

Use of Pesticides in Vegetation Maintenance



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What is a pesticide?

A pesticide is any substance or mixture of substances intended for:

**preventing • destroying • repelling • mitigating
*any pest***

Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides and various other substances used to control pests.

Under U.S. law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

Pesticide types and targets:

- ▶ Herbicide – weeds
- ▶ Insecticide – insects
- ▶ Aracnicides – mites, ticks spiders
- ▶ Fungicide – fungi, plant diseases
- ▶ Molluscicide – mollusks (slugs and snails)
- ▶ Rodenticide – rodents
- ▶ Avicide – birds
- ▶ Repellent – keeps pests away
- ▶ Plant growth regulator – stops, accelerates or changes normal plant growth
- ▶ Nematicide – nematodes
- ▶ Piscicide – fish
- ▶ Predacide – vertabrate pests

This chapter emphasizes the most commonly used pesticides for landscape use: herbicides, insecticides, aracnicides (specifically miticides for mites) and fungicides.

Remember

Never apply a pesticide without thoroughly reading the pesticide label.





What guidelines should I follow in determining when to use herbicides?

Providing safe and reliable travelways is dependent upon effective vegetation management. To accomplish this fundamental goal, there are several vegetation management methods to choose from, such as weeding by hand, mowing and trimming (see Chapter 5), applying herbicides and release of weed-eating insects. There is no one method that is suitable for managing vegetation in all rights-of way.

A sustainable approach to vegetation management is one that takes an integrated approach. This means you must consider all methods, adopt one or a combination of several methods that are best suited to your stretch of the ROW, and continuously evaluate and modify your approach in light of changing scenarios.

Herbicides can cause adverse effects on the environment, particularly when used inappropriately. When used according to the label, herbicides can be an effective vegetation management method. In the majority of highway rights-of-way, you should seek to establish a ground cover that can survive the localized environmental conditions, prevent soil erosion, protect the soil surface and facilitate the purpose of the rights-of-way.

Herbicides provide a means of preparing a site for desirable plants, encourage their establishment, and prevent invasion from undesirable species. The ability to use herbicides to selectively encourage the establishment and growth of the desired species and eliminate the others requires knowledge of herbicide performance, the proper time to introduce them, and skill in a variety of application modalities. Just as there is no one vegetation control method suited to all rights-of-way, there is also no one herbicide or mix of herbicides best for weed management in all right-of-way locations.

All landscaped areas in the ROW must not exceed 10% weed infestation of each designated area. This should be accomplished and maintained within 180 days after work begins. This includes turf and shrub/hedge areas in medians and roadsides, ground cover areas, erosion control planted areas and areas along the project boundaries (right-of-way fence line, etc.) and under median guard rails.

All landscaped areas in high visibility urban areas will have a lower

tolerance for the presence of weeds. These areas should be maintained as weed free as possible with a maximum tolerance level not to exceed 2% weed infestation.

You should use approved pre-emergent herbicides on a quarterly cycle as necessary to control excessive weeds in planting beds and open turf areas.

Specific selective post-emergent herbicides also may be applied as a blanket spray or spot spray for control of broadleaf and grassy weeds and sedges to avoid injury to desirable non-target species in these areas.

Conspicuous and priority weeds (see Chapter 9) shall be removed by the roots or effectively treated with an appropriate selective herbicide in all landscaped areas in visible urban locations.

Careful spot spraying with a non-selective herbicide (e.g., Roundup®) can be used if no other effective herbicide is available.



Cutting or topping these conspicuous weeds at the ground line will not be allowed as a means of control in high visibility urban areas. This requirement shall be strictly enforced.



How do I read a label?

Thoroughly!

Reading the label is the most important step in the use of any pesticide.

Important information about a product:

PRODUCT NAME ^{1,3}	
<p>DIRECTIONS FOR USE ^{5,15} It is a violation of federal law to use this product in a manner inconsistent with its labeling.</p> <p>_____</p> <p>_____</p>	<p>KEEP OUT OF THE REACH OF CHILDREN</p> <p>D A N G E R ¹²</p>
<p>PRECAUTIONARY STATEMENTS HAZARD TO HUMANS (AND DOMESTIC ANIMALS) ⁶ D A N G E R ¹⁴</p> <p>_____</p> <p>_____</p> <p>ENVIRONMENTAL HAZARDS ⁷</p> <p>_____</p> <p>_____</p> <p>PHYSICAL OR CHEMICAL HAZARDS ⁸</p> <p>_____</p> <p>_____</p>	<p>FIRST AID ¹⁰ (STATEMENT OF PRACTICAL TREATMENT)</p> <p>IF SWALLOWED _____</p> <p>IF INHALED _____</p> <p>IF IN EYES _____</p> <p>IF ON SKIN _____</p>
<p>ACTIVE INGREDIENTS: ² _____ %</p> <p>OTHER (INERT) INGREDIENTS: ⁴ _____ %</p> <p>TOTAL: _____ 100.00 %</p>	<p>THIS PRODUCT CONTAINS XX LBS OF XXXX PER GALLON</p> <p>WARRANTY STATEMENT</p> <p>_____</p>
<p>STORAGE AND DISPOSAL ⁹</p> <p>STORAGE _____</p> <p>DISPOSAL _____</p>	<p>MANUFACTURER'S ADDRESS ¹⁷ _____</p> <p>NET WT. / NET CONTENTS STATEMENT: ¹³ _____</p> <p>EPA Registration No. / EPA Reg. No: ¹⁶ _____</p> <p>EPA Establishment No. / EPA Est. No: ¹⁶ _____</p>

1. **Product Name or Brand Name** – The product name, brand or trademark is plainly displayed on the front panel of the product label. The brand name is the name used in ads by the company that makes the product and is the most identifiable name for the product.
2. **Active Ingredients** – Identifies the “active ingredient(s)” in the product. The active ingredient is the actual poisonous chemical that controls the pests listed on the label. Every pesticide label must list all ingredients. It must show the total amount or percent of all active ingredients and the percent and type of inert ingredients. The names of the active ingredients must be shown either by chemical name or common and chemical name.

3. **Common Name** – All chemicals have a scientific name. Many times chemicals with a complex scientific name are also given a simpler common name. Both the scientific name and the common name of active ingredients will be the same for every company. The brand name will differ depending on which company made the chemical.
4. **Other (inert) ingredients** – Tells you the percentage of “other ingredients” (sometimes called “inert ingredients”) in the product. The names of the other ingredients do not need to be shown. These ingredients do not control the pest but serve other purposes, such as dissolving the active ingredients or affecting how the product works. Presently, the inert ingredients do not need to be listed. New labeling regulations will require toxic inert ingredients to be listed.
5. **Directions For Use** – The instructions on the label must tell you how to use the product properly within its legal requirements for the best results. The directions will tell you:
 - The “target” pests the product is registered to control.
 - The crops, animals or other items the products can be used on.
 - In what form the product should be applied.
 - How to apply the product.
 - How much to use.
 - Where it should be applied.
 - When it should be applied.
 - How frequently it should be applied.
 - How soon the crop may be used/eaten after product is applied.

Eco

To protect yourself and the environment,
always follow the manufacturer’s directions.



6. **Precautionary Statements Hazard to Humans and Domestic Animals** – This section describes potential hazards to people or pets and actions you can take to reduce those hazards, for example, wearing gloves.
7. **Environmental Hazards** – If the product is potentially harmful to wildlife, fish, endangered plants or animals, or may adversely impact wetlands or water resources, this section will provide additional information on what to do to avoid environmental damage.
8. **Physical or Chemical Hazards** – This section notes hazards, such as corrosiveness or flammability of the product (e.g., if the pesticide is flammable the product should not be used near open flames).
9. **Storage and Disposal** – This section tells you how to best store the product and what to do with the unused portion of the product and the empty container.
10. **First Aid** – This section tells you what to do if someone swallows, breathes, inhales, or gets it on their skin or eyes. Labels may also contain a section labeled “Note to Physicians” which provides doctors with specific medical information.
11. **Type of Formulation** – A pesticide may be available in more than one type of formulation: liquids, wettable powders, emulsifiable concentrations, dusts and others. Different types of formulations require different methods of handling. The label will say what type of formulation the package contains and how to use it properly.
12. **Child Hazard Warning** – Every pesticide container must bear the statement “KEEP OUT OF REACH OF CHILDREN” on the front label.
13. **Net Wt/Net Contents Statement** – The label must show how much product is in the container. This can be expressed in ounces, liters, pounds, or other units.
14. **Signal Words** – The words CAUTION, WARNING, and DANGER are used to indicate how toxic the product is to humans and animals. The signal word for each pesticide is clearly displayed on the first page of the label. This section will also recommend on how to avoid poisoning, such as protective clothing or ventilation requirements. If poisoning occurs, call your local emergency

number or contact the Regional Poison Center for advice. Be sure to provide label information to the medical personnel. Pesticides or pesticide residues may contaminate water supplies, accumulate to dangerous levels in the environment, or may harm birds, fish or wildlife. To address these problems the label may contain environmental precautions applying to air, water or wildlife.



