

INTEGRATED PEST MANAGEMENT FOR MUNICIPALITIES

A Guidance Manual to Assist Contra Costa Municipalities
in Complying with Provision C.9 – Pesticides Toxicity
Control in the Municipal Stormwater Permits

Developed by the Contra Costa
Clean Water Program Ad Hoc IPM Workgroup



CONTRA COSTA
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PROGRAM

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¹The CCCWP is a consortium of 21 municipalities consisting of Contra Costa County, its 19 cities/towns, and the Contra Costa County Flood Control and Water Conservation District. The CCCWP supports and encourages activities, programs, groups, and agencies that promote and use best management practices that reduce and/or eliminate pollutants that come into contact with stormwater and urban runoff, which flows untreated to our local creeks, the Delta, and Bay.

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Definition of Terms

Aerate: to remove small cores of soil from turf to improve the exchange of air between the soil and the atmosphere, reduce compaction, reduce water runoff, improve the uptake of fertilizer, and enhance the breakdown of thatch.

Aerator (aerifier): a device for removing small cores of soil from turf.

Alkaline: having a pH of more than 7. Acid substances have a pH of less than 7. Pure water is in the middle at neutral. Examples of alkaline substances (in order of increasing alkalinity) are baking soda, Milk of Magnesia, ammonia, and lye. Examples of acid substances (in order of increasing acidity) are vinegar, lemon juice, and battery acid.

Bait station: a device that contains poison bait and allows pests to access the bait but restricts access by people and other creatures.



Ant Bait Station



Rodent Bait Station

Canopy: the extent of the outer layer of leaves of an individual tree.

Compaction: a condition in soil that occurs when soil particles are pressed together, reducing the pore space between them. Heavily compacted soils contain few large pores and have a reduced rate of both water infiltration and drainage from the compacted layer. In addition, the exchange of gases slows down in compacted soils, causing an increase in the likelihood of aeration-related problems.

Constricting hardscape: paving, walls, or other hard features in the landscape that can impede the spread and growth of the roots of a plant.

Diatomaceous earth: a soft crumbly rock composed of the fossilized remains of diatoms, which is used as an insecticide, among other things. Insects have a waxy coating to resist moisture loss, and diatomaceous earth works by adsorbing the waxy coating causing the insect to dehydrate.

Drip irrigation: an irrigation method that saves water by allowing water to drip slowly to the roots of plants, either onto the soil surface or just below the surface where plant roots are growing. Water is delivered through a network of valves, pipes, tubing, and emitters.

East Contra Costa County Municipal NPDES Permit (East County Permit): A stormwater NPDES permit and Waste Discharge Requirements issued by the Central Valley Regional Water Quality Control Board to 5 cities, towns, and Flood Control Districts.

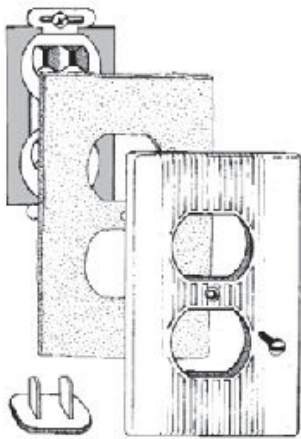
Ecotoxicity: the degree to which a substance can damage an ecosystem, including the organisms living within an ecosystem such as wildlife, plants, and insects.

Evapotranspiration: the combination of water lost to the air (evaporation) from the soil surface and from the release of water from the leaves of plants (transpiration)

Expansion joint: a space that allows for the expansion and contraction of parts that are joined in order to prevent distortion of the parts.

Fertilizer: a chemical or natural substance added to soil to increase its fertility for the purpose of growing healthy plants. Fertilizer comes in many forms including the leaves, stems, and flowers of plants that fall on the soil; manure, compost, liquid seaweed and fish emulsion; and dry synthetic fertilizer.

Foam insulator sheets: thin sheets of plastic foam that can be placed between electrical outlet covers or switch plates and walls to prevent drafts and impede the movement of insects.



Sealing Electrical Outlets

Grasscycling: the practice of leaving short grass clippings on a lawn as fertilizer. Grasscycling is one of the easiest and most environmentally-friendly methods for dealing with grass clippings.

Harborage: areas that provide hiding or living places for pests.

Header board: a wooden or hard plastic edging strip used to keep landscape elements such as turf and flower beds, or flower beds and paving separated. It can be used to define landscape features or to contain mulch, gravel, and other materials that tend to spread out. When the edging strip is wide enough to support the wheel of a mower, it can act as a “mow strip” (see below).

Herbicide: a chemical designed to kill plants.

Honeydew: a sweet, sticky substance excreted by some plant-feeding insects, such as aphids, scales, and leafhoppers. Honeydew raining down from a tree onto the sidewalk, parked cars, and other surfaces can create a sticky mess. Once honeydew dries, it can be difficult to remove. A fungus called sooty mold often grows on the honeydew.

Hydrozoning: grouping plants with similar water requirements together in the same area to facilitate proper irrigation.

Insect growth regulator (IGR): a chemical that prevents an insect from reaching maturity. Many insect IGRs are classified as “reduced risk” pesticides by the US Environmental Protection Agency.

Insecticide: a chemical designed to kill insects.

- **Insecticidal dust:** an insecticide formulated as a dust, such as diatomaceous earth or silica gel.

Integrated Pest Management (IPM): an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organisms. Pest management materials are selected and applied in a manner that minimizes risks to human health, to beneficial and non-target organisms, and to the environment.

Invasive plant: a plant that easily invades areas or spreads into places where it might not be wanted. Invasive plants have the ability to disperse, establish themselves, and spread without the aid of humans or the disturbances humans cause to the landscape. Sometimes invasive plants are accidentally introduced to an area, but often they have been intentionally introduced for ornamental or aquarium use, or for forage, food, fiber, medicinal, or soil stabilization purposes. Invasive plants have the potential to cause serious economic or environmental damage. Note that invasive plants and animals are the second greatest threat to biodiversity after habitat loss and fragmentation.

Landscape pest: a pest of trees, shrubs, herbaceous plants, or turf.

LEED: (Leadership in Energy and Environmental Design): a set of standards for the design, construction, operation, and maintenance of Green buildings, homes, and neighborhoods.

Monolithic paving: paving constructed of materials that bind together to form a single mass. It is a single block or slab of unjointed pavement, as opposed to individual bricks or paving stones. Having fewer joints means fewer areas for weeds to grow in the cracks.

Mow strip: a paved strip that separates turf from flower and shrub beds or that is installed under a fence, bench, or sign. The wheel of a mower can ride on the strip so it is possible to mow to the very edge of the turf. This eliminates having to edge the turf or deal with weeds growing under structures such as fences and benches (see also underlayment).

MSDS: (material safety data sheet): a document that contains information on the potential hazards (health, fire, reactivity, and environmental) of a chemical as well as information on how to work safely with the product. It is an essential starting point for the development of a complete health and safety program. Pesticide MSDS sheets and labels for pesticides used by a municipality must be available for employees in a central location (such as where staff meet in the morning). Ideally, copies of labels and MSDS sheets should be kept in a binder in each municipal maintenance vehicle to be readily accessible wherever chemicals are being used.

Municipal Regional Stormwater NPDES Permit (MRP): A stormwater NPDES permit and Waste Discharge Requirements issued by the San Francisco Bay Regional Water Quality Control Board to 76 cities, towns, and Flood Control Districts.

Nitrogen (N): a nutrient that is needed for plant growth and for leaf, flower, and seed production. Nitrogen is a part of every living cell and is part of chlorophyll, the green pigment in plants that is responsible for photosynthesis. Nitrogen deficient plants grow slowly and produce weak spindly stems and small leaves. The plant can become stunted, and the roots may not grow enough to support the plant. Nitrogen can move throughout the plant to where it is needed most; therefore, yellowing of the older, lower leaves while the new growth remains green is a sign of nitrogen deficiency.

Omnivorous: feeding on both plant and animal substances.

Pesticide: a chemical that is designed to be harmful to a target pest. The term “pesticide” encompasses all the other “cides”, such as herbicide, insecticide, rodenticide, fungicide, etc.

Phosphorus (P): a plant nutrient that is needed for flower, fruit, and root growth.

Plant Health Care (PHC): a method of managing landscapes that was developed from the concept of IPM as it applies to tree care and landscape maintenance. PHC differs from IPM in that it concerns management of the plant and its environment and not just plant pest management.

Potassium (K): a plant nutrient that is important for overall vigor and disease resistance.

Public right-of-way: a type of easement granted or reserved over a piece of land for transportation purposes. This can be for a highway, public footpath, rail line, canal, as well as for electrical transmission lines and oil and gas pipelines. A right-of-way is reserved for the purposes of maintenance of or expansion of existing services into the right-of-way.

Rodenticide: a chemical designed to kill rodents, such as rats, mice, and ground squirrels.

- **Anticoagulant rodenticide:** a rodenticide that kills by blocking key clotting factors in the blood creating internal hemorrhaging.
- **First generation anticoagulant rodenticides:** these include warfarin, chlorophacinone, and diphacinone. These rodenticides were developed and marketed beginning in 1950. They require consecutive days of ingestion for the animal to obtain a lethal dose. If an animal poisoned by a first generation anticoagulant is eaten by a predator, the anticoagulant can affect the predator. However, the half-life (the time it takes for the concentration of the rodenticide to be reduced by half) of most first generation anticoagulants is generally hours to days in both target and non-target animals.
- **Second generation anticoagulant rodenticides:** these include brodifacoum, bromadiolone, difethialone, and difenacoum. By the 1970’s, researchers noted resistance to warfarin in Norway rats, roof rats, and mice in Europe and North America. This prompted the development of second generation anticoagulant rodenticides, such as those mentioned above. These rodenticides are more toxic than first generation rodenticides and generally require only a single feeding to be lethal. Since it may take several days for the rodent to die, the rodent may consume multiple doses of the poison. This ingestion can result in a super-lethal concentration of rodenticide in the rodent’s body. This characteristic, coupled with the fact that the half-life of second generation anticoagulants is generally days to months, makes these poisons a much more serious threat to predators feeding on poisoned rodents.

Scale insect: a common pest of trees and shrubs. Most scales feed on plant juices and spend the majority of their life permanently attached to a plant by their mouthparts. Armored scales secrete a shield-like waxy coating to cover their bodies. Soft scales secrete only a thin, transparent waxy film. Soft scales excrete a sweet, sticky substance called “honeydew” that is a favorite food of the Argentine ant.



Photo by G.J. Lenhard, LA State Univ., Bugwood.org

Tuliptree scale (*Toumeyella liriodendri*)

Silica gel: a very fine powder synthesized from sodium silicate. Note that silica is the main chemical compound in 95% of the known rocks on earth. Silica gel is similar to diatomaceous earth in its mode of action: it adsorbs the waxy coating on the outside of an insect’s body causing the insect to dehydrate.

Soil food web: refers to the huge range of organisms that live in the soil and the complex interaction among these organisms. This is similar to the idea of a food chain, but recognizes that the process of who eats whom is much more complicated than a straight line.

Structural pest: a pest in or around structures, such as ants, cockroaches, birds, mice, rats.

Toxicity: the degree to which a substance can damage an organism.

Turf—athletic use: lawn used for sports such as soccer or football. Athletic turf is usually maintained to a much higher standard than traditional use turf.

Turf—traditional use: lawn used in landscaping for decorative, aesthetic, or recreational purposes.

Underlayment: a paved area under a fence, a bench, a sign, etc. that is used to prevent weed growth under the object and facilitate mowing around the object.

Webber: a brush with a long handle used for removing spider webs, especially those in hard to reach locations.



Using a brush to remove spider webs

Weed whip or string trimmer: a motorized device with rapidly rotating plastic cord for cutting weeds.

How to Use this Guidebook

The Municipal Regional Stormwater NPDES Permit (MRP)¹ and East Contra Costa County Municipal NPDES Permit (East County Permit)² each contain a Pesticides Toxicity Control provision (C.9 in both) requiring municipalities to adopt and implement an Integrated Pest Management (IPM) Policy or Ordinance and establish written standard operating procedures for pesticide use to help ensure that the IPM Policy or Ordinance is being implemented appropriately. Both permits also identify certain pesticides of concern that threaten water quality. For a list of these specific pesticides, please refer to the current MRP or East County Permit.

