part of the food chain for larger animals.

COOPERATIVE AGRICULTURAL PEST SURVEY

Recognizing the economic and environmental impact of introduced plant pests, the federal government has created the Cooperative Agricultural Pest Survey (CAPS) to detect and monitor invasive pests nationwide. Lists of target pests and survey guidelines for the following year are published annually.

CAPS is co-managed by the U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA–APHIS) and each state. The Utah CAPS program is cooperatively administered by the Utah Department of Agriculture and Food, and Utah State University.

Appendix 1. Utah Noxious and Restricted Weeds and Seeds

Utah Noxious Weed Act R68-8 lists the following noxious weeds

Bermudagrass	(*Cynodon dactylon variety dactylon*) Bermudagrass is not a noxious weed in Washington County
Bindweed (Wild morning glory)	(*Convolvulus, species plural*)
Broadleaved peppergrass (Tall whitetop)	(*Lepidium latifolium*)
Canada thistle	(*Cirsium arvense*)
Diffuse knapweed	(*Centaurea diffusa*)
Dyers woad	(*Isatis tinctoria*)
Leafy spurge	(*Euphorbia esula*)
Medusahead	(*Taeniatherum caput-medusae subspecies caput-medusae*)
Musk thistle	(*Carduus nutans*)
Perennial sorghum, species plural	(*Sorghum halepense*) and (*Sorghum almum*) Including but not limited to Johnson grass
Purple loosestrife	*(Lythrum Salicaria)*
Quackgrass	(*Elytrigia repens*)
Russian knapweed	(*Acroptilon repens*)
Scotch thistle (Cotton thistle)	(*Onopordum acanthium*)
Spotted knapweed	(*Centaurea maculosa*)
Squarrose knapweed	(*Centaurea virgata subspecies squarrosa*)
Whitetop	(*Cardaria, species plural*)
Yellow starthistle	(*Centaurea solsitialis*)

Utah Seed Law R68-8 lists the following prohibited noxious weed seeds

Bermudagrass	(*Cynodon dactylon variety dactylon*) Bermudagrass is not a noxious weed in Washington County
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Whitetop	(*Cardaria, species plural*)
Yellow starthistle	(*Centaurea solsitialis*)

Utah Seed Law R68-8 lists the following restricted weed seeds

Dodder	(*Cuscuta spp.*)
Halogeton	(*Halogeton glomeratus*)
Jointed goatgrass	(*Aegilops cylindrica*)
Poverty weed	(*Iva axillaris*)
Wild oats	(*Avena fatua*)

GLOSSARY OF TERMS

A

ABDOMEN - An insect's third body division.

ABSORPTION - The process by which pesticides are taken into plants by roots or foliage (stomata, cuticle, etc.).

ACARICIDE - a pesticide that kills mites. A miticide.

ACTIVE INGREDIENT - The chemical in a pesticide formulation responsible for killing, poisoning, repelling, or other biologic activity.

ACUTE EFFECT - An illness that occurs shortly after exposure to a pesticide.

ACUTE TOXICITY - Injury within 24 hours following exposure.

ADJUVANT - Material added to a pesticide mixture to improve or alter the deposition, toxic effects, mixing ability, persistence, or other qualities of the active ingredient.

ADSORPTION - The binding or adhesion of pesticide spray droplets to the plant or soil surface.

AGITATION - The process of stirring or mixing in a sprayer.

ALLERGIC EFFECTS/ALLERGY -A hypersensitivity to a specific substance, often called the allergen. An allergy may cause dermatitis, blisters, or hives; it could also cause illness, asthma, or life-threatening shock. Often the entire body is affected. Pesticide allergy symptoms are similar to other allergy symptoms– reddening and itching of the eyes, respiratory discomfort, and asthma-like symptoms.

ANNUAL PLANT - A plant that grows, matures, and produces seed in a single year then dies.

ANTIBIOTIC - Chemical substance produced by one micro-organism that inhibits or kills other micro-organisms.

ANTIDOTE - A treatment or remedy that counteracts the effects of a poison or toxin.

ANTI-SIPHONING DEVICE - A hose attachment designed to prevent backflow of a pesticide mix from the spray tank into a water source.