“Danger” labeled pesticides require that the applicator has a valid “restricted use” license from HDOA or is under the direct supervision of a certified pesticide applicator with a valid certificate issued by HDOA. HDOT Engineer’s written approval is also required prior to use of pesticides labeled “Danger.”

A label’s SIGNAL WORD indicates the product’s toxicity.

	Category	SIGNAL WORD	Dose deadly to humans
I	Highly Toxic	DANGER	A few drops to one teaspoon
II	Moderately toxic	WARNING	one teaspoon to one ounce
III	Slightly toxic	CAUTION	over one ounce

Warning and Caution statements will also tell you in what ways the product may be poisonous to humans and domestic animals. It will make recommendations on how to avoid poisoning, such as protective clothing or ventilation requirements. However, more information in this area than is legally required is needed on the labels of pesticides. Types of safety equipment are not always clearly defined, and it is not specified how much ventilation is adequate (an open window, exhaust fan, or outdoor use).

Pesticides or pesticide residues may contaminate water supplies, accumulate to dangerous levels in the environment, or may harm birds, fish or wildlife. To address these problems the label may contain environmental precautions applying to air, water or wildlife.

15. Misuse Statement – To use a pesticide product in any manner inconsistent with its labeling is a violation of federal law. You are reminded of this in the misuse statement.

16. Registration and Establishment Numbers – Every pesticide on the market must be registered with the Environmental Protection

Agency of the federal government. The registration number must be on the front panel of the label and is written as "EPA Registration No. XXX." The establishment number, which is a code for which factory makes the chemical, must also be on every pesticide container. It usually appears under the registration number.

- 17. Name and Address of Manufacturer** – The name and address of the company that made or distributed the product must be on the label. This way the purchaser of the product knows who made or sold the product and can contact them if necessary. Companies will also provide you with a materials safety data sheet upon request.



What do I need to know to apply pesticides safely?

Safety

- ▶ **Always follow the instructions on the pesticide label.**
It's the Law! Label must be available at the site of application. Workers should never handle a container that does not have a label attached. The supervisor in charge should immediately be advised of the situation.
- ▶ **Have plans for dealing with potential accidents before they happen.** These plans should consider: Labels and MSDS Sheets, Spill Cleanup Kits, Cleanup Procedures, Emergency Medical Care all of which is specified on the label.
- ▶ **When threat of heavy rains is eminent** do not treat areas that might be exposed to water sheet flows.
- ▶ **Always wear proper personal protective equipment (PPE) as required in the label.** Mixing and loading are the most dangerous tasks when handling chemicals. Whenever mixing, loading and applying pesticides you must wear protective clothing called PPE (Personal Protective Equipment). The minimum required PPE includes:
 - Unlined rubber gloves and rubber boots.
 - Long-sleeved shirt and long pants or chemical coveralls.
 - Eye protection.
 - Dust mask (or respirator with chemicals that pose a significant risk if inhaled).
 - Non-absorbent hat if spraying over your head.
 - Non-absorbent apron while mixing and loading.

- ▶ **Have fresh water on site** for emergency decontamination and standard hygiene or other items as required by the label: 10 gallons (one applicator) or 20 gallons (two or more applicators) of fresh water; have soap and paper towels available for personal cleanup.
- ▶ **In case of accidental exposure to a pesticide.** Be familiar with first aid procedures and read label for more specific information.
 - **Ingestion**
If a chemical is swallowed, read the product label to see if inducing vomiting is necessary. Avoid inducing vomiting unless you are instructed to do so on the label because this can be very harmful. Get medical help immediately by calling 911.
 - **Inhalation**
If the fumes or dust from the chemical is breathed in, move the victim to a location with fresh air. If not breathing, call 911 immediately and start artificial respiration.
 - **Skin contact**
Absorption through the skin is the most common route of pesticide poisoning. Douse the skin and clothes with water and remove contaminated clothing. Wash skin thoroughly with soap and water. Follow the label regarding medical attention.
 - **Eye contact**
Rinse eyes continuously under a stream of clean water for at least 20 minutes, blinking as much as possible. If vision is impaired, get immediate medical attention.

Safety during cleanup

- ▶ Triple rinse sprayers and empty pesticide containers with water and dispose of this rinsate (the mixture of contaminated water and low concentrations of used pesticide products) by spraying back into treatment area, or collect it for proper disposal at a later date (in accordance with stormwater best practices training and manual).
- ▶ Never clean or rinse pesticide equipment and containers within the DOT ROW or in the vicinity of storm drains or other open water areas. Never pour chemicals into open drains or sewers.
- ▶ Workers must immediately clean up any chemical spills according to label instructions and notify appropriate supervisors and agencies.

Dealing with spills of CAUTION and WARNING rated pesticides

Follow label instructions.

Wear appropriate PPE.

Contain the spill as quickly as possible by using an absorbent material, such as kitty litter, rags or even soil if nothing else is available.

Protect personal safety first. Redirect traffic as necessary using appropriate cones or flair devices.

Prevent a spill from reaching any water source: block or redirect it.

Absorb as much of the chemical as possible and put into a sealable plastic bag or heavy garbage bag; label the bag with name of the product that was spilled.

Do NOT spray area with water. You should try to contain and cover the area with adsorbent materials. If the spill is on an open soil area, shovel up all dirt until you reach uncontaminated soil and dispose of in the collection bag.

Notify local emergency response personnel, if necessary (police, fire, LEPC).

If the spill is on an open soil area, shovel up all dirt until you reach uncontaminated soil and dispose of in the collection bag.

If the pesticide has a DANGER label, contain the spill and then call for professional environmental specialists.

Safety!

Always carry a spill kit that is appropriate to the amount of pesticide you have in your vehicle or in storage.

Safety Kit Contents

- Emergency telephone numbers.
- Personal Protective Equipment (PPE) (e.g., two pairs of coveralls, rubber gloves, rubber boots, eye protection, dust masks).



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- Absorbent materials, such as absorbent clay, saw dust, pet litter, activated charcoal, vermiculite, paper or spill pillows to soak up liquid spills (amount proportional to the amount of herbicide you carry).
- Sweeping compound to keep dry spills from drifting or wafting during cleanup.
- Shovel, broom and dustpan.
- Heavy-duty detergent.
- Fire extinguisher rated for all types of fires.
- Closable, sturdy plastic container that will hold the quantity of pesticide from the largest pesticide container being handled.
- 1-10 gallons of water and soap depending on the amount of pesticide you carry.
- First Aid Kit.
- Rubbish bags and buckets.
- Other spill cleanup items specified on the labels of products used regularly.

Follow these procedures and precautions when using pesticides:

- ▶ In general, non-crop uses are exempt from EPA's Worker Protection Standards (WPS), which include exemption from posting signs prior/during/after application of pesticides in the highway rights-of-way (<http://www.epa.gov/pesticides/safety/workers/PART170.htm#170.103>). However, always check the herbicide label in the box titled "Non-agricultural Use Requirements" and also check with your Engineer for any HDOT requirements for posting signs.
- ▶ To avoid spills and protect the environment, whenever possible, mixing should be done at the base yards and not on site.
- ▶ To avoid spills during transportation, ensure that chemicals are properly secured in the vehicle.

- ▶ Containers brought to the work zone should be staged either in the bed of the truck when not in use and/or in a secondary container for potential leaks/spillage during transport/handling.
- ▶ Monitor the environmental conditions (i.e., weather and growth status of the weeds or pests, before making a pesticide application).
- ▶ Calibrate sprayer and confine spray to target species **only**.
- ▶ Apply herbicides when target species are actively growing; this is when they are most susceptible.
- ▶ Good leaf coverage will give the best results for foliar applications.
- ▶ For many species, repeat applications may be necessary.
- ▶ As much as possible employ direct methods of application (e.g., cut and stump painting, spot spraying, drill and inject) to minimize the total volume of pesticide used and any accompanying non-target effects.
- ▶ Do not spray pesticides on windy (winds over 8 mph) or rainy days. Prevent drift into neighboring residential and commercial areas. Drift should always be prevented (i.e., low pressure, coarse spray, low wind).
- ▶ If undesirable vegetation is greater than 5 ft. in height, it should be cut first to a height no greater than 6 inches and sprayed when new leaf growth is established.
- ▶ Where spraying within 5 ft. of standing water, pesticides registered for use over water should be used. Precautions should be taken when spraying in dry ditches, swales or other areas that may fill with water during heavy rainfall, non-residual, non-soil active herbicides or pesticides should be favored in this situation.
- ▶ Do not fuel or service any equipment near drain inlets, drainage channels, or receiving waters. Whenever possible perform fueling and maintenance of vehicles and equipment in designated areas within base yards.

Store all chemicals in closed containers and periodically check for corroded containers, chemical discoloration, or any changes in the con-

tainer or contents indicating a hazardous condition or deterioration. Do not store pesticides in areas subject to sheet water flow; locate them to higher ground.



What are the basic types of herbicides?

Herbicides are the most commonly used pesticides for landscape maintenance. Each herbicide can be characterized by general properties:

- Pre-emergent versus post-emergent herbicides (residual versus non-residual)
- Selective versus non-selective
- Systemic versus non-systemic
- Residual versus non-residual

These properties are described in detail in the following sections.

What are pre-emergent or post-emergent herbicides?