This document, *Integrated Pest Management for Municipalities* (Guidebook), was written to assist your municipality in complying with these provisions. This overview will help you obtain a general understanding of how to use the information and documents provided within the Guidebook.

The intended audiences for the Guidebook are the IPM Coordinators and/or Maintenance Managers in your municipality. These individuals should be familiar with this Guidebook in order to provide information on specific pest problems to municipal staff and/or hired contractors.

The documents contained in this Guidebook may be used as reference material and will provide information to assist your municipality when implementing its IPM Policy and IPM Program. The Guidebook is divided into three chapters. **Chapter 1** provides a model IPM Policy and Program that your municipality may want to consider adopting and implementing to help meet Provision C.9 requirements (including establishing standard operating procedures). **Chapter 2** provides detailed IPM guidance for managing landscape pests, plant health, turf, and weeds. **Chapter 3** provides detailed IPM guidance for managing structural pests.

The Guidebook also contains five appendices that complement the three chapters and provide additional resources. **Appendix A** includes sample landscape and structural IPM contract language. **Appendix B** contains factsheets for managing landscape weeds, and **Appendix C** contains factsheets for managing structural pests. **Appendix D** provides detailed instructions for sheet mulching. **Appendix E** contains a sample list of pest management materials for LEED Certified buildings and other municipal buildings.

¹ Issued by the California Regional Water Quality Control Board, San Francisco Bay Region (Region 2)

² Issued by the California Regional Water Quality Control Board, Central Valley Region (Region 5)

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CHAPTER 1: Model IPM Policy and Program

Model IPM Policy

The [City or Town] of [Name of Municipality] uses Integrated Pest Management (IPM) to manage pests on [City or Town]-managed facilities. For the purposes of this policy, the [City or Town] adopts the IPM definition provided by the University of California Statewide IPM Project:

Integrated pest management is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organisms. Pest management materials are selected and applied in a manner that minimize risks to human health, to beneficial and non-target organisms, and to the environment.

Goals

- Ensure effective, economic pest management on [City or Town] property while minimizing health risks to the public and [City or Town] staff and risks to the environment that could result from pest management activities.
- Protect environmental quality by preventing pollutants from entering surface and ground water.
- Comply with requirements in the [City's or Town's] stormwater NPDES permit.
- Promote transparency of the [City's or Town's] pest management actions.
- Increase public awareness of IPM.

Implementation

The [title of official] will develop and periodically review an IPM Program, which will apply to all [City or Town] pest management activities. The Program will include the following:

- Appointment of a single person or point of responsibility within the [City or Town] for [citywide or town-wide] IPM implementation and program evaluation.
- Adherence to IPM decision-making steps (see below) for managing pests on [City or Town]-owned and maintained properties and facilities.
- Participation in countywide and regional efforts to further relevant policies and activities by the US Environmental Protection Agency, the California Department of Pesticide Regulation, and the Contra Costa County Agricultural Commissioner.
- Maintenance of accurate records on IPM implementation and pesticide use.
- Ongoing and periodic staff training.
- Development of standard IPM Operating Procedures for key pests.
- Inclusion of [City or Town] IPM policies and practices in [City or Town] contracts or purchase orders for pest management.
- Maintenance of a list of available expert resources that may be accessed by staff.

[Optional] The IPM Program will be reviewed [frequency of review] by the [Council-appointed Committee], and staff will consider incorporating the Committee's comments in updates to the IPM Program.

IPM Decision-Making Steps

1. Based on field observations, evaluate locations and sites where pest problems commonly occur to properly identify the pest, determine pest population size and location, and identify any natural enemy populations.
2. Identify conditions that contribute to the development of pest populations, and identify measures that could be employed to prevent and manage pest populations.

Prevention measures may include:

- Design, construction, and maintenance of landscapes and buildings to reduce and eliminate pest habitats.
- Modification of management practices including watering, fertilizing, mulching, waste management, and food storage to discourage the development of a pest population or to increase the health and resilience of a landscape or particular plant.
- Modification of pest ecosystems to reduce food, water sources, harborage, and access to buildings.

- Education of staff and the public about the connection between pests and the availability of food, harborage, and access, and the role humans can play in preventing and reducing pest problems.
3. Determine treatment thresholds that are based on the level of biological, aesthetic, or economic damage (or other effect) that is tolerable.
 4. When a pest population reaches its treatment threshold, choose a set of treatment strategies that is appropriate for the site and the pest:
 - Evaluate non-pesticide management strategies before considering the use of pesticides.
 - Prioritize the use of physical controls such as sanitation, mowing weeds, using traps, and installing barriers.
 - Whenever possible, create landscapes that encourage naturally occurring insect parasites and predators (biological controls) to help manage pest insects.
 - When pesticides are necessary, select reduced-risk pesticides and use the minimum amounts needed to be effective.
 - Apply pesticides at the most effective treatment time, based on pest biology, monitoring, and other variables, such as weather, seasonal changes in wildlife use, and local conditions.
 - Whenever possible, use pesticide application methods, such as spot treatments and containerized baits, that minimize opportunities for mobilization of the pesticide in stormwater runoff and minimize effects on non-target organisms.
 5. Evaluate the results of treatments to improve pest management.

Note to Municipalities

While the sections above provide model language that a municipality may use to draft its IPM policy, it is important that municipal staff and their contractors understand that IPM is not simply a matter of substituting “good” pesticides for “bad” pesticides. Too often, we want an easy solution, a magic bullet that will solve all our problems in one shot. Unfortunately, pest management is complicated, and we cannot always expect a simple solution to a pest problem. IPM works because, in the end, combined multiple strategies for pest management are more effective than a single strategy. A good pest manager considers as many options as possible and tries to combine them into an effective program. The best pest managers have ideas for new and creative ways to solve pest problems. Whenever possible, IPM takes a preventive approach by identifying and removing, to the degree feasible, the basic causes of the problem, rather than merely attacking the symptoms (the pests). This prevention-oriented approach is best achieved by combining a number of strategies.

Model IPM Program

IPM Coordinator. [Name and/or Title] is the [City's or Town's] IPM Coordinator. The IPM Coordinator is responsible for coordinating, tracking, and reporting implementation of the [City's or Town's] IPM Program.

Tracking Pesticide Use. The IPM Coordinator is responsible for maintaining accurate records of pesticide use that are accessible for reference. [Note: A format for tracking pesticide use can be found at the end of this chapter.]

Interface with the County Agricultural Commissioner. The IPM Coordinator will periodically disseminate to staff information on how to identify when pesticides are being applied inconsistent with DPR regulations and how to report such incidents to the County Agricultural Commissioner.

Staff Training. All [City or Town] employees who, within the scope of their duties, apply or use pesticides will be periodically trained in IPM practices and the [City's or Town's] IPM Policy. Trainings may be organized locally, or staff may attend countywide or regional training sessions. The IPM Coordinator will track employee attendance at training sessions.

Standard IPM Operating Procedures. The [City or Town] will follow Standard IPM Operating Procedures below:

1. Use cultural practices and pest prevention measures to minimize the occurrence of pest problems.
2. Set a threshold of tolerance for pests.
3. Use biological and physical controls that are environmentally appropriate and economically feasible to control pests.
4. Use pesticides to prevent or manage damaging pests only when necessary, and select and apply them in a manner to minimize risks to humans, non-target organisms, and water sources, including stormwater. Where feasible for structural pest management, insecticides will be applied as containerized baits.
5. Avoid the use of pesticides that threaten water quality¹ especially in formulations and situations that pose a risk of contaminating stormwater runoff.

Information Resources for Staff. The IPM Coordinator will act as a resource to [City or Town] staff to help identify when Standard Operating Procedures are not applicable or sufficient to

¹ As defined in the current Municipal Regional NPDES Permit and East Contra Costa County Municipal NPDES Permit.

solve a pest problem, to determine the best course of action consistent with IPM principles, and to access expert resources when needed.

Public Outreach. Public outreach efforts will include distribution of information, as appropriate, such as “Our Water, Our World” and “EcoWise Certified IPM Certification in Structural Pest Management” or equivalent programs. The IPM Coordinator will coordinate and keep records of the following:

1. A point of contact for the public to obtain information on IPM techniques.
2. The [City’s or Town’s], countywide, and regional advertising campaigns that focus on reducing the impact of urban pesticide use.
3. The [City’s or Town’s] outreach to pest control operators (PCOs) and landscapers, or contributions to countywide or regional efforts to promote IPM to PCOs and landscapers.
4. Placement of messages focused on reducing the impact of urban pesticide use in the [City’s or Town’s] newsletters or other publications.
5. Distribution of IPM information and resources at public outreach and citizen involvement events and City websites.
6. Distribution of information about less-toxic pest management to school-age children.
7. Updates and status reports to municipal officials.

Contract Provisions. The IPM Coordinator will review contract provisions or addenda to purchase orders issued by all [City or Town] departments that contract for pest management services and monitor contract work to ensure [City or Town] IPM policies and practices are adhered to by all contractors performing pest management work on [City or Town] maintained properties and facilities.

Stormwater NPDES Annual Report. The IPM Coordinator will prepare the portion of the [City’s or Town’s] stormwater NPDES Annual Report related to Pesticides Toxicity Control.

Example of a Format for Tracking Municipal Pesticide Usage

This chart can be converted to a spreadsheet to track pesticide use for internal data collection and record keeping.

Date	Target Pest	Location	Pesticide Product Name	EPA Reg. No.	Active Ingredient Chemical Name	% Active Ingredient in Product	Amount of Product Used	Units	Contractor

Model Contractor Agreement

The staff of _____(contractor company name) do hereby agree to

- follow the IPM Decision Making Steps, as listed in this document,
- consult with the [City or Town] IPM Coordinator before making pesticide applications, and
- report to the IPM Coordinator all pesticides used in the [City or Town].

Authorized Signature

Date

Printed Name

Title

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CHAPTER 2: Guidance for Landscape IPM

Introduction

Maintaining healthy plants and a healthy landscape on multiple properties is a common challenge for municipalities. While each landscape has its own physical and spatial components that must be considered, there are three essential elements to creating and maintaining a healthy landscape.

1. **Establishing and maintaining healthy plants.** Plant health is the key factor in preventing plant disease and pest damage. Well placed, healthy plants of species compatible with the immediate environment require less maintenance time and are significantly more immune to pest and disease problems than plants that are out of place, over pruned, stressed, or otherwise unhealthy.
2. **Proper maintenance of turfgrass.** Most municipalities are responsible for maintaining athletic fields and lawns as part of park and playground spaces. Selecting the right turf species at the outset and tailoring irrigation, fertilization, and other maintenance activities to the species and the site are critical to establishing and maintaining healthy turf.
3. **Managing weeds.** Appropriate site design, plant selection, mulching, and vigorous plant and turf health will greatly reduce weed problems. Of critical importance is the management of weeds *before* they set seed to prevent them from multiplying, spreading, and proliferating.

The information in this chapter provides guidance to address these three areas.

Plant Health Care and IPM

Plant Health Care (PHC) is a method of managing landscapes that was developed from the concept of IPM as it applies to tree care and landscape maintenance. PHC differs from IPM in that it concerns the management of the plant and its environment, and not just plant pest management.

Most plant problems that occur in the landscape are not due to insects, mites, or disease alone; instead, they are the result of compacted soil, drought stress, over watering, frost damage, and other cultural or abiotic conditions.

Human activity, through its influence on plant selection, plant placement, and environmental modifications, has created highly stressful environments for plants. The primary objective of PHC is to grow healthy plants, and in so doing, minimize the effects of pests. Healthy plants are better able to fight off pest problems and/or are more tolerant of pests.

Plant the right plant in the right place in order to eliminate many factors that weaken a plant's health.

Choosing appropriate plant species for your site is extremely important and involves considering all of a plant's traits and requirements, such as

- Soil, water, and light requirements
- Pruning requirements
- Susceptibility to particular insects and diseases
- Cold hardiness
- Drought tolerance
- Size (both height and width) at maturity

You may not be in complete control of the plant palette chosen by the landscape designers contracted to design your municipal landscapes; however, you should be able to review plant choices and ask for changes in order to prevent pest, disease, and maintenance problems in the future. Be aware of the tendency of some contractors to have a "perfectly" designed site immediately after planting instead of designing for sustainable maintenance costs and the long-term viability of the landscape. Often, these shortsighted designs are over-planted, and money is wasted on the purchase and installation of an unnecessary number of plants that are placed too close to each other or to walks and buildings. This increases maintenance costs and may require the removal of excess plant material. Your agency should clearly communicate its maintenance limitations and the kind of landscaping it requires; responsible staff must participate in the design process to make sure that these requirements are met.