APPLICATION RATE - The amount of pesticide that is applied to a known area, such as an acre, 1,000 square feet, or volume of water.

AQUIFER - Underground formation of sand, gravel, or porous rock that contains water; the place where groundwater is found.

ARTHROPOD - Invertebrate animals such as insects, spiders, ticks, and crayfish of the phylum Arthropoda. They have segmented bodies and jointed appendages.

B

BACK SIPHONING - The movement of a liquid pesticide mixture from a spray tank through a hose.

BACTERICIDE - Pesticide that inhibits or kills bacteria or prevents their growth.

BAIT - A food or other substance used to attract a pest to a pesticide or trap.

BAND APPLICATION - An application of spray or dust to a continuous restricted area such as in or along a crop row rather than over the entire field.

BARE GROUND TREATMENT - Herbicide treatment that keeps the ground free of vegetation for long periods of time.

BASAL TREATMENT - Application that encircles the stem of a plant above and/or at ground level such that foliage contact is minimal. Application method commonly used to describe treatment of woody plants.

BIENNIAL - Plant that completes its growth in two years. The first year, it produces leaves and stores food; the second year, it produces fruits and seeds.
BIOLOGICAL CONTROL - The control of pests by means of predators, parasites, disease producing organisms, or competitive microorganisms.
BLIGHT - Disease characterized by general and rapid killing of leaves, flowers and stems.
BLOTCH - Disease characterized by large, irregular spots or blots on leaves, shoots, stems and fruits.
BOOM, SPRAY - A pesticide application device attached to a truck, tractor, aircraft, or other vehicle, or held by hand, to which multiple spray nozzles are attached.
BROADCAST APPLICATION - The uniform application of a pesticide or other material over an entire field or area.
BROADLEAF PLANT - A plant having more than one seed leaf and a wide leaves.
BUFFERS - Adjuvants used to retard chemical degradation of some pesticides by lowering the pH of alkaline water and maintaining the pH within a narrow range even with the addition of acidic or alkaline materials.

C

CALIBRATION - To properly adjust equipment or to determine the correct amount of material to be applied to the target area.
CANKER - Necrotic, often sunken lesion on a stem, branch, or twig.
CARRIER - The liquid or solid material added to an active ingredient to facilitate its storage, shipment, or use.
CATERPILLAR - Larvae of the moths and butterflies, but larvae of sawflies in the hymenoptera are also caterpillar- like.
CAUTION - The signal word associated with pesticide products classified as slightly toxic.
CERTIFIED APPLICATOR - A person qualified and licensed to apply or supervise the application of restricted use pesticides.
CHEMICAL CONTROL - The control or management of pests with treatments of pesticides produced by chemistry.
CHEMICAL NAME - The technical name of the active ingredient(s) found in the formulated product. This complex name is derived from the chemical structure of the active ingredient.
CHLOROSIS (adj. Chlorotic) - A yellow to white or gray condition of normally green plant tissue resulting from the partial to complete destruction of chlorophyll. Chlorosis is a common symptom of iron deficiency.
CHRONIC TOXICITY - Injury or illness that occurs more than 24 hours following exposure due to prolonged or repeated exposure.
CONCENTRATION - The amount of active ingredient in a given volume or weight of formulated product.
CONTACT EFFECTS - Injury at the point of contact, including skin discoloration and irritation (dermatitis) such as itching, redness, rashes, blisters, and burns. Also, swelling, stinging, and burning of the eyes, nose, mouth, or throat are contact effects.
CONTACT PESTICIDE - Any pesticide that controls pest organisms upon contact.
CONTAINMENT PAD - An impermeable pad used for mixing and loading pesticides and cleaning equipment that is designed to catch spills, leaks, overflows, and wash water for reuse or disposal.
CONTAMINATION - The presence of an unwanted substance in or on plants, animals, soil, water, air, or structures.
CROSS CONTAMINATION - When one pesticide accidentally mixes with another pesticide, usually in an improperly cleaned sprayer or in storage because of the airborne movement of a volatile pesticide.