Pre-emergence herbicides

- Applied to soil and effective against germinating seeds, prevents new weeds from getting established.
- Actively growing weeds generally are not affected by pre-emergence herbicides, but some may cause contact injury or kill small seedlings.
- Most pre-emergence herbicides will remain active for several months (long residual). When used in Hawaii, they must be applied every three to four months to provide continuous protection.
- Can be applied as liquid and granular application. Weed controlling properties of pre-emergence herbicides are optimized when activated by rainfall or overhead irrigation within 2 weeks after application.

Tip

Ronstar® and Oust® are examples of pre-emergent herbicides with a long residual effect.



Post-emergence herbicides

- Used to kill existing weeds; most effective on younger seedlings.
- Very effective against most herbaceous weedy species.

- The majority are liquid sprays that must be applied to and absorbed through the leaves of weeds.
- Length of time needed for visible effects on weeds may vary from several hours to two weeks.
- May be used on woody species by application to bark (basal bark), holes drilled into trunk, on ring of wood where bark has been stripped, or on cut stumps.

Tips

Post-emergents have little or no residual effect. Roundup® and Fulilade® are examples of post-emergent herbicides. However, some post-emergence herbicide can have significant residual soil activity like Milestone® and herbicides containing the active ingredient dicamba. The herbicide label will provide information on soil activity and considerations for injury to desirable plants.

What are selective or non-selective herbicides?



Selective herbicides – These kill one group of target plants, but do not kill other types. Usually the general plant groups, **grass, sedge** and **broadleaf** (broadleaf will often include a special category for vines), are used to describe the target group that a herbicide kills, but sometimes the label may describe selectivity toward individual species. Selective herbicides are safe and do not usually kill or harm non-target plants in other groups. These can often be sprayed with no damage. It important to note that the concept of selectivity often depends on how much herbicide is applied. Selectivity at one concentration may be, and often is, non-selective at a higher concentration.



Tips

- ▶ Selective herbicides are useful if you have a problem with a weed growing in an area of desired vegetation. For example:
 - Use a grass-specific herbicide on grasses growing through low-cut shrubs, such as California grass growing through oleander.
 - Use a broadleaf-specific herbicide for woody weeds that pose line-of-sight issues in rural, grassy rights-of-way.

Non-selective herbicides – This group kills almost all plants. There is no selectivity. Great care must be followed when using non-selective herbicides. These are commonly used as a spot spray to target weedy plants. Avoid drift onto non-target plants in windy weather.

Plant groups based on general types

Grasses

Grass leaves are generally narrow and upright with parallel veins. Grasses have round stems that are hollow between nodes. Each leaf consists of a sheath surrounding the stem and a blade; leaves are arranged along the stem in rows, one on each side. Many grasses have extensive dense fibrous root systems.

Sedges

Sedges resemble grasses, but their stems are solid and often triangular, with no obvious joints. The leaf sheath closes around the stem, and the leaves are arranged in threes at the end of the flower stalk. Sedges are often associated with shady wetlands. The three most common weedy sedges in Hawaii are nutsedge (nutgrass), kylinga and McCoy grass.

Broadleaf plants

Broadleaf plants generally have broad leaves with veins in a branching pattern, but some have narrow leaves with less obvious venation. They have taproots and coarse, extensive root systems. The flowering reproductive phase of growth may not occur until late in the life cycle of the plant. Most broadleaf plants are considered undesirable in grassy rights-of-way, but some low-growing legumes are tolerable because they enhance soil fertility by fixing nitrogen. Many broadleaf plants are woody plants, such as brush, shrubs and trees. Shrubs have several stems, are less than 10 ft. tall and sometimes are called “brush.” Trees usually have a single main stem (trunk) and are over 10 ft. tall.

What are systemic versus non-systemic herbicides?

Systemic

Systemic, or translocated, herbicides are absorbed by leaves and sometimes by roots after application and distributed throughout the plant.

- After the active ingredient is absorbed through the leaves or young green stems, it is translocated to all parts of plant.
- Results in more complete kill: shoots, roots, rhizomes and stolons.

- Most effective control for perennial weeds and woody plants.
- Usually a slower kill than from non-systemic herbicides.
- Repeat applications are often necessary.
- May have residual effects in soil; can be taken up by roots.

Tip

Glyphosate (Roundup® and other products) and Garlon® are examples of systemic herbicides.



Non-systemic

- Must come in contact with and be absorbed through leaves.
- Fast acting – evidence of die back can be seen in a day or so.
- Affects only the tops or shoots of weeds “top-kill” or “burn” but will provide complete control for annual weeds.
- Very little translocation to lower parts of plant – perennial and biennial weeds can re-grow from roots or rhizomes.
- Repeat applications are usually necessary for effective control of larger plants.

Weed control decisions based on plant life cycles

Plants may be classified by their life cycle: annual, biennial or perennial. Understanding plant life cycles helps in determining the best time to use particular management techniques, or whether management is even necessary.

Annuals

- An annual plant germinates from seed, reaches full growth, and produces seed within a year.
- Plants classified as annuals in temperate areas die out in cold weather and new seeds germinate in early spring.
- Annuals in Hawaii germinate and grow throughout the entire year and present a constant problem.
- Pre-emergents applied consistently every three or four months are very effective in controlling annual weeds, as well as preventing other weeds becoming established from seed.
- Examples of annuals that persist throughout the year in Hawaii are goosegrass, crabgrass and spiny amaranth.

Perennials

- Perennial plants live more than two years.

- They usually have an extensive root system, which helps them overwinter in temperate areas.
- They may be grasses or broadleaf plants, herbaceous or woody, and their form may be vine, shrub or tree.
- Perennials may germinate from seed but often also can reproduce and spread using vegetative structures, such as tubers, rhizomes and stolons, which contain stored food. When these organs are the source of growth, the perennial seedling is generally harder to control.
- Woody perennials may live for many years. The most obvious members of this group are trees, shrubs and woody vines.
- Control methods for established perennials are often timed to coincide with periods of active growth – when systemic herbicides are more effectively transported to all parts of the plant.



Adjuvants – What are they and how do I use them?

An adjuvant is a chemical added to a pesticide formulation or tank mix to increase its effectiveness or safety. Most pesticide formulations contain at least a small amount of adjuvants. Spray adjuvants are used with post-emergence herbicides to help the plant absorb the active ingredient and spread it to the inside of the leaves. It also improves rain-fastness or “stickiness” by allowing the herbicide to spread evenly over the leaf surface and dry quickly.

The Weed Science Society of America defines an adjuvant as any substance in an herbicide formulation or added to the spray tank to modify herbicidal activity or application characteristics. Some products are formulated with sufficient additives, so the user usually does not need to add them to the tank (Roundup Ultra®). Other products require addition of adjuvants for all uses.

Three types of adjuvants used to enhance herbicide performance: surfactants, crop oil concentrates and ammonium fertilizers.

- **Surfactants:** Some of the most common adjuvants are surfactants – “surface active ingredients” – that alter the dispersing, spreading and wetting properties of spray droplets. Surfactants decrease the surface tension of the herbicide mix, making it much easier for the plant to absorb it. You may notice that a surfactant is categorized as ionic or non-ionic, which indicates that it is appropriate for use with a particular herbicide.

- **Crop oil concentrates (COCs):** These are a combination of a surfactant and a non-phytotoxic (not toxic to plant growth) oil. COCs are usually either a petroleum-based oil or modified vegetable oil. In situations where weeds are under stress from environmental conditions, such as drought, a methylated seed oil (MSO) may work best. A methylated seed oil (MSO) is a vegetable-based oil that has been chemically altered with methanol, which allows the oil to penetrate protective wax coatings on the leaves of weeds.
- **Nitrogen (ammonium-based) fertilizers:** Enhance effectiveness of some herbicides, and solve problems with hard water.

Remember

Most of the time, unless the label says otherwise, you will need to use an adjuvant with your pesticide.



Check the label. Many adjuvants can cause severe damage to vegetation if too much is used in the spray mix. Follow the label mixing instructions.



Other common adjuvants are:

- Wetting agents – allow wettable powders to mix with water.
- Emulsifiers – allow petroleum-based pesticides (ECs) to mix with water.
- Invert emulsifiers – allow water-based pesticides to mix with petroleum carrier.
- Spreaders – allow pesticide to form a uniform coating layer over the treated surface.
- Stickers – allow pesticide to stay on the treated surface.
- Penetrants – allow the pesticide to get through the outer surface to the inside of the treated area.
- Foaming agents – reduce drift or can be used for marking treated sections of the target site.
- Anti-foaming agents – reduce foaming of spray mixtures that require vigorous agitation.

- Thickeners – reduce drift by increasing droplet size.
- Safeners – reduce the toxicity of certain herbicides to specific plants. Safeners are used when the herbicide needed is toxic to a desirable plant and generally used in specialized agronomic settings.
- Compatibility agents – aid in combining pesticides (and fertilizers) effectively.
- Buffers – allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity.

Remember

The herbicide label is the best source of information and specifies the legally permitted adjuvant to be used with that product. Herbicide manufacturers expend considerable effort to determine what adjuvants provide the most consistent product performance. Sometimes labels give users options on what adjuvant to use with respect to environmental conditions, target species, and tank-mix partners.