The following are examples of some of the things to consider when choosing trees and shrubs for a particular site:

- *Is the soil compacted, or are there constricting hardscape features at the site?* These can restrict the root spread of a tree or shrub. These problems can lead to poor drainage that either prevents plants from getting water or drowns them in soils that

never dry out and have no air spaces. Soil compaction is the most common stress factor in urban landscapes.

- *How much irrigation is being delivered to the plants already on-site (or how much do they need)?* Plants differ greatly in their needs for water. Problems arise from improper irrigation. For example, drought tolerant plants in heavily irrigated lawns or shrub beds may be prone to root rot. Use “hydrozoning” in your plantings. This means grouping plants with similar water requirements together.
- *Is the soil alkaline (pH greater than 7)?* Most landscape plants thrive in soils with a pH near neutral (pH 5 or 6). Alkaline soils can pose problems for plants that are not adapted to them. For example, *Liquidambar*, azaleas, and rhododendrons can suffer from iron-deficiency-induced chlorosis in alkaline soils.
- *Is the site shady or sunny?* Plants differ in the number of hours of sun they need each day. Sun-loving plants growing in medium to heavy shade with poor air circulation can, for instance, be much more susceptible to powdery mildew.

Reduce other stress factors that lead to pest problems and poor plant health.

Taking care to reduce stress factors is important in the control of pest issues and plant health. For example:

- *Soil compaction is the most common stress factor in the landscape setting and causes numerous problems.* It is easier to prevent compaction at a construction site or to correct compacted soil conditions and work to improve drainage before planting than it is to try to remedy problems after plants are installed.
- *Understand the cultural needs of your plants and how to care for them.* Poor irrigation management (too much or too little water), incorrect sun exposure, too much pruning, and over fertilization all cause stress to plants.
- *Understand how to plant trees and shrubs properly to give them the best start and a long life* (see *Planting Landscape Trees* at the end of this section, and <http://www.isa-arbor.com/education/onlineresources/cadplanningspecifications.aspx>).
- *Drought can cause serious stress, die-back, and death.* In general, irrigate deeply and infrequently and use 3” of mulch to prevent evaporation from the soil. Keep mulch at least 4” away from the trunks of trees to prevent disease. If water is very limited, consider removing all competing plant cover, except for the appropriate trees, and mulching the area. Trees represent a large investment in the landscape, and it takes much longer to replace mature trees than shrubs and herbaceous plants.
- *Plants that are under drought stress can be highly susceptible to devastation from spider mites and other pests.*

- *Insecticides that affect a broad spectrum of insect life and that are used indiscriminately or on a schedule can kill the natural enemies of major and minor insect pests.* The absence of natural enemies allows pests that would normally be under control to multiply without natural checks and cause more serious damage.
- *Excess soil moisture and poor drainage favor many root diseases of plants.*
- *Bark damage resulting from improper pruning, storm damage, and lawn mowers creates wounds that allow fungi and bacteria to enter the plant and cause disease.*

As plants mature, their pest resistance abilities and cultural requirements change.

Landscape maintenance practitioners should be educated about the life cycle changes in the plants they care for and adapt their maintenance practices accordingly.

Use the principles of IPM to manage landscape pests.

IPM is a decision-making process that is used to determine if, when, and how to treat a pest infestation. Information gathered from regularly monitoring the site combined with information about the biology of the pest and the ecosystem in which it is found are used to inform the decision-making process. If treatment is warranted, the management program should include as many different tactics as feasible. Treatments are chosen to be effective, economical, precise, and the least hazardous to humans, pets, wildlife, and the environment.

IPM is always site-specific. Every landscape and every situation is different, and what works or applies in one spot may not in another.

All too often, when people see a bug, they reach for a chemical without stopping to think. Many times, this reaction is prompted by a fear and misunderstanding of insects and a desire to have perfect plants. Step back for a moment and survey the situation.

Is Treatment Necessary

The mere presence of an insect or mite does not necessarily indicate a problem. The following questions can help you determine if treatment is really necessary:

- *What is the name of the plant?*
- *What is the name of the insect or other pest?*
- *Is the creature you see actually feeding on your plants? Is real damage taking place?*

Not all plant damage is serious enough to cause irreparable harm. Understand what is causing the damage, investigate the extent of the damage, and monitor the situation. An excellent reference book is *Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide* from the University of California Statewide IPM Project (ANR Publication #3359), see: http://www.ipm.ucdavis.edu/IPMPROJECT/ADS/manual_landscape.html

- *If it is real damage, is it caused by a creature such as an insect, bird, or snail; by a disease; or by an “abiotic” disorder such as drought stress, fertilizer burn, or air pollution?* Refer to *Abiotic Disorders of Landscape Plants* from the University of California (ANR Pub. #3420, <http://anrcatalog.ucdavis.edu/Details.aspx?itemNo=3420>)

If you aren't sure of the answers to any of the above questions, the County Department of Agriculture at 2366-A Stanwell Circle in Concord (925-646-5250) can help. They have a biologist on call every day from 8 A.M. to 5 P.M. Bring them a sample of the plant, the damage you are seeing, and any insects or mites you see (capture several of them in a jar or plastic bag, and be careful not to crush them).

When you know what is causing the problem, read as much as you can about it. Knowledge is the key to a good IPM program; you cannot manage a pest you do not understand.

- *Are there natural enemies present?*

The natural enemies of insect and mite pests are predators, parasites, and pathogens. Although you may not have noticed them, natural enemies are almost always present in landscaping, unless it is regularly treated with pesticides. Photos of and information about the most common natural enemies are available at the UC Statewide IPM Program Web site. See http://www.ipm.ucdavis.edu/IPMPROJECT/ADS/poster_naturalenemies.html.

More detailed information about specific predators and parasites is available at <http://www.ipm.ucdavis.edu/PMG/NE/#PREDATOR>.

If you observe natural enemies attacking your pest, you may want to postpone or alter your treatment to avoid killing the natural enemies.

- *How many pests can you tolerate?*

People differ in the number of pests or amount of damage they are willing to tolerate. IPM encourages people to think about their tolerance levels and to experiment with tolerating a greater number of pests and weeds or a greater amount of damage, especially in situations where the damage is not serious. Insects provide food for other wildlife, especially birds, and having some plant-feeding insects and mites around will keep desirable natural enemies in the landscape.

- *Is the amount of time and effort expended in managing the problem worth the result?*

Can you justify the management measures you will have to employ, particularly if they include pesticide use? Sometimes it is easier in the long run to remove the plant and find another that will have fewer problems.

When to Treat

If you have decided that you really have a pest problem and that some kind of treatment is necessary, proper timing is very important for effective pest management. There is almost always a window of opportunity or period of maximum vulnerability when treatment will give you the most “bang for your buck.”

- Some insects are affected by treatments only at certain times in their lives. For example, insecticidal oils are most effective on the “crawler” stage of scale insects. At other times of the scale’s life cycle, the insect is under a hardened shell that effectively protects it from pesticide.
- Weeds are more easily controlled when they are small.
- Spraying landscapes at regularly, pre-determined intervals not only wastes money and pesticide, but also unnecessarily exposes people, wildlife, and the environment to toxic chemicals. In addition, during many of these treatments, pests may not be present or may be present in such small numbers that they aren’t causing a problem.
- Indiscriminate pesticide treatments can kill natural enemies that are often more vulnerable to pesticides than the pests themselves.

How to Treat

IPM emphasizes integrating a number of treatment methods into a comprehensive plan for managing the pest problem. Because of the complexity of the natural world, it is seldom possible to effectively manage a pest with a single treatment method. And as was mentioned in the section above on Plant Health Care, many pest problems are caused or aggravated by environmental stresses on the plant.

What kinds of treatments are effective against your pest? Not all techniques work for every pest. You will have to do some research. A good place to start is the UC Statewide IPM Program Web site, which has a series of Pest Notes on many different problems: <http://www.ipm.ucdavis.edu/>. Another resource is the U.C. Cooperative Extension. The job of the Extension Advisors is to help the public, so don’t be hesitant to contact them:

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http://www.ipm.ucdavis.edu/IPMPROJECT/landscape_pro_resources.html

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Pesticides are only one kind of treatment. IPM does not prohibit the use of pesticides. They are valuable tools; however, they should be selected to be the least-hazardous to people, pets, wildlife, and the environment. In general, pesticides should be used as “spot treatments,” where and when they are needed.

IPM Treatment Methods

- **Education** is a very important part of IPM. Education of the public helps gain support for your IPM program in the landscape. Education can help change public

expectations for “perfect” lawns and landscapes, thus relieving some pressure on staff. Maintenance staff, as well as administrators, need to be educated about new landscape management methods in order to gain their support and cooperation. IPM is a knowledge-based management practice, so maintenance crews and supervisors need training in nurturing plants and soil and in recognizing and dealing with the pests, diseases, and abiotic disorders in your area.

- **Mechanical and physical** methods to manage pests include using sticky traps to capture insects; pruning out webbing caterpillars and destroying them; removing diseased portions of a plant; using proper sanitation with regard to the disease; and using mulch to conserve water in the soil and to prevent weed growth.
- **Horticultural** methods include all of the points mentioned in the Plant Health Care section above. Healthy plants growing in the right place and nurtured with the right care are more resistant to pests, and, if attacked, are better able to fight pests off or sustain some damage without serious consequences.
- **Removing and destroying the plant** may be the best option when you are confronted with an infestation of pests or disease. This is especially true when the plant has chronic problems. Replace the plant with one that is easy to care for and has few or no pest problems.
- **Biological control** methods include using predators, parasites, and pathogens to attack insect and mite pests. There are some commercially available biological controls, but in general, biological control in the landscape involves protecting the natural enemies already in the area and manipulating the landscape to encourage them to come to the area and remain there.
 - *Pesticides kill natural enemies.* Pesticides can severely disrupt biological control because parasites and predators are often more sensitive to pesticides than the pests are. Even if natural enemies are not killed outright by a spray application, many pesticides leave toxic residues that can kill long after the application. Avoid using broad spectrum, long lasting pesticides, especially when you observe natural enemies in the landscape. Use spot treatments wherever possible.
 - *Use flowering plants to keep natural enemies in the landscape.* Many predators and parasites only exhibit their predatory or parasitic function in their larval (immature) stage. The adults of these natural enemies feed on nectar and pollen. Having a diversity of flowering plants that bloom throughout the year will keep these beneficial insects in your landscape and help them thrive. See the chart below for a list of plants that attract beneficial insects.

Some Plant Species that Can Provide Nectar and Pollen and Their Flowering Periods

Plant Species	Moisture*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Willow species	W												
<i>Ceanothus</i> species	D												
Redbud	D-I												
Mule fat	I-W												
Yarrow species	D-I												
Coffeeberry	D-I												
Hollyleaf cherry	I												
Soapbark tree	I												
Buckwheat species	D												
Elderberry species	I-W												
Toyon	D												
Creeping boobyalla	I												
Bottle tree	I												
Narrowleaf milkweed	D-I												
Coyote brush	D-I												

*Moisture requirement key: dry (D); dry to intermediate (D-I); intermediate (I); intermediate to wet (I-W); wet (W)

From *Natural Enemies Handbook: The Illustrated Guide to Biological Control*, p. 46, Flint and Dreistadt, UCANR, 1998.

- Manage ants.* Ants, especially the Argentine ant, can disrupt naturally occurring biological control. The Argentine ant feeds on “honeydew” produced by aphids, scales, mealybugs, and whiteflies. Argentine ants will “farm” these insects to protect them from parasites and predators, just as a dairyman would protect and milk his cows. If the ants are prevented from reaching the pest insects, natural enemies will often reduce the pest population below the point where it is a problem. A useful deterrent to prevent farming ants from climbing the plants is “Tree Tanglefoot” or an equally sticky substance that the ants cannot climb through.

Liquid baits that use sugar as an attractant are a very effective method for managing ants in the landscape. Use liquid baits that contain boric acid (orthoboric acid) or borax (sodium tetraborate decahydrate) as the poison. It is preferable to use baits that contain only 1% to 2% of either boric acid or borax because the lower percentage allows more foraging ants to take bait back to the nest to feed to nest mates, instead of succumbing to the poison on the way home. Argentine ants will feed on liquid sugary baits year-round. Place bait stations along ant trails, at the base of the affected plant, or near

the nest, if you can locate it. (Note that there may be a number of nests.) For more information on baiting ants, see the Argentine Ant factsheet in Appendix B.