CROWN - The point where stem and root join in a seed plant.
CULTURAL CONTROL - A pest control method that includes changing sanitation and/or work practices. It alters the environment, the condition of the host or site, and/or the behavior of the pest.
CUTICLE - The outer protective covering of plants which aids in preventing water loss.

D

DAMAGE THRESHOLD LEVEL - The lowest pest population density at which damage occurs.
DANGER–POISON - The signal word associated with pesticide products classified as highly toxic. This signal word is also associated with pesticide products that are corrosive or cause irritation to skin and eyes.
DECONTAMINATE - To remove or degrade a chemical residue from the skin or a surface.
DEFOLIANT HERBICIDE - A herbicide used to remove foliage.
DEGRADATION - The breakdown of a pesticide into an inactive or less active form. Environmental conditions, microorganisms, or other chemicals can contribute to the degradation of pesticides.
DELAYED TOXICITY - Illnesses or injuries that do not appear immediately after exposure to pesticides. The effects generally occur between 24 hours and several days after exposure.
DERMAL - Pertaining to the skin.
DERMAL TOXICITY - The measure of injury to the body when exposed to the skin.
DESICCANT HERBICIDE - A herbicide that removes water from plant foliage.
DIAGNOSIS - The identification of the nature or cause of the problem or fault.
DIEBACK - Progressive death of shoots, branches, and roots generally starting at the tip.
DILUENT - Any inert liquid, solid, or gaseous material that is combined with a pesticide active ingredient during the manufacturing process. Also, the water, petroleum product, or other liquid in which the product is mixed before application. Also referred to as the carrier.
DIRECTED APPLICATION - Precise application to a specific area or plant such as to a row or bed or to the leaves or stems of plants.
DISEASE - Any malfunctioning of host cells and tissue that results from continuous irritation by a pathogenic agent or environmental factor and that leads to the development of symptoms.
DISPERSING AGENT - An adjuvant that facilitates the mixing and suspension of a pesticide formulation in water.
DORMANCY - State of inhibited germination of seeds or growth of plants. A state of suspended development.
DORMANT SPRAY - Spray applied during the dormant season when plants are inactive.
DOSE OR DOSAGE - Amount or rate of chemical applied to a given area or target.
DRIFT - The airborne movement of a pesticide spray, dust, particle, or vapor beyond the intended contact area.
DRY FLOWABLE - A dry, granular pesticide formulation that forms a suspension when added to water. Same as a water dispersible granule.
DUST - A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay to talc.

E

ECOLOGY - The study of the effect of environmental factors such as soil, climate and culture on organisms.
ECONOMIC INJURY LEVEL - The lowest pest population density causing economic damage.

EFFICACY - The ability of a pesticide to produce a desired effect on a target organism.
EMERGENCE - Appearance of the first part of the crop plant above the ground.
EMULSIFIABLE CONCENTRATE - A pesticide formulation produced by mixing an active ingredient and an emulsifying agent in a suitable petroleum solvent. When it is added to water, a milky emulsion is usually formed.
EMULSIFYING AGENT - Material which facilitates the suspending of one liquid in another.
EMULSION - Mixture in which one liquid is suspended in tiny globules in another liquid, such as oil in water.
ENDANGERED SPECIES - Plants or animals whose population has been reduced to near extinction.
ENTOMOLOGY - The study of insects.
ENVIRONMENT - The external conditions and influences surrounding living organisms.
EPA ESTABLISHMENT NUMBER - A number assigned to each pesticide production facility by the EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product.
EPA REGISTRATION NUMBER - A number assigned to a pesticide product by the EPA when the product is registered by the manufacturer or the designated agent. The number must appear on all labels of that particular product.
ERADICATION - Pest management strategy that attempts to eliminate all members of a pest species.
EROSION - The process of wearing away soil.
EVALUATION - To examine or investigate for the purpose of judging the value, extent, or success.
EXPOSURE - Unwanted contact with pesticides or pesticide residues by people, other organisms, or the environment.
EXPOSURE ROUTE - The dermal (skin), oral (ingestion), or respiratory (inhalation) route by which a substance may enter an organism.
EXUDATE - Substance, usually liquid, discharged from a plant or animal through a natural opening or from diseased tissue through a wound.