How do I use dry and liquid pesticide formulations?

Dry versus liquid chemicals

Pesticides are available in either dry form (usually as granules or powder) or in liquid form. The decision to use dry or liquid chemicals depends on the type of applicators available, local conditions and a variety of other factors. Before using any chemical, be sure to read the product label, wear necessary personal protective equipment (PPE) and follow label instructions for proper handling and application procedures.

Some product labels prohibit use of application equipment held against the body. Do not use backpack sprayers or hand held rotary spreaders carried against the chest when using these products.



Granular formulations

Pesticides in granular form are ready-to-use and need no mixing or special preparation. Granular pesticides are applied with a spreader and require watering after application for activation. See Chapter 11, "Fertilizers," for more information on the calibration and use of spreaders.

Because of the potential for environmental contamination, granular spreader applications should normally not be used close to roadsides. Following application, granules can sit on the surface for an extended time before dissolving and can be lost to wind, rain or runoff, posing a hazard to wildlife and possible damage to the landscape.

Powder formulations

Most powder formulations are concentrated dry mixes of the active ingredient and are intended to be mixed with water and sprayed onto the target area. The most common powder formulations are labeled as wettable powder and will be designated as such with a WP or W as a part of the brand name. Some dry formulations are designated as DF, meaning dry flowable. A dry flowable may look like a granular but it is intended to be mixed with water in the same way as a powder formulation. Dry flowable formulations are produced to reduce the fugitive dust potential of powdered formulations.

Liquid chemicals

Some liquid chemicals are ready-to-use, and generally targeted for use by homeowners and plant hobbyists. However, concentrated liquids targeted for commercial applications must be diluted with water prior to application. Pesticides applied as a liquid spray tend to be less expensive and more effective than granular chemicals. Liquids are generally not visible once applied but can be tank mixed with a water soluble dye to aid in getting complete coverage and tracking application across large areas.

Since most liquid products require dilution with water, errors made in mixing or calibrating will result in improper amounts of active ingredient applied and results may not be described on the product label. Be sure to follow label directions on handling and application procedures carefully.



Remember

Since liquid chemicals are applied with a sprayer, special precautions must be taken. Avoid using sprayers in windy conditions. Airborne spray can pose a hazard to the person spraying, as well as other people or wildlife and vegetation near the application area. Use an appropriate nozzle for the application. Spray pressure and the nozzle design determine the rate of flow, attributes of the spray droplet and the spray pattern.



What kinds of pesticides am I allowed to use in the ROW?

- ▶ You can use only pesticides that are registered for use in Hawaii. A list of pesticides registered in Hawaii is available online at <http://state.ceris.purdue.edu/htm/hi.htm>
- ▶ In addition, pesticides must also be specifically registered for use in ROW.
- ▶ Only use pesticides with a CAUTION or WARNING signal word along roadsides.
- ▶ Pesticides labeled "Danger" must be used only with prior written approval of the Engineer and can only be applied by either a licensed applicator or under the direct supervision of a licensed applicator in the ROW.
- ▶ Follow all federal and state laws about pesticide use in Hawaii. State laws are outlined in HRS §149A and HAR§ 66-4. Standard legal requirements are usually met easily by following the label, which is approved by the Hawaii Department of Agriculture.

Get approval before you buy or use a pesticide

Many of the pesticides you can use will be supplied by HDOT. Some of these are Roundup® (glyphosate) for non-selective (kills everything) spot spraying and Ronstar® and Oust®, which are pre-emergents with long residuals used to prevent new weeds from sprouting from seeds. Oust® and Roundup® will often be applied together as a tank mix to kill existing plants and control weeds emerging from seeds.

You will be allowed to purchase and use other pesticides that are not on the official HDOT list with the prior written approval of the Engineer. You will not be paid for any pesticides you purchase unless an itemized price list of any required pesticides has been submitted to the Engineer for prior approval. Cost for the pesticide will be paid according to the proposal schedule.

The Engineer will check that a pesticide approved for use within the ROW was used as intended by checking the pesticide logs you submit after each application.



How do I use herbicides to control different types of weeds?

Weeds are considered to be any undesirable plants not originally planted. Noxious weeds are defined and listed by the "Hawaii Invasive Species Council List of Plant Species Designated as Noxious Weeds for Eradication or Control Purposes by the Hawaii Department of Agriculture (06/18/1992)."

Weed infestations in grass are a sign of a weakened turfgrass stand. Insects, diseases, nematodes, poor soil conditions, inadequate fertility, improper mowing, and insufficient watering can all weaken a turfgrass stand, reducing density and vigor. Reductions in turfgrass density create spaces in which weeds establish. Herbicides may temporarily remove these weeds, but failure to correct the factors leading to weed encroachment will increase the chances that the weeds will return and continue to be a problem. **The best approach to minimizing weed problems is to maintain a healthy, dense turf.**

The three basic types of weeds, grassy weeds, broadleaf weeds and sedges, can be adequately controlled with a continuing and consistent herbicide program.

Use pre-emergent herbicides to prevent new weeds from invading grass, ground covers and planting beds

There are many effective pre-emergent products available for the control of most grassy and broadleaf weeds in established lawns. Some of them also have post-emergent activity.

Following are some products that are safe on warm season grasses and approved for IVM/ROW use in Hawaii. *Denotes popular choices.

***Specticle® (active ingredient: indaziflam)**

- Pre-emergent control of annual grasses, sedges and broadleaf weeds; also a long residual reducing the frequency of use.

Team® (active ingredients: trifluralin and benefin)

- Pre-emergent control of many grasses and broadleaf weeds.

***Ronstar® (active ingredient: oxadiazon)**

- Pre-emergent control of many grasses and broadleaf weeds.

***Snap Shot® (active ingredients: isoxaben and trifluralin)**

- Pre-emergent control of many grasses and broadleaf weeds.

Gallery® (active ingredient: isoxaben)

- Pre-emergent control of many grasses and broadleaf weeds.

***Oust XP® (active ingredients: sulfometuron methyl)**

- Pre-emergent control of many grasses and broadleaf weeds; also a long residual reducing the frequency of use.

Oust Extra® (active ingredients: sulfometuron methyl and met-sulfuron methyl)

- Pre-emergent control of many grasses and broadleaf weeds.

Barricade® (active ingredient: prodiamine)

- Pre-emergent control of wide variety of grassy and broadleaf weeds in all warm season turf.

Use post-emergent herbicides to control a variety of established weeds

There are many selective post-emergent herbicides labeled for the control of broadleaf, grassy and sedge type weeds that can be over-sprayed onto non-target plants without damage. This can be done with limited spot sprays or blanket broadcast sprays over a large turf area. Read the label carefully as some grasses may be more susceptible to damage than others. Among those approved for use in ROW in Hawaii are:

Selective post-emergent herbicides to control broad-leaf weeds and shrubs in turf or open soil areas

Spike® (active ingredient: tebuthiuron)

- Very effective post-emergent herbicide for control of many woody broadleaf weeds via root absorption. Not to be used in areas with desirable trees and shrubs.

Certainty® (active ingredient: sulfosulfuron)

- Control of sedges and grassy and broadleaf weeds in all warm season turf.

Lontrel® (active ingredient: clopyralid monoethanolamine salt)

- Control of wide variety of broadleaf weeds in all warm season turf.

***Garlon® (active ingredient: triclopyr)**

- Effective in controlling many broadleaf weeds in grassy stands.

Milestone® (active ingredient: aminopyralid)

- Controls broadleaf weeds in grassy stands.

Super Trimec® (active ingredient: isooctyl, propionic acid, dicamba)

- Controls broadleaf weeds in turf.

Selective post-emergent herbicides to control grassy weeds in turfgrass, ground covers and shrub beds

There are a few post-emergence herbicides for control of grassy weed species that can be over sprayed in low-cut shrub hedges, ground cover, and even certain types of turf. Among those safe on most warm season grass and approved for IVM/ROW use in Hawaii are:

***Fusilade II® (active ingredient: fluaziflop)**

- Will control grassy weeds, but is labeled for use on zoysia turf at specified labeled rates.

Poast® (active ingredient: sethoxydim)

- Will control grassy weeds, but is safe on centipede grass.

It is more difficult to control grassy weeds in desirable turf grass areas with selective post-emergent herbicides. In this case it is very important to select the correct products. A good post-emergent for grassy weeds that does not damage most turf species is harder to find.

Until recently, many course-bladed grassy weeds, such as crabgrass, could be controlled in Bermuda grass and zoysia with the use of arsenic-containing active ingredients (MSMA, MCMA and others). However, these have been taken off the market by most Hawaii suppliers due to an EPA ban.

Controlling grassy weeds in grass and shrub beds using post-emergent herbicides

There are a few post-emergence herbicides for control of grassy weed species that can be over sprayed in low-cut shrub hedges, ground cover, and even certain types of turf. Among those safe on most warm season grass and approved for IVM/ROW use in Hawaii are:

***Fusilade II® (active ingredient: fluaziflop)**

- Will control many grasses, but is safe on zoysia.

Post® (active ingredient: sethoxydim)

- Will control many grasses, but is safe on centipede grass.