- *Consider using commercially available biological controls.* There are some predators and parasites available commercially that could be effective in the landscape. The Association of Natural Biocontrol Producers (ANBP) is a trade organization that maintains a list of producers at <http://anbp.org/index.php/members-products>. ANBP members must produce their organisms according to the organization's code of ethics and must conform to specific American Society for Testing and Materials (ASTM) standards.
- **Least-hazardous chemical controls** include products such as insecticidal soaps and oils derived from plants such as mint or the neem tree (azadirachtin). The City of San Francisco maintains a list of reduced risk pesticides for use in the City's IPM program which can be found at <http://www.sfenvironment.org/article/city-staff/pest-management#list>. Click on "Reduced Risk Pesticide List."

When you are considering using a pesticide, ask these questions:

1. Is damage really at the point where the plant will be in jeopardy?
2. Can the damaging insect population or damaged plant part(s) be removed by hand or by pruning?
3. Is the plant worth spending the time, money, and pesticide on?
4. Are there selective and environmentally friendly pesticides that are effective for the problem?
5. Among the effective pesticides, which is the least-hazardous?
6. Is the pesticide safe for bees?
7. Can I confine the treatment to a small area? What will be the most precise application method?

Successful Plant Health Care and IPM rely on monitoring and gathering information.

Regular inspections of your landscape plants using the observational principles discussed above can provide useful information to help you determine the condition of your landscape plants, let you know if there are any pest problems, and guide your landscape management decisions. This kind of educated monitoring with purpose can be performed as informed maintenance crews go about their daily work.

The more you and your staff know about how to care for the plants in your landscapes at various life stages, the healthier your landscapes will be. The more you understand about the insects, mites, and other potential pests—their habits, their life cycles, and the factors that affect their spread—the better you can anticipate conditions that trigger pest problems. With knowledge and experience, you can prevent problems from occurring or catch them before they become serious.

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Planting Landscape Trees

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The performance of a landscape tree depends a great deal on how it is planted. Survival after initial transplanting, rate of growth and establishment, root development, and many other factors can be improved by proper planting techniques. Topics to consider when planting include the size and shape of the planting hole, whether to add soil amendments or fertilizer, pruning, staking, mulching, and watering.

PLANTING HOLE PREPARATION

Plant a young tree “high,” whether it is bare-root, balled, or container-grown. Dig the hole no deeper than approximately 2 inches (5 cm) less than the depth of the soil in the container or the depth of the soil ball. Planting a tree too deeply or in loose soil may lead to the root ball settling below grade and potential crown rot problems.

Soils compacted by construction, vehicular traffic, or agricultural use must be broken up before planting to ensure adequate air and water penetration. After loosening compacted soil using a shovel or excavation equipment, irrigate thoroughly and delay planting for 2 weeks to allow the soil to settle. An evaluation of the soil drainage should be completed prior to planting. Dig a hole at the planting site and fill with water. The water should drain through the planting hole within 24 hours. If not, more extensive soil modifications may be necessary.

In soils of reasonable tilth, the planting hole should be at least twice the diameter of the container or root ball. In more compacted soil, the hole should be three to four times the diameter of the root ball. In either case, the sides of the hole should slope slightly in toward the bottom and should be roughened to allow easier root penetration. When planting bare-root trees, make the hole large enough to accommodate the roots without crowding. Backfill the hole with soil dug from the hole, or use more friable surface soil if the soil from the hole is mainly hard clods. With container-grown trees, take care to not cover the root ball top with soil because the finer-textured backfill soil can prevent the root ball from being wetted (fig. 1).

In order for a tree to grow well as it matures, its roots must grow into the soil of the planting site. Amending the backfill soil merely creates an artificial container through which the roots must grow. Limited research has found no benefit from backfill amendments.

If the soil at the planting site will not satisfactorily sustain a tree, extensive conditioning and modification of the entire rooting area would be needed, but this is seldom practical. Roots grow and develop in moist soil where oxygen is available. Roots grow little or not at all in dry soil, in compacted soil, or in soil that is saturated. Trees will have shallow roots if planted on shallow soils that have impervious layers or an underlying shallow water table.

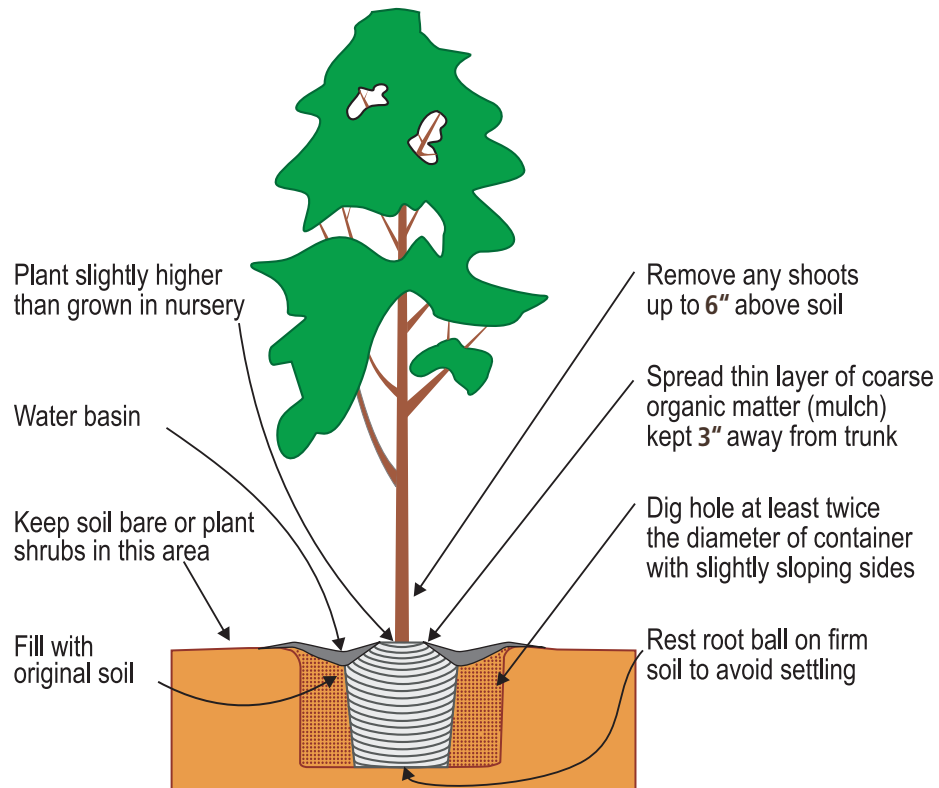


Figure 1. Proper planting of a container-grown tree.

FERTILIZING

Adding fertilizer, soil amendments, or root stimulants to the planting hole or backfill soil is not recommended. Most nursery-grown trees are well fertilized during production and seldom respond to fertilizing at planting except in the most infertile soils.

PRUNING

The less a young tree is pruned, the more total growth the tree will make. However, the growth may not be where you want it or where it will develop the most desirable tree structure. After planting, remove broken, dead, or diseased branches and branches that interfere with more desirably placed ones. Remove or cut back branches that will compete with the central leader (the topmost shoot). Leave small shoots along the trunk below where you want the lowest permanent branch; remove large low branches or cut them back to two or three buds. These low shoots will protect the trunk and increase its strength. Check the tree every 2 to 3 weeks during the growing season to see how it is doing; direct its growth by pinching back shoots that are too vigorous or shoots that you will not want later.

STAKING

Newly planted trees may need staking for protection, anchorage, or support (fig. 2). The type of staking depends on the landscape situation and the ability of the tree to stand upright. The more freedom to move the top of a tree has, the better it is able to develop structure to stand upright and withstand storms. Stakes are not necessary for trees that can stand by themselves or are planted where little or no protection is needed. Most conifers, trees with upright growth habits, and trees planted bare-root usually do not need support.

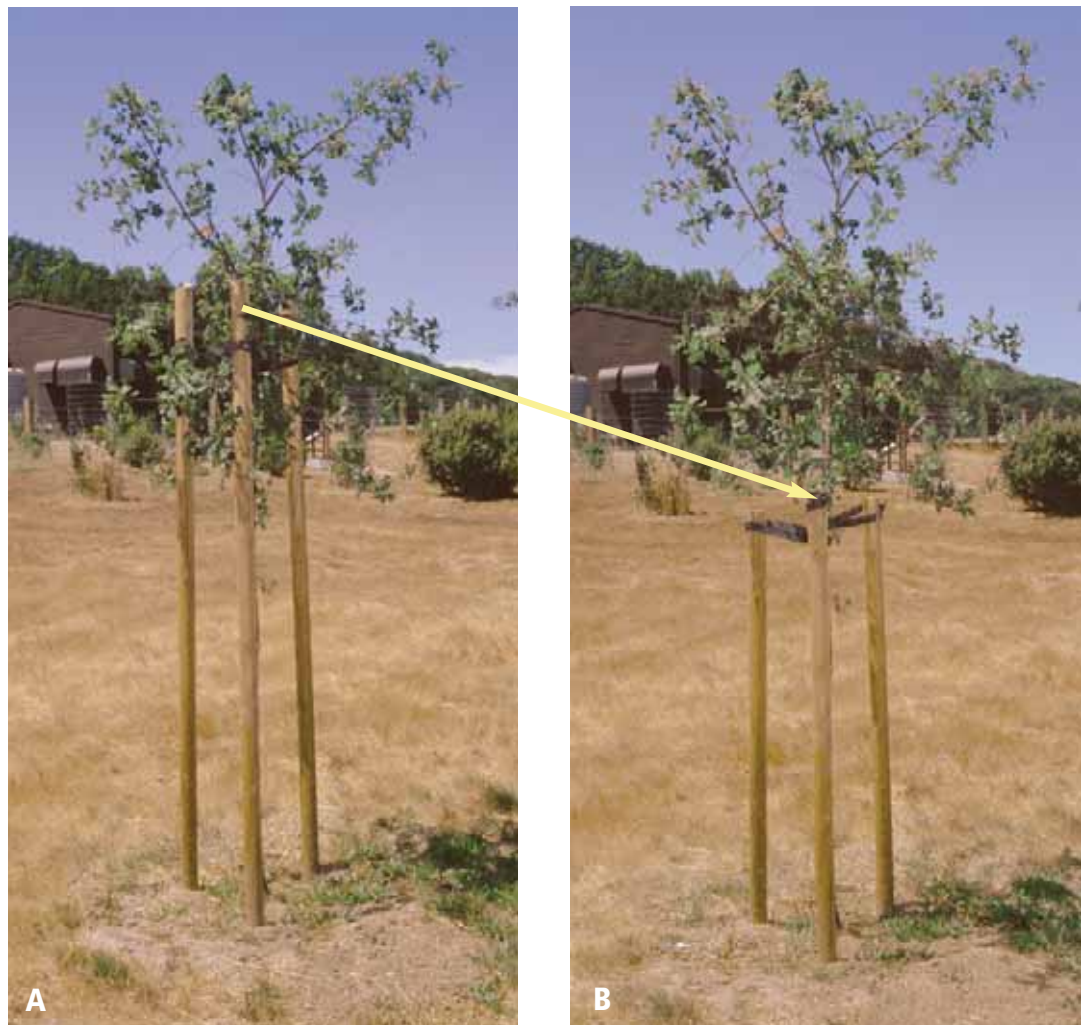


Figure 2. (A) Valley oak tied and staked too high. (B) Stakes and ties properly adjusted.

Stakes should not extend too high into the tree canopy, where they can injure the lateral branches; injured branches can be infested by insects or infected by pathogens. Stakes should not be higher than necessary to hold the tree upright while allowing the top to move in the wind. To find the correct height, grasp the trunk with one hand and bend the top. If the top returns to its upright position when released, tie the trunk at that height. The tie should provide some flexibility but should prevent the trunk from rubbing against the stakes. Tree stakes should be removed as soon as the tree has rooted well enough for support. In most cases, the stakes should not be left in place for more than 1 year.

Protective stakes are needed for trees that can stand without support but that need protection from equipment, vehicles, or animals. To protect trees from equipment and vehicles, stakes need only be high enough to be seen, so as not to be a tripping hazard. Three taller stakes with wire mesh or other covering may be needed to prevent animal damage.