F

FAMILY - A classification unit of genera with certain characteristics that make them related.
FIFRA - The Federal Insecticide, Fungicide, and Rodenticide Act, a federal law dealing with pesticide regulations and use.
FLOWABLE - A pesticide formulation in which a very finely ground solid particle, composed of both active and inert ingredients, is suspended in a liquid carrier. These formulations are mixed with water before spraying.
FOLIAR APPLICATION - Pesticide application to plant leaves or foliage.
FOLIAR BURN - Injury to shoot tissue caused by dehydration because of contact with high concentrations of fertilizers and pesticides.
FORMULATION - The pesticide product as purchased, containing a mixture of one or more active ingredients, carriers, and other additives.
FUMIGANT - A pesticide that kills destructive microorganisms, animals and plants as a gas.
FUNGICIDE - A pesticide used to destroy or inhibit fungi and other plant pathogens.
FUNGUS - A group of saprophytic and parasitic spore producing organisms usually classified as plants that lack chlorophyll and include molds, rusts, mildews, smuts, mushrooms, and yeasts.

G

GALL - Swelling or overgrowth produced on a plant as a result of infection by certain pathogens.
GENERAL USE PESTICIDE - A pesticide that can be purchased and used by the general public.
GENUS - (pl. Genera) A group of species with common characteristics.
GERMINATION - The beginning process when a plant sprouts from a seed.
GRANULAR - Dry formulation of pesticide and other components in discrete particles generally less than ten cubic millimeters in size.
GRASS - Plant having a single seed leaf and narrow leaves. A member of the family Gramineae (Poaceae).
GROUND COVER - Low growing broadleaf plant used to cover the soil.
GROUNDWATER - Water sources located beneath the soil surface.
GROWTH STAGES - The growing process that includes (1) tillering stage: when a plant produces additional shoots from a single crown, as in wheat; (2) jointing stage: when the internodes of the stem are elongating; (3) boot stage: when the seedhead of a plant begins to emerge from the sheath (usually grain crops).
GRUB - The larvae of certain beetles and also some flies.

H

HABITAT - The environment in which an organism lives.
HAZARD - The likelihood of an injury from pesticide use. Hazards constitutes both toxicity and exposure.
HEAT STRESS - A potentially life threatening condition where the body becomes over heated.
HERBACEOUS - The soft tissue of a plant that lacks woody sturucture.
HERBICIDE - A pesticide used to control, suppress, or kill plants or severely interrupt their normal growth processes.
HONEYDEW - The sweet, sticky excretion of aphids, leafhoppers scales, mealybugs, whiteflies.
HOST - Plant or animal from which a parasite gets its nutrients.
HUMUS - The organic fractions of soil in which decomposition is so far advanced that its original form cannot be distinguished.

I

INCOMPATIBLE - Two or more materials that cannot be mixed or used together.
INCUBATION PERIOD - The time from introduction of inoculum to the host and when the disease becomes microscopically evident.
INERT INGREDIENT - The chemical in a pesticide formulation that does not possess pesticidal activity.
INFECTION - Establishment of a pathogen within a host.
INFECTIOUS DISEASE - A pathogen caused disease that can be transmitted between plants.
INGREDIENT STATEMENT - The portion of the label on a pesticide container that gives the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.
INHALATION TOXICITY - The property of a pesticide to be poisonous to humans or animals when breathed in through the nose or mouth.
INHIBIT - To prevent something from happening, such as a biological reaction within the tissues of a plant or animal.
INOCULATION - The process of transferring inoculum to a host.
INOCULUM - Infectious pathogen or its spores, mycelium, or virus, bacteria or mycoplasma particles that are capable of infecting plants or animals.
INSECT - Any of the class Insecta with a well defined head, thorax, abdomen, six

legs, and typically one or two pairs of wings.
INSECTICIDE - Pesticide used to control, suppress, or kill insects or severely interrupt their normal growth processes.
INSOLUBLE - Refers to a chemical that does not dissolve in a liquid. For example, a wettable powder does not dissolve in water but rather forms a suspension.
INSPECTION - A critical examination and evaluation aimed at forming a judgment or determination.
INSTAR - Insect stages between molts.
INTEGRATED PEST MANAGEMENT (IPM) - A planned pest control program in which various techniques are used to keep pests from causing economic, health related, or other problems.
INVERT EMULSION - An emulsion in which water droplets are suspended in an oil rather than the oil droplets being suspended in water.