Selective post-emergent herbicides to control sedge-type weeds in grass and shrub beds

The most common sedges that are a weed problem in Hawaii are nut-sedge (nutgrass), kylinga and McCoy grass.

Several products will control these weeds and are safe to overspray onto most warm season turf grasses. Take care when overspraying these products onto broadleaf ground covers, since severe damage can result.

Three products commonly used to control sedges are:

***Image® (active ingredient: imazaquin)**

- Very effective in controlling kylinga and McCoy grass. Active as a foliar spray and as a root drench. Has some pre-emergent activity on kylinga and McCoy grass. Causes severe injury when over sprayed onto wedelia.

Sedgehammer® (formerly called Manage®) (active ingredient: halosulfuron-methyl)

- Most effective in controlling nutgrass, lesser control of kylinga and McCoy grass. Severe damage to wedelia.

***Certainty® (active ingredient: sulfosulfuron)**

- Controls a wide variety of broadleaf weeds, including nut-sedge, kylinga and McCoy grass.

***Monument® (active ingredient: 2-pyridinesulfonamide, trifloxulfon-sodium)**

- Controls certain grass and broadleaf weeds, as well as sedges, such as purple nutsedge and kylinga.

Any given herbicide may be more or less effective against certain weeds, but may also impact desirable grasses. The subject is described in detail by: Brosnan, J. T., and J. DeFrank. 2008. *Chemical Weed Control Options for Turfgrasses in Hawai'i*. Also available online at http://turfgrass.ctahr.hawaii.edu/downloads/weedcontrol_NEW.pdf



Remember

You should use selective chemicals (e.g., broadleaf- or sedge-specific herbicides to control these weeds in grass to prevent damage to the grasses. Use grass-specific and sedge-specific herbicides in broadleaf ground covers to prevent damage to desirable broadleaf plants).

Always check the label of selective herbicides for compatibility with target and non-target species. Certain sedge-killing herbicides also severely damage some broadleaf ground covers (Image® and Sedgehammer® have been observed to kill wedelia).

Non-selective post-emergent herbicides



Use non-selective post-emergent herbicides as spot sprays to control all weeds in bare soil, pavement cracks or other areas where there is no desirable planting.

The most commonly used non-selective herbicides all contain some

form of the active ingredient glyphosate, which has systemic activity and will effectively kill most plants of all three groups, as well as other ornamentals.

Non-selective herbicides to use for pre-plant weed removal and soil preparation are:

**Arsenal® (active ingredient: isopropylamine salt of imazapyr)
(53%)**

- Good non-selective herbicide for general use in the ROW when replanting large areas

**Habitat® (active ingredient: isopropylamine salt of imazapyr)
(28.7%)**

- Good non-selective for weed removal in aquatic environments.

A typical list of herbicides every crew should have:

Use of specific herbicides should be rotated to prevent some weeds from becoming immune to treatment by one active ingredient.

A suggested list:

A mixture of Roundup® and Oust® for post and pre-emergent control of all weeds and grass under guard rails and in narrow medians.

Pre-emergents

***Specticle® (active ingredient: indaziflam)**

- Control of many grass and broadleaf weeds.

***Ronstar® (active ingredient: oxadiazon)**

- Control of many grasses and broadleaf weeds.

Oust Extra® (active ingredients: sulfometuron methyl and metsulfuron methyl)

- Control of many grasses and broadleaf weeds.

Selective post-emergents to control broadleaf weeds

Milestone® (active ingredient: aminopyralid)

- Control of hard to control legume weeds and shrubs.

***Garlon® (active ingredient: triclopyr)**

- Effective in controlling many broadleaf weeds in turf.

Super Trimec® (active ingredient: isooctyl ester of 2,4-D, propionic acid, dicamba)

- Controls broadleaf weeds in turf.

Selective post-emergent to control grasses

***Fusilade II® (active ingredient: fluaziflop)**

- Controls all grasses, but is safe on zoysia. Good for safe control of grass growing into hedges and ground covers

Selective post-emergent to control sedges (nutgrass, kylinga)

***Certainty® (active ingredient: sulfosulfuron)**

- Controls a wide variety of broadleaf weeds, including kylinga and McCoy grass.

***Monument® (active ingredient: 2-pyridinesulfonamide, trifloxsulfon-sodium)**

- Control of sedges, certain grasses and broadleaf weeds. Safe on Bermuda grass and zoysia.

Non-selective herbicides

Arsenal® (active ingredient: isopropylamine salt of imazapyr) (53%)

- Good non-selective herbicide for general use in the ROW when replanting large areas.

Habitat® (active ingredient: isopropylamine salt of imazapyr) (28.7%)

- Good non-selective for weed removal in aquatic environments.

Roundup® (active ingredient: glyphosate)

- The most widely known example of a glyphosate herbicide is Roundup® and all of the related products made by Monsanto. Other generic products are now available.

In maintenance areas without formal landscaping but only vegetative cover for erosion control purposes, or in very rural low maintenance areas, mowing as a primary weed control method is acceptable.



Eco

Only herbicides labeled for aquatic use, such as Habitat[®], should be used in drainage areas like swales and ditches and when spraying close to waterways, such as ponds, lakes and streams.

Periodic spraying with Roundup[®] or other glyphosate products in combination with a broad spectrum pre-emergent (Oust[®]) should be used instead of mowing or string trimming under and around guard rails, in narrow medians, and other narrow vegetation zones along roadsides. All pavement expansion joints and cracks are to be continuously maintained free of weeds in the same manner.

This type of spraying is most efficiently done using a large volume tank sprayer on a truck. The spray nozzles should be of the type that dispenses a maximum 3-ft.-wide pattern when applied from the side of the truck. This method of weed control is much faster than a multiple person crew with weed eaters and is much less disruptive to traffic. It will also prove to be a longer lasting method of weed prevention and control.

If the weeds have grown above the height of the guard rail, or have thick woody stems, mow or weed eat to ground level first and begin a regular spray program when the re-growth is no more than one foot high.

Remember

You are not responsible for controlling vegetation on private adjoining property that intrudes into the right-of-way areas. Spray up to the boundary line.



Damage caused by pesticides

It is your responsibility to maintain all plantings in good health free of harmful weeds, insects and disease. Any damage to humans, vegetation, environment or other property, within or outside the highway right-of-way, due to your misuse of pesticides is your sole responsibility.

Plant materials that die as a result of damage due to misuse of pesticides or uncontrolled insect or disease infestation shall be replaced with the same species. Replacement should be completed at your cost within four weeks of notification from the Engineer.

Eco

Be very careful when applying herbicides around desirable plants. Some active ingredients, especially when over applied, can leach through the soil and affect the roots of nearby non-target plants.



Herbicides should always be used safely and sparingly. Keep in mind the following when using herbicides:

Do not use herbicide on an entire planting area to reduce normally expected maintenance. This is called “blackout” and it includes the use of herbicide to kill grass to reduce how often you need to mow. There will be severe penalties for this practice.

- ▶ Do not spray beyond the weedy area that needs to be treated. For example, adjust your sprayer nozzle so that you are not spraying 5 ft. beyond the guard rail.
- ▶ Do not dump excess chemicals, or clean and rinse your gear at the work site.
- ▶ Do not use inappropriate chemicals near waterways. Always check the label and use herbicides accordingly. If spraying near waterways, use herbicides such as Aquamaster® that are specifically formulated for that purpose. You can inadvertently introduce chemicals into the water that may be harmful for stream life and coral reefs.
- ▶ Do not use herbicide in eroding areas. Some areas need plant roots to keep the top soil from being blown or washed away. Killing all vegetation in these areas will increase erosion.



Foliar application using a backpack sprayer.

- ▶ Do not spray herbicide during peak traffic hours. You may spray only between 8 a.m. and 2 p.m. and between 8 p.m. and 5 a.m. This limits traffic disruption and exposure to herbicides.
- ▶ Do not spray when it is windy or when it is raining or about to rain. Strong winds will blow herbicide away from your treatment area where it may damage or kill other vegetation or affect neighbors' property or health. Rain will wash herbicides off the plants and render them ineffective. In addition, the herbicides may end up in the watershed.
- ▶ Do not use non-selective herbicides in bio-retention areas. This practice may result in death of beneficial plants and loss of bio-retention function. Also, herbicide residue in this area is likely to end up in surface water as these areas are close to inlet drains.



What do I need to know about pesticides to control insects, mites and diseases?

These pests are normally a lesser problem in ROW vegetative maintenance; however, insects and mites may occasionally become a localized problem. Fungal diseases may also rarely need to be treated. Insect infestations often can be effectively controlled with regular pruning and adequate irrigation and fertilizer programs.

Maintenance crews should be constantly aware of an increasing insect problem and report it before it is out of control. Short-term applications of the proper pesticide or combination of pesticides will normally eventually control these infestations. Treatment should be limited to reported infestations, not on a continuing long-term basis.

Insects, mites and other bugs can be effectively controlled in localized spots with a combination treatment of systemic and non-systemic insecticides depending on the species of pest. The only major distinction of pest species is to identify either an insect or mite problem and use an appropriate effective pesticide. In either case, a quick knock down of the population can be accomplished with several treatments of an appropriate non-systemic pesticide and long-term control maintained by an accompanying application of a systemic insecticide, preferably one that can be applied as a foliar and root drench (e.g., Merit®).