Anchor stakes are needed for trees whose trunks can hold the trees upright but whose roots may not be able to support the trunks, particularly in a wind when the soil is muddy. Stakes used for protection are usually tall enough for attaching ties to the tree trunk to anchor the roots securely and still allow the top to move in the wind.

Support stakes are required for trees unable to stand by themselves. Top support for these trees should be as low on the trunk as possible but high enough to return the tree upright after deflection. Use two or three support stakes. Tie the trunk to them at only one height to allow the trunk below the tie to bend in the opposite direction from the top during a wind. Tie material should contact the trunk with a broad, smooth surface and it should be elastic enough to minimize trunk abrasion and girdling.

COMPETITION FROM TURF AND WEEDS

When trees are planted in a turfed area, keep the turf or other vegetation at least 12 inches (30 cm) away from the trunk of young trees for at least the first 2 years. The growth of young trees may be retarded by turf growing close to their trunks, even though additional water and fertilizer are applied (fig. 3). A 2-foot-diameter (60-cm) area of bare soil, or an area of mulch, around the tree trunk will also reduce damage to young trees by lawn mowers. Mechanical damage to the trunks of young trees can have a severe dwarfing effect.

WATERING

The basin for watering a newly planted tree should be constructed so that water will drain away from the trunk. Even if the soil is moist at the time of planting, thoroughly irrigate the tree to settle the soil around the root system. Remember that most of the root volume occupies a rather limited area, particularly through the first growing season. During this early period, lighter and more frequent watering than what is recommended for established trees is needed until the roots grow into the parent soil. One or two irrigations per week during high water-use periods may be desirable. If the parent soil is poorly drained, be careful not to overwater the tree. Once established, thorough, infrequent irrigation around the “dripline” (ends of branches) is most beneficial for good tree growth.



Figure 3. Maintaining an area of bare soil around young trees prevents other vegetation from competing for water and nutrients. The growth rate of the oak tree at left, planted in a 9-square-foot (0.8-sq-m) area of bare soil with sprouting weeds controlled by herbicide, surpassed the growth of a similar tree grown in turf (right). Both trees were planted as 1-year-old-liners in tree shelters.

FOR MORE INFORMATION

You'll find more information on planting and care of fruit trees in the following ANR publication:

California Master Gardener Handbook, Publication 3382.

Visit our online catalog at <http://anrcatalog.ucdavis.edu>. You can also place orders by mail, phone, or fax, or request a printed catalog of publications, slide sets, and videos from

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IPM for Turfgrass

Maintaining the vigor and health of a lawn is the best way to prevent damage from turfgrass pests, including weeds and disease. If substantial weeds or disease are already present, it may be time to renovate or repurpose the lawn, if that is an option. This outline is intended to serve as a general guide for municipal turfgrass/sports field maintenance and pest management. Specific information can be found on the Web site links provided within this section. For a comprehensive and specific guide to Integrated Pest Management for turf see this University of California website: <http://www.ipm.ucanr.edu/PMG/selectnewpest.turfgrass.html>

The UC Statewide IPM Program provides a comprehensive, easy to follow “Guide to Healthy Lawns that includes information on

- How to choose and identify your turf species
- How to prepare your site and plant turf
- How to care for new lawns
- How to care for established lawns
- How to manage pests and diagnose problems

It can be found at <http://www.ipm.ucdavis.edu/TOOLS/TURF/>

Components of an Integrated Turf Management Program

1. Choose grass species that are well suited to the purpose of the turf.

There are two basic categories of turfgrass suitable for traditional and athletic use: cool season and warm season.

Cool-season grasses have a year-round growing season and maintain their green color through winter. They include Kentucky bluegrass, turf-type tall fescue, and perennial ryegrass.

Warm season grasses go dormant in the late fall and stay brown into early spring. They include bermudagrass, buffalograss, and kikuyugrass.

For nontraditional and nonathletic turf, consider selecting fine leaf Fescues, which have decreased water and mowing requirements. See: <http://anrcatalog.ucdavis.edu/pdf/8391.pdf>

2. Maintain healthy soils.

Well-drained soils with sufficient organic matter content are most suitable for growing turfgrass, but most San Francisco Bay Area soils have a high clay content and are easily compacted. Knowing what type of soil you have, as well as its nutrient availability, is essential information for managing turfgrass. Send soil samples for analysis to a qualified soil testing laboratory and follow the recommendations before seeding or sodding a lawn. Perform a soil analysis annually thereafter to maintain healthy soils. Amending soil with compost, and top-dressing existing turfgrass with compost can increase water holding capacity, reduce compaction, add valuable microorganisms and nutrients, and reduce the need to fertilize.

For more information on the soil food web and weed management in lawns see: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868 and also <http://www.ipm.ucanr.edu/PMG/PESTNOTES/pn74113.html>

3. Irrigate uniformly and efficiently.

Irrigation management should focus on efficient water delivery. This helps reduce disease susceptibility of turfgrass, as well as reducing water consumption.

Important components of efficient irrigation:

- Water should be uniformly distributed to the turfgrass area.
- Water must get into the root zone. Scheduling irrigation cycles by programming multiple start times on a given watering day followed by non-water days will help facilitate deep root development, maximize water infiltration and reduce runoff. Irrigation run times should be shorter than the amount of time it takes for the water to pool on the surface, and programming should be designed to allow the water to percolate down and soak the soil.
- Irrigation should be based on an estimate of the actual amount of water used by the grass plants. This is known as reference evapotranspiration (ETO). Most irrigation controllers manufactured today have ETO-based features that adjust the irrigation delivery for recent weather conditions. Another source of ETO information is the California Irrigation Management Information System (CIMIS) at <http://www.cimis.water.ca.gov/>
- Turf areas should be monitored regularly to adjust or replace irrigation heads. Nozzles should be observed and adjusted for pressure, alignment, and even water distribution. This will prevent overly wet or overly dry areas.
- Conduct regular water audits in the spring to make sure your irrigation systems aren't leaking and are working properly.

- Check the WaterSmart Center on the EBMUD Web site (<http://www.ebmud.com/>) for water conservation information, including free audits and rebate programs. EBMUD will perform a free audit about every five years and will explain to staff what to look for, how to set timers, what equipment to use, and what rebates are available.
- The Contra Costa Water District (<http://www.ccwater.com/>) also has water conservation programs for a variety of landscapes.
- EBMUD will provide rebates for “irrigation-only submeters” to help you determine how much water your landscape is using. These can also help to detect leaks.
- Irrigate in the morning—usually the wind is not blowing and it is cooler, so less water will evaporate.
- Rotator sprinkler heads, such as MP Rotators, can save on water, prevent runoff, and irrigate more efficiently.
- In-line drip emitter tubing with pre-installed pressure compensating (PC) emitters can make drip installation quicker and reduce drip irrigation maintenance.

For more information on efficient irrigation see:

“Using ETO (Reference Evapotranspiration) for Turfgrass Irrigation Efficiency” by W. Richie, R. Green and V. Gibeault in California Turfgrass Culture Volume 47, Nos. 3 &4, 1997 (http://www.ucanr.org/sites/IPM/pdf/misc/M_Gardener_Work_Book.pdf)

“Irrigation Efficiency for Turfgrass Managers by Ali Harivandi,” U.C. Cooperative Extension Advisor. (http://ucanr.edu/sites/EH_RIC/newsletters/Vol2_No2_Spring_199837628.pdf)

“Managing Turfgrass During Drought,” by M. Ali Harivandi, et al. from U.C. Division of Agriculture and Natural Resources (<http://anrcatalog.ucdavis.edu/pdf/8395.pdf>)

4. Fertilize turfgrass properly.

An adequate supply of nutrients is required to maintain optimum turfgrass health. Nitrogen (N), Phosphorus (P), and Potassium (K) are the most commonly required supplemental nutrients for turfgrass and other cultivated plants. These nutrients are represented by three numbers (in that order, N-P-K) on all fertilizer labels that represent the percentage of each element in the package.



The following are only general recommendations; remember, be guided by your specific soil test results.

Nitrogen

Cool season grasses need no more than 4 lbs. actual nitrogen per 1000 sq. ft. per year. More is not better. An appropriate application schedule for the San Francisco Bay Area is 1 lb. actual nitrogen/1000 sq. ft. on March 1, April 15, September 1, and October 15.

Warm season grasses need 6 lbs. actual nitrogen per year and are recommended to receive monthly applications at $\frac{3}{4}$ lb. actual nitrogen/1000 sq. ft. from March through October.

Phosphorus

Phosphorus is vital to root system development and should be applied before seeding or sodding at the rate of 1 lb./1000 sq.ft. For established turf, applications should be made at 1-2 lbs./1000 sq. ft. in spring or fall, when it is needed most. It may also be applied when using a complete fertilizer.

Potassium

Potassium is important for disease resistance, but because this element is readily available in soil minerals, large supplemental amounts are not required.

The recommendation for the Central California Coast region is 1 lb. of potassium/1000 sq. ft. before seeding or sodding and then 1-2lbs./1000 sq.ft./year applied equally in late spring and early fall or when a complete fertilizer is applied.

For more information on lawns in clay soils, see “Managing Lawns on Heavy Soils” by M. Ali Harivandi, Environmental Horticulture Advisor, San Francisco Bay Area; and Victor A. Gibeault, Environmental Horticulturist, Cooperative Extension, University of California Riverside (<http://anrcatalog.ucanr.edu/pdf/7227.pdf>).

5. Aerate turf regularly.

Soil compaction is the hidden enemy of turfgrass. Compacted soils inhibit water, air, and nutrient infiltration to the root zone and reduce turfgrass health. Weeds that are adapted to compaction such as annual bluegrass, clover, crabgrass, and knotweed often invade compacted turf.

An effective turfgrass management program anticipates and reduces compaction with maintenance that includes regular aeration while the turf is healthy and vigorous. Aerators or aerifiers remove small cores of soil and create pores and channels in the root zone for the air, water, and nutrient intake that facilitate root growth. Aeration,

combined with top dressing turfgrass with compost, can significantly reduce compaction.



Pull-behind, cam-driven aerator



Walk-behind aerator

For more information on compacted soils and aeration, see “Turfgrass Traffic and Compaction: Problems and Solutions,” by M. Ali Harivandi, University of California Agriculture and Natural Resources Publication 8080 (<http://anrcatalog.ucanr.edu/pdf/8080.pdf>)

6. Mow at the correct height.

Accurate mowing practices are a vital part of turfgrass management. Mowing too low weakens and thins grass by reducing food-producing tissue, which starves the grass stand, encourages weed invasion, and increases susceptibility to compaction and pests. Mowing too high may encourage the buildup of thatch, limit active turfgrass use and become unsightly.

A single mowing height cannot be recommended for all turfgrass species. There are specific height recommendations for various turf species, but some general rules apply:

- Mow at the tallest allowable height within the recommended height range for the turf species being grown.
- Mow frequently enough so that no more than 1/3 of the leaf height is cut. If the grass has become too tall for this, mow more frequently and gradually lower the mower blades.
- Maintain sharp mower blades for clean cuts.
- Clean the mower between lawns to minimize weed seed transport from the mower.
- Avoid mowing when it is hot or the soil is dry because it can injure the turf.

Proper mowing practices facilitate the use of “grasscycling.” This practice, which consists of broadcasting the grass clippings back onto the turf, is a good source of nitrogen and other nutrients.

For more information on best mowing practices and species-specific mowing heights, see <http://www.ipm.ucanr.edu/TOOLS/TURF/MAINTAIN/mowamt.html>

IPM for Weeds in Landscapes

Maintaining healthy plants and eliminating weeds in the environment can be a challenge for municipal staff. Weeds are hearty and opportunistic, but there are a number of approaches that staff can use to prevent weeds from germinating, reduce the likelihood of their spreading, and reduce their presence on municipally managed property. These approaches begin with proper site design and preparation, followed by choosing the most appropriate methods for removing weeds that have managed to take root.

Designing and Re-Designing Landscapes to Avoid Weeds

Design the entire site. Don’t leave awkward spaces that are prone to weedy growth as in the photos below.



Use underlayments and mow strips. Underlayments (paving under fences, trash cans, benches, and other site furnishings) and mow strips (paving under fences, poles, and posts) can prevent weeds and make maintenance easier. The wheel of a mower can ride on the mow strip or underlayment so it is possible to mow to the very edge of the turf. This eliminates having to edge the turf or control weeds growing under fences and site furnishings.