L

LABEL - All printed material attached to or part of a pesticide container. The label is a legal document.
LABELING - The pesticide product label and all supplemental pesticide information that complements the information on the label but may not necessarily by attached to or part of the container.
LARVA - (pl. Larvae) The immature or worm stage (caterpillar, maggot, grub) of an insect that passes through four stages (egg, larva, pupae, adult) in its development.
LEACHING - Process by which some pesticides move down through the soil, usually by being dissolved in water, with the possibility of reaching groundwater.
LEGAL STATUS - Classified such that an activity is permitted or allowed by law.
LESION - Localized area of discolored, diseased tissue.
LIFE CYCLE - The changes between birth and death of the organism.

M

MAGGOT - Larvae of the higher diptera, especially families related to houseflies.
MECHANICAL CONTROL - Physical control of pests using devices or machines that kill the pests and/or alter their environment.
MICROORGANISM - Tiny living organism such as bacteria, fungi, nematode or virus.
MIST - Pesticide sprays composed of droplets that has particle size sufficient to settle fairly rapidly, but still remain suspended long enough to be effective.
MILDEW - Fungal disease in which the mycelium and spores are seen as a whitish growth on the host surface.
MITE - Any of numerous small arachnids that often infest animals, plants, and stored foods.
MITICIDE - A pesticide used to destroy or inhibit mites.
MODE OF ACTION - The way in which a pesticide reacts with a pest.
MOLD - Any profuse or woolly fungus growth on damp or decaying matter or on surfaces of host tissue.
MULCH - Any material (straw, sawdust, leaves, plastic film, etc.) spread on the soil.

N

NECROSIS - Death of plant cells usually resulting in the affected tissue turning brown or black.
NONINFECTIOUS DISEASE - A disease caused by unfavorable growing conditions that cannot be transmitted from plant to plant.
NONLETHAL - Not capable of causing death.
NONPOINT SOURCE POLLUTION – Pollution that comes from a widespread area. The movement of pesticides into

streams or groundwater following a broadcast application to an agricultural field, large turf area, or right-of-way is an example of non-point-source pollution.
NONSELECTIVE HERBICIDE - Herbicide that is generally toxic to plants, without regard to species. Toxicity may be a function of dosage, method of application, etc.
NONTARGET ORGANISM - Any plant or animal other than the intended target of a pesticide application.
NOXIOUS - Something that is harmful to living organisms, such as noxious weeds.
NOXIUS WEED - A plant defined by law as particularly undesirable.
NOZZLE - A device for metering and dispersing a spray solution.
NUISANCE WEED - A plant not defined by law that causes management problems.
NYMPH - The immature stage (resembling an adult) of an insect that passes through three stages (egg, nymph and adult) of development.

O

OBLIGATE PARASITE - Parasite that in nature can grow and multiply only on or in living organisms.
ORAL TOXICITY - The occurrence of injury when a pesticide is taken by mouth.
ORGANIC MATTER - Plant or animal materials that can be broken down and re-synthesized in soil.
OVERSEED - Seeding in existing turf, usually with temporary turf grass, to provide green, active grass growth during dormancy of the original turf (usually a warm-season turf grass).