Diseases of trees and shrubs are often more difficult to detect and diagnose, but can be treated with appropriate fungicides. These are examples of common pesticides used for control of insects, mites and diseases that impact roadside vegetation health. They are listed by active ingredient, trade name, concentration (% for dry, lb/gal for liquids), primary application, most common use in a roadside setting and the product's signal word.

Eco

Use insecticides sparingly to control unusual outbreaks, not as a routine measure. Most insects are very beneficial as predators of harmful bugs and as plant pollinators. Be particularly careful of protecting honey bees. Over application will kill these beneficial insects.



Active Ingredients	Trade Name	Concentration	Application	Common Use	Signal Word
acephate	Orthene®	75 SP	systemic	wide spectrum	Caution
bifenthrin	Talstar®	10WP, 0.2G	knock down contact	wide spectrum/mites	Warning/Caution
carbaryl	Sevin®	4F, 6.3G	contact	wide spectrum	Caution
cyfluthrin	Tempo®	2EC, 20WP	knock down contact	wide spectrum	Warning/Caution
fluvialinate	Mavrik®	2F	knock down contact	wide spectrum/mites	Caution
imidacloprid	Merit®	75 WSP, 0.5G	systemic foliar, soil drench	wide spectrum	Caution

For more information on pests, visit online:

Knowledge Master

UH-CTAHR Integrated Pest Management Program

<http://www.extento.hawaii.edu/Help/about.asp>



What do I need to know about pesticide applications?

Techniques for applying herbicides

Foliar application

For foliar application, spray the pesticide/water mixture directly onto the leaves and stems of a plant. Foliar sprays for relatively small areas or lo-

cations that are difficult to get into should be made with a low pressure (20-50 psi) backpack sprayer at rates of one gallon or less per minute using a fan nozzle for broadcast spraying or a cone nozzle for spot spraying. Use a consistent back and forth motion, thoroughly covering the foliage but not to the point of runoff. Allow herbicide treatments to dry for at least three hours to ensure adequate absorption and translocation. In larger areas with vehicle access, use a larger spray tank. The spray boom should be equipped with one or more fan nozzles of the appropriate size and spray pattern.



Tip

In areas with significant public use, it is recommended to close off the treatment area until the herbicide has dried completely.

It is difficult to achieve adequate control with foliar application because complete coverage of all foliage is essential for control, but over application (that leads to spray runoff) reduces effectiveness. Therefore, multiple follow-up applications are needed to accomplish full control. When making foliar applications it is important to control spray drift. Some desirable species might be very sensitive to spray drift and could get damaged inadvertently. Addition of tracer dye to the spray solution is recommended so that individuals are not missed or sprayed twice.



Remember

Complete foliar coverage is essential for effectiveness.

Basal bark application

The herbicide is mixed with absorbent oil and applied directly to the bark at the base of a standing tree. Use a paint brush to treat the lower 12 to 18 inches of the stem/trunk on all sides with the herbicide/oil mixture. Adequate application all around the bark is essential; applying to only one half side of the bark will result in killing only half of the tree.

Basal bark treatment is very successful for trees with smooth barks and trunks less than six inches in diameter, but it is not effective on older

trees with thick bark. Note that basal bark application does not provide rapid control. Control effects are visible only after several weeks and total control may take several months.

Do not use the basal bark method if treated tree can fall and endanger people, property or vehicles. Use cut stump method instead.

Cut surface application

Cut surface treatments typically include hack and squirt, cut stump methods and girdle. The advantages to these methods are:

- They are economical.
- The chances of non-target damage are minimal.
- Minimal application time.

All cut surface application methods use backpack sprayers or spray bottles.

Hack and squirt

Use a small axe, machete or hatchet to cut through the bark and into the sapwood of the tree. Ensure that hacking is done in a downward motion, leaving a cup to hold the herbicide solution. If the cut does not hold the herbicide solution, the treatment will be ineffective. Hack the entire circumference of the tree and use a squirt bottle to apply approximately 1 ml in each cut.



Hack and squirt application technique

Hack and squirt technique is ideal for control of large trees that cannot be managed with basal bark applications. Treatment can be applied anytime during the year, although heavy sap flow during certain seasons can push the herbicide out making the treatment ineffective. Rainfall soon after application can also wash off the herbicide rendering the treatment ineffective. This treatment is highly selective and minimizes injury to neighboring desirable species.

Cut stump

Apply herbicide to the cut stump of a tree to prevent resprouting from the cut surface. Apply the herbicide as soon as possible after cutting the

tree at the base. Make sure to remove sawdust from the surface before you apply the herbicide. If applied immediately, herbicide/water solution is sufficient. If application is delayed and the cut surface has begun to dry, herbicide/basal oil mixture must be used and applied to the top and around the collar of the stump.

For bigger stumps (greater than 3 inches in diameter) apply herbicide only to the outer edge, avoiding runoff since the living tissue in larger trees is only around the outer edge. It would be wasteful and ineffective to apply herbicide to the entire cut surface. However, for smaller stumps (less than 3 inches in diameter) it is appropriate to apply herbicide to the entire cut surface. Herbicide can be applied using a backpack sprayer, squirt bottle or paint brush. A tracer dye should be added to the herbicide to ensure proper treatment of the stumps.

Girdle

To girdle (also known as frill method), use an axe or similar tool to make continuous cuts around the base of the stem, deep enough to reach the sapwood. The cuts should be angled downward and should be no less than 1 inch apart. Apply recommended herbicide to the entire cut surface just to the point of overflow.

Soil application

Some pre- and post-emergent herbicides are applied to the soil and taken up through the roots of target plants. Granular/pellet type herbicides are designed for dry soil application.

You can apply these by mechanical spreaders, blowers or aircrafts. Apply the herbicide to the soil in thin streams on a grid pattern. This technique is particularly useful in areas with high stem density of undesirable plants. You can apply a single band to fence rows, but larger stems should be treated individually. Soil application is not a selective technique, so you should use caution if desirable vegetation is in the vicinity. The application rate and size of the grid depend on the soil texture and species composition. See individual herbicide labels for instructions. When using granular/pellet type herbicides, water the area to “activate” the herbicide. Soil application is a slow process and may require multiple years to fully control some species.

Spray application

Some pesticide spray treatments require spraying the entire area, such

as when using a selective herbicide to control broadleaf weeds in turf, or an insecticide to control armyworms. This type of application over the entire area is called a **blanket spray** and is often done with a large spray tank mounted on a truck, trailer or other piece of equipment. **Fan nozzles** put out a wide band of water and are used for blanket spraying. Several fan nozzles can be combined in a boom type connection to cover a wider area in a single pass.

Other applications, known as **spot sprays**, are used to cover a smaller target area. Spraying only the dandelions growing in a turf area, for example, is a common type of spot spray. Spot sprays can also be used to kill weeds growing in bed areas or in the cracks between concrete gutters and asphalt. Spot sprays can be done efficiently with hand held or backpack sprayers. **Cone nozzles**, which put out a more concentrated circular pattern of water, are preferred for spot spraying. When treating weeds growing in the turf, be sure to assess the nature of the weed problem before using a blanket spray application. Spot sprays are often good enough.

Sprayers typically used for lawn chemicals consist of a storage tank ranging in size from one-gallon to truck-mounted tanks holding hundreds of gallons. A hose with one or more spray nozzles is connected to the tank. The tank is pressurized by hand pumping or by a pressure pump. It is important to maintain a constant pressure for uniform operation of the sprayer.

It is very important to use the proper spray nozzle. The spray nozzle determines how much liquid is applied and also the pattern of the applied spray.

To make a spray application, walk or drive along spraying the liquid over the application area. For some small sprayer models, you can carry the tank in one hand while holding the hose in the other. For other small sprayers holding up to 5 gallons, the tank is carried on your back. These are called knapsack or backpack sprayers which are often more efficient to use than smaller, hand held sprayers. Backpack sprayers do not have to be refilled as often, which saves time on the job.

Sprayer maintenance

Always read the product label for cleanup instructions and wear appropriate personal protective equipment (PPE) while cleaning the sprayer. Typical cleanup procedures are as follows:

- ▶ Maintain all chemical application equipment in good operating condition. Check for proper operation of controls, valves and regulators prior to leaving the base yard. Ensure that all hoses are attached properly and that no leaks will occur.
- ▶ Dispose of excess chemical according to product label.
- ▶ Triple-rinse empty containers and dispose of containers according to instructions.
- ▶ Clean the sprayer, including nozzles and screens, with detergent and water.
- ▶ Be sure rinse water does NOT run into storm or sewer drains.

Operating a sprayer

Before using a sprayer to apply lawn chemicals, it is a good idea to practice spraying water until you are able to spray an area with uniform coverage. This is also very important in calibrating the sprayer to obtain the desired application rate for the pesticide (see below). Use the following procedure to practice with your sprayer.