In the photo below on the left is an example of an effective underlayment for a sign, but the underlayment on the right is too small and will require trimming.



In the photos below, concrete mow strips are included as an integral part of the landscape design.



A header board (bender board) can be used to define the landscape and help contain plantings and grass intrusion as in the left photo. Underlayments (and mow strips) can be retrofitted to the landscape as with the bench in the right photo.



Using concrete under the bleachers, as in the left photo, prevents the weed problems seen in the right photo.



Pedestrian traffic should dictate paving to prevent the compacted and weedy area shown in the photo on the left.



Structural landscape elements should be placed in paving, as in the left photo, rather than in turf seen in the right photo.



Minimize joints in paving, especially in low traffic and low maintenance areas. Monolithic (or stamped) paving (as shown in the left photo) can be attractive and produce fewer weeds.



“Camouflage plants” can allow maintenance crews more time to manage weeds without extreme measures. Informal beds, meadows, prairie forbs, and decorative grasses can disguise weeds temporarily to give maintenance crews more time to deal with weeds.



Site Preparation for Weed Reduction

Before planting, prepare the site carefully. Planning and the judicious use of a low toxicity herbicide, as well as some additional labor, can prevent later headaches with weeds.

- Minimize soil disturbance during construction activities.
- Don't allow equipment to be driven through weedy areas and into the new site.
- Eliminate existing weeds on site before they go to seed.

- Irrigate soils to germinate weed seeds, and remove or treat the weeds that emerge. Repeat this process, if possible. This reduces the potential for existing weed seed to sprout later.
- Sheet mulching can be used to cover and kill all kinds of weeds, even weeds like Bermudagrass.

Sheet mulching consists of laying down at least two layers of cardboard directly on top of the weeds or turf that you want to get rid of, lightly wetting the cardboard, and then covering the cardboard with at least 3" of wood chip mulch. This method can also be used as a preventive weed treatment on new construction projects. Vigorous weeds may poke through the sheet mulching in places, but these few can be removed by hand or spot treated with a low toxicity herbicide.

How to Sheet Mulch

(See also the factsheet in Appendix D - Lose Your Lawn: the Bay-Friendly Way, for more sheet mulching tips.)

1. If the weeds at the site are thick and/or tall, mow the area first before proceeding.
2. Lay cardboard down over the weeds, turf, or bare soil in the area.
Corrugated cardboard can be purchased in 250-foot rolls of different widths. Local sources include Monahan Paper in Oakland (510-835-4670) and Paper Mart in Orange, CA:

<http://www.papermart.com/Product%20Pages/Product.aspx?GroupID=4608&SubGroupID=4609#4609>

"Single face regular 'b' flute" corrugated paper holds up well during installation and has a 40% recycled content. There may be other suppliers that carry cardboard with a higher recycled content.

Note that heavier grades of cardboard (for instance, 70# paper) hold up longer.



Single face "b" flute roll

3. Overlap the edges of the cardboard at least 6 to 8 inches.

4. Wet the cardboard and cover with at least 3" of wood chips for maximum weed control.



5. Drip irrigation can be installed on top of the cardboard.



6. Small plants can be planted in holes punched through the cardboard. Larger plants should be planted and mulched around. Mulch around existing plants.



Alternatives to Herbicides for Weed Management

Prevention Methods

Manage weeds before they go to seed. Weed control is easiest when plants are small, but if control at this stage is not possible, remove or mow weeds before they go to seed. This

will help manage current weed populations and reduce the number of weed seeds available to sprout in the future.

Identify and monitor. Identify persistent weeds and problem areas and monitor regularly for weeds that are flowering or about to produce seed. Early detection and flower and seed head removal help contain and control weeds.

Think about how you can redesign the area to prevent weed problems (see the section above, “Designing and Re-designing Landscapes to Avoid Weeds”)

Don’t use plants that are known to be invasive. Understand the plant species you are installing and don’t plant something that will become a headache later. The California Invasive Plant Council (Cal IPC) has information about how not to plant a pest. (<http://www.cal-ipc.org/landscaping/index.php>)

Maintain healthy soil. Weeds like healthy soil too, but to keep desirable plants growing vigorously and outcompeting weeds, you need healthy soil.

- Except for turf, fertilizer is not needed for plants growing in healthy soil.
- In general, native plants do not need fertilizer.
- Try to leave as much plant material on the ground where it falls. Plants temporarily withdraw nutrients from the soil to build new leaves, stems, flowers, etc. When a plant dies and decomposes, or sheds leaves and flowers that decompose, those nutrients are returned to the soil. Soil nutrients are depleted when the plant is harvested and removed from the site or when all the fallen plant debris is removed without being replaced by some other kind of organic matter.
- Add as much organic matter, such as mulch or compost, to your soil as practical, but take care not to pile mulch up around the base of the plant stem or tree trunk. These materials reduce compaction, improve the quality of the soil, and act as fertilizer.

Mulch at optimal times. Mulch in early spring and early fall to match the times when weed seeds are germinating. Maintain a 3” layer of mulch and never pile it around the stems or trunks of plants, especially trees. Keep mulch at least 4” away from the base of the plant or tree trunk.

Minimize the introduction of new weed seeds by monitoring the sources of organic fertilizer and mulch. Make sure that purchased mulch and manure are weed free. Use only manure that has been composted at temperatures high enough to kill weed seeds. Monitor areas that are newly mulched to catch imported weeds before they take over.

Require weed-free seed in specifications and demand weed-free nursery plants. Don’t inadvertently import weeds to your site.

Reduce weed seed germination. Stop problems before they start.

- Increase the mowing height to the maximum recommended for your turf species in order to shade the soil surface.
- In landscapes, use desirable plants to shade out weeds.
- Minimize soil disturbance during planting and maintenance to reduce the number of weed seeds brought to the surface where they can germinate.
- Use mulch to cover bare soil to prevent weeds from coming up.

Minimize the transportation of weed seeds from one site to another. Avoid driving equipment through weedy areas, and clean equipment that has been in weedy areas before using it elsewhere. Clean clothing and tools after working in weedy areas so you don't spread weeds.

Horticultural Methods

Cover the soil. Weed seeds can sense when they are exposed to light, and the light stimulates sprouting. Preventing light from reaching the soil surface will prevent germination. This can be accomplished in a number of ways:

- Mulching—use material such as bark, which is low in nitrogen, to discourage germination. Weed seeds that land on top of the mulch can sprout, but they are easy to remove by hand.
- Paving—consider porous paving that will prevent weeds yet allow water to percolate into the soil, rather than run off into the storm drain.
- Maintaining dense, vigorous plantings to shade out weeds.
- Growing a dense cover crop in unlandscaped areas to reduce weed encroachment.
- Raising mowing heights in turf to allow grass to shade bare spots.
- Regular overseeding of bare spots in turf to fill those spots with grass rather than weeds.

Manage irrigation. Deliver water only to desired areas/plants, not to weeds or areas where weeds could become a problem.

Irrigate deeply and less frequently. If you can lengthen the drying time between irrigations, you will make it more difficult for weed seeds to sprout or survive.

Prevent soil compaction. Consider installing permanent paths in high traffic areas. Ideally, paths should be permeable to allow water to pass through. They can be constructed of

wood chips directly on the soil, wood chips on top of cardboard (sheet mulching), or permeable pavers.

Mechanical Methods

Flame weeding. Flame weeding uses an open flame, usually fueled by propane, to vaporize the water in a plant's cells. Properly used, it kills the plant without setting it on fire. There are some factors to consider when using this method and some limitations to consider. They are as follows:

- Flaming does not kill perennial weeds and grasses, and larger broadleaf weeds usually recover from flaming.
- Flaming is most effective under specific timing conditions. For example, for flaming to be effective against broadleaf weeds, the weeds must be small.
- Flaming takes more time than spraying and may be more expensive.
- Flaming does introduce the risk of fire, and appropriate care must be taken.
- Flaming is a winter tool and can be effective on small plants even in the rain.
- Flaming in mulch is extremely hazardous and not advised because mulch may smolder and ignite later.

As with other weed management techniques, certain equipment is required:

- Torch—many types are available at garden suppliers or on the internet
- Propane canister to fit torch
- Personal fire extinguisher on your belt or live water hose nearby. You may want a five-gallon backpack water supply, such as is used for extinguishing fires in the backcountry. This is called a backpack water pump or fire pump. This could remain in the truck, if the truck is within easy reach of the whole site.



Weed Flamers

Hoeing. Hoeing severs the plant shoot from its root or pulls the entire plant out of the soil. Hoeing for weed control is best done when weeds are small. The seeds of most annual weeds are very small, and when they sprout, they are tiny and fragile. They are easily killed by soil disturbance. Small seeds don't have the reserves of a larger seed and cannot sprout from deep in the soil. Disturbing the soil or turning it over with a hoe can also cause a flush of weed seedlings because weed seeds have been brought to the surface where they can easily germinate.

Stirrup Hoe (or scuffle or hula hoe)

- This kind of hoe runs below the surface of the soil to cut weed shoots from roots.
- The stirrup hoe doesn't disturb the soil as much as a traditional chopping hoe, which can bring up too many weed seeds to the soil surface.
- Stirrup hoeing should be done shallowly—only around 1" deep—in order not to disturb the soil.
- It is best used when the soil is slightly dry and the weather is warm and dry. This will hasten the death of any uprooted plants.



Stirrup Hoe (Scuffle Hoe)

Brush "hoe" for cracks in paving

These can be very effective for removing weeds in paving. Some motor-driven brushes can also be used as edgers.



Manual Long-handled Weed Brush



Motor-driven Weed Brush (Kersten WeedBrush®)

Mowing. Mowing removes the tops of plants, and is very effective for preventing the dispersal of weed seeds if timed properly.

- Timing is important. Mowing is best used before weeds set seed, but not so early that the plant will grow back and have to be mowed several times.
- Many weeds cannot survive the frequent mowing that manicured turf requires, but grass should be mowed as high as practical to shade the soil and prevent weed germination. Scalping a lawn opens areas to enough light to allow germination.
- Mowing low-maintenance areas before weeds set seed can reduce the amount of seed that might be blown or carried to other nearby sites. If you must mow a weedy area where the plants are going to seed, thoroughly clean the mower before moving to less weedy sites.
- Weed whips or string trimmers are another form of mowing. Using a weed whip on weeds that are going to seed will scatter the seeds and increase your problems. Seed heads should be cut and bagged before weed whipping.

Hand Removal. Hand removal is very effective and can be quick for small infestations.

- It is easiest to accomplish when weeds are young and soil is moist.
- Weeds growing in mulch are easy to remove by hand.
- As with all weeding, plants should be removed before they go to seed. If the plants have seeds, remove them carefully, bag them, and dispose of the bag.
- Weeds should be dug out by the roots. If just the tops are removed, most weeds will regrow.



Hori hori for digging weeds



Using a hori hori to dig out bristly oxtongue

Biological Methods

Grazing with Livestock. The only biological control method that is practical and readily available for landscape maintenance personnel is grazing with goats, or perhaps sheep.

Grazing is not selective. Animals will eat most anything, and desired plants must be protected with fencing.

- Grazing is generally used in less urbanized areas, along creeks, and sometimes along road rights-of-way to manage for fire or flood danger. Grazing is also used to clear brush, like blackberries or poison oak, or to remove invasive weeds such as pampas grass and thistles.
- The cost of grazing with goats is very site-specific.
 - The cost of loading and unloading the goats is fixed, so small areas can cost more than large ones.
 - Costs can vary depending on
 - Ease of access for the goats
 - Availability of water—if water must be trucked in for the goats, costs rise
 - Security of the site—as the amount of fencing increases, costs rise; if fencing must be erected and taken down a number of times, costs increase
 - Season of the year—demand for grazing peaks in late spring through summer, and it can cost more to use goats during those times than in fall or winter
- Goats can be useful where it is dangerous for humans to work (e.g., steep and/or rocky areas) and in sensitive sites where endangered or threatened animal species must not be disturbed. Note that grazing animals may not be appropriate if endangered or threatened plants exist in the area. As mentioned above, you must exclude the grazing animals with fencing from any plants you want to protect.
- Contra Costa County Public Works has a number of years of experience using grazing for vegetation management and would be happy to provide help to municipalities. Call Tanya Drlik, Contra Costa County IPM Coordinator, at 925-335-3214 to get in touch with the most experienced County staff.