P

PARASITE - An organism that lives on or in a living host and that gets all or part of its nutrients from the host.
PARTICLE DRIFT - Spray particles which are carried away from the application area by air movements at the time of or soon after application.
PATHOGEN - Any organism capable of causing disease. Most pathogens are parasites.
PELLET - Dry formulation of a pesticide in discrete particles, usually larger than ten cubic millimeters.
PERCOLATE - To pass slowly through a material or spread throughout an area.
PERENNIAL - Plant that lives from year to year, but for three years or more under normal growing conditions.
PERSISTENT HERBICIDE - Herbicide which will, for an extended period of time, harm plants or interfere with regrowth of vegetation.
PERSONAL PROTECTIVE EQUIPMENT (PPE) - Devices and clothing that protect pesticide applicators, handlers, and workers from exposure to pesticides.
PEST - An undesirable organism (insect, bacterium, fungus, nematode, weed, virus, rodent) that is injurious to humans, desirable plants and animals, manufactured products, or natural products.
PESTICIDE - Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigrating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.
pH - Measure of a solution's acidity or alkalinity. Seven is numerically equal to a neutral solution, pH increases with increasing alkalinity, while pH decreases with increasing acidity.
PESTICIDE CONCENTRATE - A pesticide formulation before any dilution occurs.
PESTICIDE HANDLER - A person who works directly with pesticides, such as during mixing, loading, transporting, cleaning, storing, disposing, and applying,

or who repairs pesticide application equipment.
PHEROMONE - A biochemical substance produced by insects to attract others of the same species through the sense of smell.
PHOTODEGRADATION - Breakdown of chemicals by the action of sunlight.
PHOTOSYNTHESIS - Process by which plants convert sunlight into energy.
PHYSIOLOGY - The study of processes, activities and phenomena related to life.
PHYTOTOXIC - Injurious to plants such as from a pesticide treatment.
PLANT GROWTH REGULATOR - Substance used for controlling or modifying plant-growth processes without appreciable phytotoxic effect.
POINT SOURCE POLLUTION - The contamination of water and soil from a specific, identifiable place or location, such as a spill site or a permanent mixing, loading, and cleaning site.
POISON CONTROL CENTER - An agency, generally a hospital, that has current information on proper first-aid techniques and antidotes for poisoning emergencies.
POLLUTION - Contaminating the environment with harmful chemicals or waste products.
POSTEMERGENT HERBICIDE - Herbicide applied after emergence of the crop or weed.
PRECIPITATE - A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.
PRE-EMERGENT HERBICIDE - Herbicide applied before emergence of a crop or weed.
PREHARVEST INTERVAL - The length of time following the application of a pesticide when harvesting is restricted.
PRE-PLANT HERBICIDE - A herbicide that is applied before the crop is planted.
PRESCRIPTION - A proven formula for the control of pests.
PRESSURE RINSE - The process of decontaminating an empty pesticide container with water by using a special high-pressure nozzle to rinse the container.
PREVENTION - An action that makes it impossible or very difficult for an unwanted activity to happen.
PROTECTANT - Pesticide applied to a plant in advance of the pathogen to prevent infection.
PROTECTED STATUS - An animal or plant species that is designated as endangered, threatened, or experimental, and is protected by federal or state law.
PSI - Pressure measured in pounds per square inch.
PUPA (pl. Pupae) - The resting state of an insect that passes through four stages (egg, larvae, pupa and adult) in its development.
PUSTULE - Small blister-like elevation of epidermis created as spores form underneath and push outward.

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.
REGISTERED PESTICIDES - Pesticide products that have been registered by the Environmental Protection Agency for the uses listed on the label.
RESIDUAL - The ability of a pesticide to persist after application in amounts that will kill pests for several days to several weeks or longer.
RESISTANCE - Inherent ability of a host to suppress, retard, or prevent entry or subsequent activity of a pathogen or other injurious factor.
RESTRICTED ENTRY INTERVAL (REI) - The amount of time that must elapse between treatment of the crop and the time when a person can reenter and handle the crop without wearing protective

clothing and equipment or receiving early-entry training.
RESTRICTED USE PESTICIDE - A pesticide that can be purchased only by certified pesticide applicators and used only by certified applicators or persons under their direct supervision. Not available for use by the general public because of high toxicities and/or environmental hazards.
REVEGETATION - The process of planting or seeding areas with no plant cover.
RHIZOME - Underground stem capable of sending out roots and leafy shoots.
RING SPOT - Circular area of chlorosis with a green center; a symptom of various virus diseases.
RINSATE - A liquid obtained from rinsing pesticide containers and application equipment.
RISK - The frequency of an adverse effect in a given situation.
ROOT ZONE - The upper six to eight inches of soil, where most turf-grass roots are concentrated.
RUNOFF - The liquid spray material that drips from the foliage of treated plants or from other treated surfaces. Also, the rainwater or irrigation water that leaves an area and may contain trace amounts of pesticide.
RUSSET - Brownish, roughened areas on the skin of fruit resulting from cork formation.
RUST - A fungus with orange spores or the disease caused those fungi.