- ▶ Mark out an area of asphalt or concrete where you can practice spraying.
- ▶ Fill your sprayer with water and pressurize.
- ▶ Begin walking and spraying, moving in a straight line and keeping the nozzle at a constant height from the ground. Maintain a constant walking speed and continue back and forth, covering the entire area evenly.
- ▶ The amount of water applied over a given area depends on your walking speed, the distance of the nozzle from the ground and the type of nozzle used. Try to keep all of these constant.
- ▶ Once you have covered the entire area with water, observe how it evaporates. You should be able to tell easily how uniformly you are spraying.
- ▶ Keep practicing, adjusting your technique until you are able to spray the area with uniform coverage.

Calibrating a sprayer

Calibrating a sprayer is determining the rate at which liquid is applied. This information is used to calculate the amount of chemical to mix with water. It is essential for the sprayer and the applicator (you) to be properly calibrated to ensure that the correct amount of chemical is applied.

Determine your calibrated spray volume to cover 1,000 sq. ft.

- ▶ Practice with a spray applicator (use water only) until you are able to distribute liquid with uniform coverage. (Refer to the previous section on operating a sprayer.)
- ▶ Measure out a test area on a site that has a typical roadside terrain. An area of 1,000 sq ft. is most convenient and will give more accurate results than smaller test areas. The width of the test should be at least four times the width of the spray pattern. (If the spray pattern is 2 ft. wide, a test area of 8 x 125 ft. will give the required 1,000 sq. ft.)
- ▶ Fill the sprayer with water to a marked level and pressurize. Use at least 3/4 of the volume of the tank.
- ▶ Walk the test area, spraying water evenly over the entire marked area (1,000 sq. ft.) using the technique you have practiced.
- ▶ Determine the amount of water you used by measuring how much water is required to refill the tank to the marked level. Repeat this process until you get a consistent volume of water to cover 1,000 sq. ft.
- ▶ This amount of water is your own individual calibrated spray volume to cover 1,000 sq. ft. Use this volume to calculate how much water is needed to mix with the recommended amount of concentrated pesticide to cover the entire area of your application.
- ▶ Let's say during your calibration run you applied 117.5 ounces to your test area of 1,000 ft.². To treat an entire acre (43,560 ft.²) with the same equipment, spray pressure and walking pace, you would need 40 gallons. If the herbicide labels direct you to apply 32 ounces of concentrate per acre, you will need to do a little math to determine how much to put into your 5-gallon backpack sprayer.

A simple algebraic concept, sometimes called solving for X, can be used to answer the question: How much concentrate do I add to a 5-gallon backpack sprayer when I apply 120 ounces of spray to a 1,000 ft.² test area? The math procedure is this:

$$\frac{32 \text{ ounces of herbicide}}{40 \text{ gallons – to treat 1 acre}} = \frac{X\text{-ounces, an unknown}}{5 \text{ gallons – the back pack}}$$

If you cross multiply, you get

$$40 * X = (5 * 32) = 160$$

40X = 160 means that X = 4. When you replace 4 for X in the first equation, you see that 4 ounces of concentrated herbicide are required in the 5-gallon backpack to cover all treated areas at the label recommended rate of 32 ounces per acre.

Pesticide application calculations

Do not prepare a pesticide batch that exceeds the amount necessary to treat the infested area.

It is very important to know how much pesticide to prepare before you start the application. This avoids over application, waste and unnecessary disposal.

To make accurate calculations of how much pesticide to prepare, you must calibrate your equipment and technique on a regular basis.



What should I know about training, reporting and supervising pesticide use?

Training

- ▶ Annual training is available through the Department of Agriculture. Contact the Pesticide Risk Reduction Education Program (see contact information next page).
- ▶ Contact the HDOT Engineer in charge of maintenance in your area to find training requirements and schedules. Contractors should read the course manual, available online at http://www.stormwaterhawaii.com/program_plan/pdfs/app_h1.pdf
- ▶ Those involved in the application of herbicides and other pesti-

cides shall complete a video training about rules related to pesticides/herbicides and stormwater before applying pesticides. Retraining shall be repeated annually thereafter. The Engineer should receive a training completion report for all staff working on vegetation maintenance along Hawaii's State roads.

- ▶ Applicators should be supervised by a registered commercial applicator with training from University of Hawaii and be registered in this capacity by the Department of Agriculture. DOA pesticide training includes basic pest recognition skills.

For information about training requirements for pesticide applicators contact:

Pesticide Risk Reduction Education Program
Plant and Environmental Protection Sciences Department
3190 Maile Way, Room 307
Honolulu, HI 96822
E-mail: charlie@hpirs.stjohn.hawaii.edu
Phone: (808) 956-6007 / FAX: (808) 956-9675
Website: <http://pesticides.hawaii.edu>

Guidelines for restricted-use certified applicators supervising non-certified applicators

(http://pesticides.hawaii.edu/studypackets/Supervising_Non-cert.pdf)

Certified applicators whose activities indicate a supervisory role must demonstrate a practical knowledge of Federal and State supervisory requirements, including labeling, regarding the application of restricted-use pesticides by non-certified applicators.

Remember

Restricted-use pesticides require the Engineer's prior written approval.



- ▶ Restricted pesticides can be applied by non-certified applicators **ONLY** under the direct supervision of a certified commercial applicator and upon **prior approval of the HDOT Engineer**.
- ▶ The availability of the certified applicator must be directly related to the hazard of the situation. In many situations where the certified applicator is not required to be physically present, direct supervision shall include written instructions to the competent person.

- ▶ Detailed guidance must be available for applying the pesticide properly, as well as provisions for contacting the certified applicator in the event he/she is needed. In other situations, as required by the label, the actual physical presence of a certified applicator may be required when application is made by a non-certified applicator.

Reporting & Inspection

HDOT staff and contractors must maintain a record of all pesticides used on the project, including the pesticide name, application location, dates and rates of application, and total quantity used per day. Forms are provided as a part of the stormwater training. You must complete and submit the Fertilizer Usage Log, Herbicide/Pesticide Usage Log and Disposal of Expired Landscaping Chemical Log. See Chapter 14, "Reporting," for details. Submit completed forms to HDOT on a quarterly basis, on request, or as determined by the Engineer. HDOT inspectors or the Engineer have the right to visit your site to ensure you follow the standards for pesticide use. The inspector will check the landscape to ensure that non-target vegetation is not damaged by careless pesticide use. See Chapter 15, "Inspecting Vegetation Maintenance Work."



In a Nutshell

1. When controlling weeds in the ROW, always follow the instructions on the pesticide label.
2. Have a plan to deal with potential spills or accidents involving pesticides.
3. Know the general properties of each herbicide you usually use, and when (not in wind/rain), where and how to apply it.
4. Understand HDOT-approved use of herbicides in urban vs. rural settings.

Appendix 10A

FIFRA is the federal law governing the use of registered pesticides in the U.S. This law is often cited when making pesticide recommendations with special precautions not to “use any registered pesticide in a manner inconsistent with its labeling (FIFRA sec. 12(a)(2)(G)).” However, this same law in section 2(ee) states that it is not unlawful to use a registered pesticide “against any target pest not specified on the labeling if the application is to the crop, animal, or site specified on the labeling ... ”

In this appendix, many of the recommendations for control of a specific species may not be found on the herbicide label; but in all cases the herbicides mentioned are labeled for use on highway rights-of-way. In other words, it is OK to use an herbicide on a specific weed species as long as the site (i.e., highway right-of-way) is mentioned on the label.

Top HDOT Target Species and Roadside Control Methods

- ▶ **Opiuma (*Pithecellobium dulce*)**
For larger trees cut and cover cut surface with glyphosate or triclopyr to prevent resprouting or use basal of bark application triclopyr. For small trees and seedlings use foliar application of triclopyr. Use soil applications of: (1) Velpar L[®], a liquid formulation with use pattern that includes undiluted application as basal bark application or (2) Spike 20P[®] pellets directly out of the container. Note, opiuma is not on the Spike[®] label but might be effective against it.
- ▶ **Albizia (*Falcataria moluccana*)**
Use 1/2 ml undiluted or 1 ml diluted (1 to 1 ratio Element 3A[®] to water) into the pocket between the bark and inner stem/trunk by each cut. Capstone[®] is a combination of aminopyralid and triclopyr and is very versatile for highway rights-of-way usage.
- ▶ **African Tulip (*Spathodea campanulata*)**
Cut-surface applications of dicamba and foliar application of glyphosate. Banvel[®] and Vanquish[®] both have cut-surface treatments listed on the label; African tulip tree is not listed, but applications might be effective.
- ▶ **Bougainvillea (*Bougainvillea spectabilis*)**
Apply glyphosate to cut stems. Repetition of treatment is likely necessary.

▶ **Banyan (*Ficus macrocarpus*)**

The most effective way to kill large banyans is by placing 3-5 ml of herbicide (glyphosate or triclopyr) into holes drilled into each foot around trunk. Because of the compartmentalization of the trunks from the rooted and merged roots, the trunks must be drilled at each segment to ensure effective control. This can best be done by making follow-up treatments after symptoms from earlier treatments reveal unaffected stem segments.

▶ **Ironwood (*Casuarina equisetifolia*)**

For shoots and saplings use foliar applications of triclopyr. For trees use cut-surface applications of glyphosate or dicamba. A ready to use oil-based formulation of triclopyr is also available as Pathfinder II®. Pathfinder II® can be used directly out of the container as a basal bark or cut stump treatment. Capstone® is a combination of aminopyralid and triclopyr and is very versatile for highway rights-of-way usage.