Managing Specific Weeds

The UC Statewide IPM Program (<http://www.ipm.ucdavis.edu/>) has a wealth of information on managing many different pests, including specific information on many landscape weeds

(<http://www.ipm.ucdavis.edu/PMG/menu.homegarden.html>). In addition, the section on Natural Environment Pests (<http://www.ipm.ucdavis.edu/NATURAL/index.html>) includes information on managing particular invasive weeds (scroll down on the webpage to find the list of invasive weeds).

Another excellent resource for managing invasive weeds is *Weed Control in Natural Areas* available from the UC Weed Research and Information Center (WRIC). You can find the book under “Publications” on the WRIC Web site (<http://wric.ucdavis.edu/>) along with other books and much more information about managing weeds, including a weed identification tool.

The California Invasive Plant Council (<http://www.cal-ipc.org/>) has a great deal of information about invasive plants including some management information.

For your convenience, Appendix B includes copies of the UC Statewide IPM Program Pest Notes for some of the weeds commonly found in Contra Costa County landscapes. The sources for weed factsheets not from the UC Statewide IPM Program are identified below in parentheses.

- Annual Bluegrass
- Arundo or Giant Reed (from *Weed Control in Natural Areas*)
- Blackberries
- Bristly Oxtongue (from *Weed Control in Natural Areas*)
- Brooms
- Cape Ivy (from *Weed Control in Natural Areas*)
- Clover
- Crabgrass
- Dallisgrass
- Dandelions
- Fennel (from *Weed Control in Natural Areas*)
- Field Bindweed
- Fennel
- Nutsedge
- Oxalis (from *Weed Control in Natural Areas*)
- Poison Oak
- Spurges
- Yellow Starthistle

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CHAPTER 3: Guidance for Managing Structural Pests Using IPM

Structural Pest Management

Structural pests are pests that are found inside a building, directly around the outside of a building, or that can invade buildings. Some pests can be managed by municipal staff, and others are best managed by professionals.

Pests that can be managed by municipal staff and/or a structural pest control company include the following:

- Ants
- Cockroaches
- Spiders
- Flies
- Rats
- Mice
- Pigeons

Pests that are best managed by professionals include the following:

- Bees
 - To remove a swarm or hive within a wall, call a structural pest control company.
 - To relocate a swarm, contact the Mount Diablo Beekeepers Association at (925) 458-3900 (<http://www.diablobees.org/swarmlist/>).
- Yellowjackets
- Bed bugs
- Large rat infestations
- Large numbers of pigeons

- Wood-destroying organisms, such as termites, wood boring beetles, and wood rot (Note: to manage these organisms, a pest control company must have a Branch 3 license in addition to the Branch 2 license that is needed for the pests mentioned above.)

The Contra Costa County Mosquito and Vector Control District can assist municipalities with the following pests:

- Rats and mice
- Skunks
- Yellowjackets that are nesting in the ground: if you can find and mark the location of the nest, the District will remove it for you.

Contra Costa Mosquito and Vector Control District 155
Mason Cir
Concord, CA 94520
(925) 685-9301

To submit an online service request:

http://contracostamosquito.com/service_request.htm

For fact sheets and guidance on how to handle the pests mentioned above, see Appendix C.

Keys to Successfully Managing Structural Pests

To survive, pests need food, water, and a place to shelter and reproduce.



Food



Water



Habitat

To get into a structure, they need access in the form of holes, gaps, cracks, open doors, etc.



Hole and gap in a wall that will allow insects and rodents to move into, out of, and around a building



Gaps under and between double doors through which rodents and insects can easily pass

If even one of these factors can be reduced or eliminated, the environment will support fewer pests. Diligent food sanitation practices, along with building repair and maintenance focused on closing pest access points, are the keys to successful structural pest management. These are all things the municipality must do in-house.

Contracting with a Structural Pest Management Service Provider (Exterminator)

IPM Certification

Note that Provision C.9 of both municipal stormwater permits for Contra Costa County localities requires that the pest management service provider be IPM certified or that the contract include specific IPM language.

The existing IPM certification programs in the U.S. are the following:



EcoWise Certified—an independent 3rd party certification program

<http://www.ecowisecertified.org/>



GreenShield Certified—an independent 3rd party certification program

<http://www.greenshieldcertified.org/>



GreenPro—an industry certification program

<http://www.npmagreenpro.com/>

IPM Contract Language

If you do not hire an IPM certified company you must include IPM language in your contract. For sample structural IPM contract language, see Appendix A.

Communication with the Pest Management Service Provider

You must have a defined pathway for complaints about pests in buildings to reach the pest management service provider.

- Ideally only one or two people at each building or site should be responsible for collecting complaints about pests.
- The complaints should be relayed to one municipal staff person (or two, at most) who is responsible for contacting the service provider. This will help avoid confusion.
 - This person must understand the contract with the service provider.
 - Ideally, the person should screen the complaints to decide if they should go to the service provider for immediate service or if they can wait until the regularly scheduled service for the building. Depending on your contract, you may have to pay extra for immediate service.
 - In the beginning, staff may not have the skill or experience to effectively screen complaints, but they can always consult with the service provider.

Checklist for the Pest Management Service Provider's Initial Site Visit

The company you have hired should perform an initial site visit at each one of the buildings they will be servicing. This visit should include the following:

- An introduction to the person or persons responsible for complaints about pests in the building, with a discussion about how the company's service will work; make sure everyone is clear about how to report a complaint.
- A thorough inspection of the site to
 - Understand the pest management history at the site
 - Determine any conditions in the building that might lead to pest problems/invasions. At a minimum, the following should be inspected:
 - Food preparation/storage areas
 - Lunch/break rooms
 - Public waiting areas

- Utility rooms/janitors' closets
- Waste handling areas/bins/compactors/garbage chutes
- Entry and exit doorways
- Outdoor storage areas
- A written report on pest conducive conditions at each building that should be remedied either by the municipality or the service provider
- A written report stating the regular service schedule for each building
 - Service frequency will vary with each building: buildings with food preparation facilities may need to be inspected every week while an office building with good sanitation may need only a quarterly visit or may be serviced on an "on call" basis.

Choosing Pesticides to Use on Municipal Property

- You may wish to include text such as the following in your purchase order or contract with the pest control service provider:

It is the [Municipality's] policy to follow an integrated pest management approach and to give preference to prevention and to non-pesticide solutions whenever and wherever possible. When chemical controls are deemed necessary, [Service Provider] will, as a general rule, use least-toxic pesticides, such as soap and water, plant oils and extracts, and low toxic insect baits. The least amount of pesticide needed to achieve the desired result will be applied in the most precise manner available.

- To help you with choosing less hazardous pesticides appropriate for use in structural pest management, use the following resources:
 - EcoWise Certified Pesticide Criteria with Examples: http://ecowisecertified.org/ecowise_about_who.html (Click on the link marked "Materials Criteria/Examples"
 - City of San Francisco Reduced Risk Pesticide List: <http://www.sfapproved.org/pest-control-for-city#list>
 - Be sure to check Provision C.9 of either the MRP or the East County Permit for pesticides that the respective Regional Water Boards consider problematic.
 - See Appendix E for an example of a list of pesticides for municipal buildings.

Choosing Pesticides for LEED Certified Buildings



The following language should be inserted in your pest management contract if you have any LEED Certified buildings in your municipality:

Pesticides applied in the [Municipality's] LEED Certified buildings are restricted to the following: any pesticide product where all active ingredients and known inert ingredients meet Tier III of San Francisco's hazard criteria.

For The City of San Francisco's Reduced Risk Pesticide List, visit <http://www.sfapproved.org/pest-control-for-city#list>

See Appendix E for an example of a list of pesticides for LEED Certified buildings.

Hiring a Structural Pest Management Service Provider for Occasional or Unusual Problems

This can be handled in different ways, but it is important to be as specific as you can about what you want from the service provider. Frequently people use "pest control" as the scope of work; however, pest control is the outcome of some kind of treatment by the pest management service provider, not a scope of work. A general scope of work that could cover an IPM approach for most pest problems would include the following:

1. A thorough inspection of the area where the problem has been found, along with a written report of the inspection that includes identification of the pest
2. A consultation on the options available for remedying the situation; the options must include non-chemical strategies, if they are available and appropriate, and less hazardous chemical strategies, if they are necessary. For example, non-chemical strategies include:
 - a. Doing nothing
 - b. Providing education to building occupants and/or the public
 - c. Sanitation measures
 - d. Pest proofing and building repair
 - e. Physical controls such as vacuuming, trapping, erecting barriers, altering temperature and humidity

- f. Cultural controls such as instituting policies that will result in reducing the availability of food, water, and harborage for pests; altering landscape maintenance practices that create conducive conditions for pests
3. An estimate of the costs for each option
4. Implementation of the selected options for the target pest, after consultation with the municipality
5. Recommendations for follow-up actions for the municipality or the company
6. Recommendations for preventive measures the municipality can employ
7. Recommendations for pest monitoring activities to be carried out by either the municipality or the company

Hiring a Pest Management Service Provider by the Hour

Hiring a service provider by the hour is one way to get occasional service when you have a problem that municipal staff cannot handle. Be sure to convey to the company that you want the seven points mentioned above to be covered in their service.

Establishing a Preferred Vendor Contract with a Pest Control Company

Establishing a preferred vendor contract is more involved and will take more initial work by municipal staff, but you may receive a better price and higher quality service. This approach may be more appropriate for a larger city that might have more problems needing the attention of a professional.

The municipality would develop a request for proposal (RFP) that includes some specific scopes of work for various pests (the factsheets in Appendix C could help in developing the scopes) and send it out to a number of pest control companies asking them to bid on and to improve the scopes of work.

This encourages competition and allows the municipality to improve their scopes of work.

The company that wins the bid would become a “Preferred Vendor” and would develop a relationship with the municipality but would not be guaranteed any work.

Important Information for Municipal Staff Who Handle Structural Pest Management

Legal Issues

- Municipal staff do not need a license to apply general use pesticides (as opposed to “restricted use” pesticides) on land or in buildings that the municipality owns or controls, but staff must have yearly, documented pesticide safety training. The County Department of Agriculture regularly inspects municipal safety training records.
- The municipality must report their pesticide use electronically to the County Department of Agriculture monthly.
- When municipal staff use pesticides on parks, rights-of-way (such as roadsides and medians), golf courses, or cemeteries, the municipality must have a written recommendation from a licensed Pest Control Advisor.

Training Requirements for Municipal Staff Who Apply Pesticides

1. Staff must attend pesticide safety training at least yearly and must be trained on all pesticides they might apply using the labels and MSDSs for each pesticide.
2. The municipality must have a written training program. For a pesticide safety Training agenda that is acceptable to the County Agricultural Commissioner, see <http://www.co.contra-costa.ca.us/2206/Pesticide-Regulation> and click on “Safety Training.” This form can be used as your municipality’s written training program.
3. The training must cover the California Department of Pesticide Regulation Pesticide Safety N Series, Numbers 1, 2, 4, 5, 7, and 8. (See: <http://www.cdpr.ca.gov/docs/whs/psisenglish.htm>)
4. Each staff person’s training must be documented, and a copy must be kept in their personnel files for at least two years. For a training record form that is acceptable to the County Agricultural Commissioner, see <http://www.co.contra-costa.ca.us/2206/Pesticide-Regulation> and click on “Training Records”.

For questions about pesticide safety training, call the County Department of Agriculture in Concord at 925-646-5250.

Common Pests that Municipal Staff Can Most Likely Handle on Their Own

- Rats and Mice
- Ants
- Cockroaches
- Spiders

A new mobile app allows you to turn your smart phone or other mobile device into a mobile field guide to help you identify urban pests. The three-volume iPest series from the University of Florida Extension is designed for anyone dealing with urban pests, including pest management professionals and building managers. The app provides photographs of pests (mostly insects), indicates identifying features, and provides a brief summary of biology and behavior.