S

SALINITY - Excessive soluble salts in the soil.
SANITATION - Term used for cultural methods that reduce inoculum.
SCALD - Turf collapse and browning because shallow, standing water gets too hot.
SCALE INSECTS - Insects that characterized by hard, convex coverings over their body with no visible appendages or segmentation.
SCALP - To remove excessive amounts of functioning green leaves with mowing. Gives a shabby, brown appearance from exposing crowns, stolons, dead leaves, and even bare soil.
SELECTIVE HERBICIDE - A herbicide that is more toxic to some plant species than to others.
SIGNAL WORDS - Words that appear on pesticide labels to denote the relative acute toxicity of the product.
SILVICIDE - A pesticide used to destroy or inhibit trees and woody vegetation.
SITE - The crop, animal, structure, commodity, or area where a pesticide is applied to control pests.
SKELETONIZE - To remove the green portions of a leaf, leaving veins, midribs or transparent membranes.
SOD - Plugs, squares or strips of turf grass, with adhering soil used in vegetative planting.
SOIL APPLICATION - Pesticide applied mainly to the soil surface rather than to vegetation.
SOIL MOBILITY - Variable characteristic of a pesticide based on its chemical nature. Highly mobile pesticides leach rapidly through the soil and may contaminate groundwater. Immobile pesticides or those with low soil mobility remain attached to soil particles and are resistant to leaching.
SOIL MODIFICATION - Alteration of soil characteristics by adding soil amendments; commonly used to improve physical conditions.
SOIL PROBE - A cylindrical soil-sampling tool with a cutting edge at the lower end.
SOIL STERILANT HERBICIDE - A herbicide which renders the soil incapable of supporting plant growth. Sterilization

may be temporary or practically permanent.
SOIL STERILIZATION - Treating soil by heat or chemicals to kill living organisms.
SOIL STRUCTURE - The relative proportion of sand, silt, and clay in a soil.
SOIL TYPES - Term use in classifying different kinds of soil by physical characteristics.
SOLUBILITY - The extent to which one substance is able to dissolve in another.
SOLUBLE POWDER - A powder formulation that dissolves and forms a solution in water.
SOLUTION - Mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are completely dissolved.
SPECIES - Taxonomic classification, below the genus of related organisms capable of interbreeding
SPORE - A tiny propagative unit of a fungus that functions as a seed but differs by not containing a preformed embryo.
SPOT TREATMENT - Pesticide applied over small, restricted area(s), of a larger area such as the treatment of weed patches within a larger field.
SPRAY DEPOSIT - The pesticide that hits the plant or other surface.
SPRAY DRIFT - The movement of airborne spray particles from the intended contact area.
SPREADER - A adjuvant used to enhance the spread of a pesticide over a treated surface, thus improving the coverage.
STAND - The number of established individual shoots per unit area.
STOMA (pl. Stomata) - A tiny opening in the epidermis of a leaf or stem through which gases are exchanged.
SUPPLEMENTAL LABELING - EPA approved written, printed, or graphic material supplied by the pesticide manufacturer that provides additional product information not present on the current container label.
SURFACE WATER - Water on the earth's surface in rivers, lakes, ponds, and streams.
SURFACTANT - A material in pesticide formulations imparts emulsifiability, spreading, wetting, dispersability, or other surface-modifying properties.
SUSPENSION - Liquid or gas in which very fine solid particles are dispersed but not dissolved.
SWATH - The width of the area covered by one sweep of an airplane, ground sprayer, spreader, or duster.
SYMPTON - Any detectable change in an organism resulting from the activities of a pathogen or other pest also, an indication of pesticide poisoning in humans and other animals.
SYNERGISM - The action that produces a greater cumulative effect when two pesticides are used together than when used individually.
SYSTEMIC - Pesticide absorbed or injected into the plant and then spread internally through the plant.