▶ **Kiawe (*Prosopis pallida*)**

For saplings use basal bark applications of 2,4-D and triclopyr at 2% of product in diesel. For trees use crop oil or triclopyr ester at 5% product in diesel oil. A ready to use oil-based formulation of triclopyr is also available as Pathfinder II®. Pathfinder II® can be used directly out of the container as a basal bark or cut stump treatment. Capstone® is a combination of aminopyralid and triclopyr and is very versatile for highway rights-of-way usage.

▶ **Formosa Koa (*Acacia confusa*)**

Use cut-surface application of 2,4-D, dicamba, glyphosate, picloram (45), and triclopyr, or low-volume basal bark application of 20% triclopyr in oil, or 5% triclopyr ester in diesel oil. On smaller trees and seedlings use foliar application of 2,4-D at 1lb/acre and triclopyr at 1lb/acre. A ready to use oil-based formulation of triclopyr is also available as Pathfinder II®. Pathfinder II® can be used directly out of the container as a basal bark or cut stump treatment. Capstone® is a combination of aminopyralid and triclopyr and is very versatile for highway rights-of-way usage.

▶ **Haole Koa (*Leuceana leucocephala*)**

Use foliar application of triclopyr, cut-surface application of picloram, or basal bark and stump bark application of 2,4-D in diesel. A ready to use oil-based formulation of triclopyr is also available as Pathfinder II®. Pathfinder II® can be used directly

out of the container as a basal bark or cut stump treatment. Capstone® is a combination of aminopyralid and triclopyr and is very versatile for highway rights-of-way usage.

- ▶ **Schefflera, Octopus Tree (*Schefflera actinophylla*)**
Use basal bark or cut-stump application of triclopyr.
- ▶ **Java Plum (Deadwood) (*Syzygium cumini*)**
For saplings up to 10 ft. tall use drizzle applications of triclopyr ester in crop oil at 1 lb/acre, or foliar application of triclopyr or picloram. For trees use basal bark applications of triclopyr ester at 10% product in oil, triclopyr, 2,4-D, or imazapyr. However, large trees have thick bark that makes basal bark treatments ineffective. Use cut-surface applications of triclopyr amine at 50% product in water, or 10% triclopyr ester, or use cut surface applications (to drilled holes) of 2,4-D, dicamba, glyphosate or triclopyr.
- ▶ **Fiddlewood (*Citharexylum spinosum*)**
Use imazapyr/methyl metsulfuron combination at 1.2 oz and 0.2 oz active ingredient per gallon of water. This can be absorbed by roots as well as foliage.
- ▶ **Maile Pilau (*Paederia foetida*)**
Use foliar application of triclopyr and glyphosate. Repeated applications may be necessary to achieve control. Consider potential damage to vegetation supporting the vines.
- ▶ **Sleeping Grass (*Mimosa pudica*)**
Several herbicides can be used, including dicamba, glyphosate, picloram (0.25 lb/acre) and triclopyr (1 lb/acre).
- ▶ **Wire Grass (*Eleusine indica*)**
Use foliar application of glyphosate, imazapyr or sulfometuron.
- ▶ **Guinea Grass (*Panicum maxima*)**
Use foliar application of glyphosate, imazapyr or sulfometuron.
- ▶ **Bushy Beard Grass (*Andropogon glomeratus var. pumilus*)**
Carefully cut and bag the flowering heads. Spray standing stalks with glyphosate.
- ▶ **California Grass (*Urochloa mutica*)**
Use foliar application of glyphosate, imazapyr or sulfometuron.

Appendix 10B

Top Few Commonly Used Pesticides in Hawaii

Listed below are the most commonly used pesticides for roadside vegetation management. They are listed by trade name, active ingredient, concentration (% for dry, lb/gal for liquids), primary application (pre-emergence or post-emergence), most common use in a roadside setting (TVC is "total vegetation control"), and signal word on label. Please check with the Engineer about an updated list of herbicides with which you may be working.

Active Ingredients	Trade name	Concentration of a.i. in product	Application	Common use/ Typical targets	Signal Word
aminopyralid	Milestone VM [®]	(40%) 2 lb/gal	POST/selective	broadleaf	CAUTION
fluzafop	Fusilade DX [®]	24.5%	POST/selective	all grasses, except zoysia	CAUTION
glyphosate	AquaMaster [®] Roundup [®] , others	4 lb/gal (5.4 lb ai/gal)	POST/non-selective	all plants	CAUTION
imazapyr	Arsenal [®]	2 lb/gal	PRE, POST	brush	CAUTION
sulfometuron	Oust XP [®]	75%	PRE, POST	TVC	CAUTION
triclopyr	Element 3A [®]	3 lb/gal	POST/selective	broadleaf, brush	CAUTION
Indaziflam	Specticle 20wsp [®]	20%	PRE	annual grass sedges, broadleaf	CAUTION
2-pyridinesulfonamide	Monument 75 WG [®]	75%	POST/selective	certain broadleaf, sedge, grass control	CAUTION
oxadiazon	Ronstar 50 wsp [®]	50%	PRE/selective	grass & broadleaf control	WARNING
oxadiazon	Ronstar G [®]	2%	PRE/selective	grass & broadleaf control	CAUTION

For the majority of the vegetation control work in the highway rights-of-way, use the following wide-spectrum pesticide formulation. This type of application is referred to as a spray to wet application. This application rate is the same as 100 gallons per acre. In the table below the amount of herbicide per 100 gallons is provided.

Chemical	Herbicide amount per 100 gallons (oz)	% of herbicide in finished spray (%)
Milestone [®]	4.2	0.03
Roundup Pro [®]	128	1.0
Element 3A [®]	64	0.5
Crop Oil Concentrate	128	1

Chapter 10: Use of Pesticides in Vegetation Maintenance

Below is a list of additional pesticides that can be used for roadside vegetation management. They are listed by trade name, active ingredient, concentration (% for dry, lb/gal for liquids), primary application (pre-emergence or post-emergence), most common use in a roadside setting (TVC is “total vegetation control”), and signal word on label. Please check with the Engineer about an updated list of herbicides with which you may be working.

Active Ingredients	Trade name	Concentration	Application	Common use/ Typical targets	Signal Word
aminopyralid + triclopyr	Capstone®	0.1 lb/gal 1.0 lb/gal	POST/selective	broadleaf	CAUTION
2,4-D MCPP dicamba	Primera Triplet SF®	2.4 lb/gal 0.63 lb/gal 0.22 lb/gal	POST/selective	broadleaf	DANGER (RESTRICTED)
dicamba	Vanquish®	4 lb/gal	POST/selective	broadleaf, brush	CAUTION
diuron	Karmex XP®	80%	PRE	TVC	CAUTION
diuron imazapyr	Sahara DG®	62% 8%	PRE, POST	TVC	CAUTION
isopropylamine salt of imazapyr	Habitat®	28.7%	POST/Selective	aquatic vegetation in and around standing & flowing water – swales, ditches, etc.	CAUTION
hexazinone	Velpar DF®	75%	PRE, POST	brush	DANGER
imazapic	Plateau	2 lb/gal	PRE, POST	TVC	CAUTION
metsulfuron	Escort XP®	60%	POST/selective	broadleaf, brush	CAUTION
oryzalin	Surflan A.S.®	40.4%	PRE	Annual grass, broadleaf	CAUTION
sethoxydim	Poast®	18%	POST/selective	many grasses, except centipede grass	WARNING
sulfentrazone sulfometuron chlorsulfuron	Throttle XP®	48% 18% 9%	PRE, POST	TVC	CAUTION
sulfometuron metsulfuron	Oust Extra®	56% 15%	PRE, POST	TVC	CAUTION
trifluralin + benefin	Team®	0.67% 1.33%	PRE	grass & broadleaf weeds	CAUTION
imazaquin	Image®	0.67%	POST/selective	sedges	CAUTION
trifluralin, isoxiben	Snapshot®	2.0% 0.5%	PRE	grass & broadleaf weeds	CAUTION
isoxiben	Gallery 75 DF®	75%	PRE	broadleaf weeds	CAUTION

Highway Manual for Sustainable Landscape Maintenance

These are examples of common pesticides used for control of insects, mites and diseases that impact roadside vegetation health. They are listed by active ingredients, trade name, concentration (% for dry, lb/gal for liquids), primary application, most common use in a roadside setting, and signal word. Please check with the Engineer about an updated list of pesticides with which you may be working.

Active Ingredients	Trade Name	Concentration	Application	Common Use	Signal Word
acephate	Orthene®	75 SP	systemic	wide spectrum	Caution
bifenthrin	Talstar®	10WP, 0.2G	knock down contact	wide spectrum/mites	Warning/Caution
carbaryl	Sevin®	4F, 6.3G	contact	wide spectrum	Caution
cyfluthrin	Tempo®	2EC, 20WP	knock down contact	wide spectrum	Warning/Caution
fluvalinate	Mavrik®	2F	knock down contact	wide spectrum/mites	Caution
imidacloprid	Merit®	75 WSP, 0.5G	systemic foliar, soil drench	wide spectrum	Caution