T

TANK MIX - A mixture of products in a spray tank.
TAPROOT - A single, large, primary root.
TARGET - The plants, animals, structures, areas, or pests at which the pesticide or other control method is directed.
TEMPERATURE INVERSION - A weather related event that occurs when cool air is trapped near the ground under a layer of warn air. Under these conditions very little vertical mixing of air occurs, and small spray droplets or vapors may remain suspended in the cool air layer for long periods and move with any air flow. Damage from spray drift often occurs under such conditions.

THATCH - A tightly intermingled layer of organic residue between the base of the grass and the soil.
THICKENER - A drift control adjuvant such as cellulose or gel used to promote the formation of a greater proportion of large droplets in a spray mixture.
THORAX - The middle region of an insect's body, where the legs and wings are attached.
TILLER - A lateral stem or shoot that develops from the central crown.
TOLERANCE - The ability of an organism to tolerate a pesticide.
TOPDRESSING - Applying a prepared soil mix to the turf surface.
TOTAL VEGETATION APPLICATION - Applying of single or multiple pesticide at one time or in sequence to provide pre-emergent and/or post emergent control of all plants. The term usually involves application to noncrop areas.
TOXIC - Poisonous to living organisms.
TOXICITY - The ability of a pesticide to harm a living organism.
TRADE NAME - A brand name that is registered as a trademark by the manufacturer.
TRANSLOCATED HERBICIDE - Herbicide that is moved within the plant. Translocated herbicides may be either phloem-mobile or xylem-mobile, but the term is often used in a more restrictive sense to refer to herbicides that are moved in the phloem.
TRANSMISSION - Spread of pathogens from plant to plant.
TRIPLE RINSE - The process of decontaminating an empty pesticide container by partially filling the container with water, replacing the lid, shaking the container, and then pouring the rinsate in the spray tank. This process is repeated three times.
TUBER - A swollen underground stem with numerous buds.
TUMOR - Abnormal swelling or growth.

U
ULTRA LOW VOLUME (ULV) - Sprays that are applied at 0.5 gallon or less per acre, often as the undiluted formulation.
UNCLASSIFIED PESTICIDES - Pesticides that are commonly referred to as general-use pesticides. They can be bought and used by the general public without special permits or restrictions.
UNPROTECTED STATUS - Animal or plant species that is not protected by federal or state law.

V
VAPOR DRIFT - The movement of pesticide vapors from the application site that can injure nontarget plants or animals.
VARIETY - A subspecies or a near relative with minor differentiations.
VECTOR - Agent that transmits pathogens.
VEINATION - Vein arrangement of a leaf.
VIABLE - Alive, especially with reference to seeds capable of germinating.
VIRUS - Submicroscopic parasite that cause mosaics, ring-spots, and other plant diseases. Viruses only reproduce in living cells.
VOLATILITY - The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.
VOLATILIZE - Vaporize or change from a liquid to a gas at certain temperatures.

W
WARNING - The signal word used on pesticide products that are considered moderately toxic.
WATER SOLUBLE CONCENTRATE - A liquid pesticide formulation that dissolves in water to form a true solution.
WATER TABLE - The upper level of the water saturated zone in the ground.

WEED - A plant growing where it is not wanted or where it is in direct conflict with the well-being of humans and their activities.
WETLAND - Area with aquatic soils and vegetation.
WETTABLE POWDER - A dry pesticide formulation in powder form that forms a suspension when added to water.
WETTING AGENT - An adjuvant used to reduce the surface tension between a liquid and the contact surface for more thorough coverage.
WETLAND - Area with aquatic soils and vegetation.
WILT - Loss of rigidity and drooping of plant parts, generally caused by insufficient water in the plant.
WINDBURN - Death and browning of leaves caused by desiccation.
WORKER PROTECTION STANDARD (WPS) - A federal regulation that intends to reduce the risk of pesticide poisoning and injuries among agricultural workers and handlers. The WPS requires agricultural employers to provide protections to workers and handlers, including but not limited to: safety training, posting of application sites, and decontamination supplies.