For more information see <http://entomology.ifas.ufl.edu/baldwin/webbugs/ipest.htm>

APPENDIX A: Sample IPM Contract Language

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APPENDIX A1

Model Language for a Landscape IPM Contract¹

Contract Specifications for [City or Town] of [Name of Municipality]'s Landscape Integrated Pest Management (IPM) Program

The goal of the [City or Town] of [Name of Municipality]'s IPM Program is to reduce the amount and toxicity of pesticides used on [City or Town] property in order to protect water quality and human health and to avoid ecotoxicity. Preferred pest management techniques include an emphasis on pest prevention, which includes growing healthy plants in healthy soil; regular monitoring of landscaped areas to catch problems early; encouraging naturally occurring biological controls; using alternative plant species or varieties that resist pests; using cultivation, pruning, fertilization, and irrigation practices that reduce pest problems; and altering pest habitat and landscape design to reduce pest development (among other strategies). Pesticides will be used to prevent or control damaging pests only when necessary and will be selected and applied in a manner to minimize risks to humans, non-target organisms, and water sources, including stormwater.

- A. Within 45 days and annually on the anniversary of this agreement, the Contractor shall submit to the [City's or Town's _____ Division] an IPM Plan that complies with the [City or Town] of [Name of Municipality]'s IPM Policy. The IPM Plan will include a list of the pesticides that the Contractor proposes to use on municipal property, should the need arise. Authorization of all potential products to be used by the Contractor will be completed by municipal staff before service commences. The IPM Plan shall be reviewed annually for updates and modifications with [_____ Division] Staff. Frequent and thorough site inspections, on foot, will be needed to ensure no major infestations occur. [_____ Division] staff will provide site-specific historical data for known infestations. Contractor shall provide a label and a Material Safety Data Sheet (MSDS) for any chemical that will be used.
- B. No pesticides of any kind will be used on designated Pesticide-Free Parks. The IPM Coordinator will provide a list of pesticide-free parks.

¹ The Contra Costa Clean Water Program would like to acknowledge that the language provided here was adapted from the Palo Alto Parks IPM Contract Language.

- C. Pest control shall be performed only by qualified, trained personnel, under the supervision of a State licensed professional, using materials approved by municipal staff. Any pesticide shall be applied with extreme care to avoid any property damage and any hazards to people, pets, wildlife, or water sources in the area or adjacent areas. Application shall be in strict accordance with all governing regulations. The Contractor must provide, within 30 days of the Notice to Proceed, their Maintenance Gardener Pest Control Business License from the California Department of Pesticide Regulation, and the names and license/certification numbers of any individuals responsible for supervising pesticide applications or applying pesticides in accordance with this agreement. Bay Friendly landscaping Certification is highly desirable for all personnel who will work on municipal property.
- D. All pest infestations shall be reported to the [Insert title of municipal staff person]. Records of all pest control operations stating dates, locations, times, methods of application, chemical formulations, applicators' names, and weather conditions shall be made and retained in an active file for a minimum of three (3) years.
- E. A written report of all applications shall be provided to the [_____ Division] on a monthly basis. The Contractor must use a form created by [City or Town] of [Name of Municipality] municipal staff. It is also the responsibility of the Contractor to file monthly chemical use reports with the County Agriculture Department.
- F. All chemicals requiring a special permit for use must be registered with the County Agricultural Commissioner's Office and a permit obtained with a copy to the [_____ Division].
- G. All regulations and safety precautions listed in the "Pesticide Information and Safety Manual," published by the University of California and the Pesticide Safety Information Series (PSIS) published by the California Department of Pesticide Regulation shall be adhered to.
- H. Spraying is not permitted during heavy traffic (vehicle, bicycle, or pedestrian) periods or when winds create uncontrollable material drift.
- I. Pesticides may not be used within 250 feet of any playground area or creek.
- J. Temporary notice shall be posted during and after a site has been sprayed. All areas sprayed shall be flagged and signed.
- K. Contractor agrees to control gophers, squirrels, moles and other rodents causing damage to [City or Town] Property included in this contract. Traps are the only acceptable form of rodent control. Rodenticides for gophers, ground squirrels, or other rodents may not be used. In the event of visible evidence of such pests,

contractor will restore the area to its proper condition if the damage is current and prevention is within the contractor's control.

L. Contractor shall replace any plant material that has suffered severely due to lack of proper pest management techniques, if such pest control is possible and practicable.

M. All treated areas must be monitored during and after pesticide application until material has settled and treatment area is completely dry. No unprotected person, pet, or wildlife may enter a treated area until all re-entry intervals have been satisfied.

N. Weeding

All areas, including but not limited to: shrub beds, flower beds, groundcover beds, tree wells, paved areas, sidewalks, cracks, stairways, pavers, expansion joints, decomposed granite paths, picnic areas, playgrounds, under bleachers/benches, must be kept weed free at all times. Weeds shall be removed whenever the appearance becomes unsightly or when requested to do so by [_____ Division] staff.

O. Staking and Guying

Maintain and replace stakes and guys with equal material. Maintain and replace plant ties to provide support without chafing of bark. Additional stakes and/or guys shall be placed from time to time to correct misshaping caused by wind. Stakes and guys shall be removed upon request of [Insert title of Municipal Staff person].

P. Fertilization

Fertilizers shall not contain pesticides. The Contractor shall fertilize shrub, ground cover, and planter bed areas as needed, taking into consideration that the [City or Town] of [Name of Municipality] wants to avoid the excess plant growth that contributes to increased maintenance needs and green waste. The Contractor shall fertilize trees as requested.

Q. Nurturing Soil Health

Leaf drop shall become part of the mulch layer in the tree, shrub, or groundcover areas in an attractive manner and away from high traffic areas. Leaf drop shall not be allowed to enter storm drains.

Mulch shall be maintained under all trees and shrubs and on bare soil with a minimum 3-inch layer of organic material that is no closer than 4 to 6 inches from the base of any plant. To the greatest extent practicable, the Contractor shall not procure mulch products that originate from forest products. When possible, the Contractor shall give preference to mulch products that are produced on-site or from regionally generated plant debris including that made at the [City or Town] of [Name of Municipality].

R. Replacement of Material

Remove dead and damaged plants and replace with material of equivalent condition and variety and of appropriate size, subject to approval of the [Insert Title of Municipal Staff]. Labor shall be provided by the Contractor in a timely manner. Plant material shall be provided by the [_____ Division] unless damage is caused by Contractor's negligence (i.e. chemical damage, mechanical damage, water stress).

Damage not resulting from Contractor's negligence, such as vandalism, vehicle, or weather shall be reported promptly to the [Insert Title of Municipal Staff] together with an estimate of materials needed for correction. The [City or Town] will provide all necessary materials. Labor shall be provided by the Contractor in a timely manner.

Prior to beginning maintenance, the Contractor and the [City or Town] of [Name of Municipality]'s IPM Coordinator shall inspect and inventory all plants, trees, and shrubs to determine their number and condition.

APPENDIX A2

Model Language for a Structural IPM Contract

Contract Specifications for [City or Town] of [Name of Municipality]'s Structural Integrated Pest Management (IPM) Program

1. Premises Covered by These Specifications

See Attachment A

2. General

A. Description of Program: This contract will be part of a comprehensive IPM Program for the premises listed herein. IPM is a decision-making process for achieving long-term, cost-effective, and environmentally sound pest suppression and prevention. Pest populations are kept low enough to prevent intolerable damage or nuisance. IPM employs a wide variety of technological and management practices, including the following:

- Structural and procedural modifications to reduce food, water, harborage, and access used by pests;
- Other non-pesticide strategies such as monitoring for pest presence and trapping for pest management;
- Pesticide compounds, formulations, and application methods that present the lowest potential hazard to humans, non-target organisms, and the environment; and
- Coordination among all facilities management programs that have a bearing on the pest control effort.

B. IPM Service Requirements:

- The Contractor shall furnish all supervision, labor, materials, tools, and equipment necessary to accomplish the monitoring, trapping, pesticide application, and pest removal components of the IPM program.

- The Contractor shall provide to the building location contact and the Facilities Manager written, detailed, site-specific recommendations for structural and procedural modifications to aid in pest prevention as soon as the conditions are identified. In addition, the Contractor will provide a prioritized monthly summary report of all recommendations for structural and procedural modifications that the [City or Town] of [Name of Municipality] has not implemented yet to the Facilities Manager and the IPM Coordinator.
 - The Contractor shall report to the building location contact, the Facilities Manager, and the IPM Coordinator any evidence or conditions conducive to pest infestation that is not covered in the contract, at the time such condition is first noticed.
- C. Contractor Responsibilities:
- The Contractor shall be responsible for the implementation of the pest control program required by this contract and for fully complying with the applicable federal, State, and local pesticide laws and regulations within the legal jurisdiction that the premises covered by this contract are located.
 - **[You can note here any meetings the Contractor is required to attend regularly, and any other responsibilities.]**
- D. Contractor IPM Certification: The Contractor must maintain IPM certification by EcoWise Certified (www.ecowisecertified.org), Green Shield Certified (www.greenshieldcertified.org), *OR* GreenPro (www.npmagreenpro.org). If the Contractor is using GreenPro certification, the branch office that will provide the [City or Town] of [Name of Municipality] pest control services must be specifically certified and must either have gone through a field audit or be preparing to go through a field audit. The Contractor must submit written verification of this from GreenPro.
- E. Contractor Personnel: The Contractor is responsible for providing personnel who have been trained and certified by the State of California to handle and apply the classes of pesticide products necessary to implement the pest control program required by this contract. Contractor shall hold a valid California Branch II Operator's License. The Contractor shall provide only qualified pest management personnel with experience in the conduct of IPM programs.
- *IPM Service Technicians:* Technicians shall hold California Branch II Field Representative's Licenses and have at least five (5) years' experience prior to assignment on municipal property. The [City or Town] of [Name of Municipality]'s preference is for a single primary technician to handle the service. The Contractor can name an alternate to provide service when the primary technician is ill or on vacation, and another technician to provide after-hours and weekend services.

- *Contract Supervisor*: A supervisor and an alternate must be identified in the service. The supervisor must have the Contractor's authority to act on matters pertaining to the performance of services required under the contract. This individual shall assure safety and carry out coordination and continuity of the program routine. The supervisor and alternate shall both have a working knowledge of this contract, the detailed Pest Management Plan, and the schedule for each site. The supervisor and alternate must both meet, at a minimum, the qualifications identified under "IPM Service Technicians".

3. Pests Included and Excluded

A. The Contractor shall adequately suppress the following pests:

- Indoor populations of rodents, insects, arachnids, and other arthropods;
- Outdoor populations of potentially indoor-infesting species that are within the property boundaries of the specified buildings and that are invading the structure or are very likely to invade;
- Nests of stinging insects within the property boundaries of the specified buildings; and
- Individuals of all excluded pest populations that are incidental invaders inside the specified buildings, including winged termite swarmers emerging indoors.

B. The following vertebrate pests that require special service are included in the contract:

- Birds, bats, snakes, and all other vertebrates.

Cost for service for these pests will be estimated by the Contractor when any of these pests is found invading Municipal facilities.

C. Populations of the Following Pests are Excluded from this Contract:

- Termites and other wood-destroying organisms;
- Mosquitoes; and
- Pests that primarily feed on outdoor vegetation.

4. Initial Building Inspections

The Contractor shall complete a thorough, initial inspection of each building or site (see Attachment A for complete list of buildings included in the contract) by [DATE] which is 20 days prior to the starting date of the contract. The purpose of the initial inspections is for the following to occur:

- A. The Contractor to evaluate the pest control needs of all locations;
- B. The Contractor to identify problem areas and any equipment, structural features, structural deficiencies, personnel practices, or management practices that are contributing or may contribute to pest infestations;
- C. The Municipality and the Contractor to determine the frequency for servicing each site;
- D. The Municipality and the Contractor to discuss facilitation of Contractor access to all necessary areas of the facility or site;
- E. The Municipality to inform the Contractor of any sites that require after-hours or weekend service;
- F. The Municipality to inform the Contractor of any sensitive areas at each facility that have particular restrictions, and inform the Contractor of areas that require special safety precautions in order to service the facility; and
- G. The Contractor to provide the name(s), qualifications (at least Branch II Field Representative License with 5 years experience), and cell phone number(s) of the technician(s) who will provide service to the Municipality.

5. IPM Plan

The Contractor shall submit to the IPM Coordinator and the Facilities Manager, for approval, a Pest Management Plan for the [City or Town] of [Name of Municipality] Structural IPM Program no later than sixty (60) days after the completion of the initial site inspections. Upon receipt of the Pest Management Plan, the [City or Town] will render a decision regarding its acceptability within five (5) working days. If aspects of the Pest Management Plan are incomplete or disapproved, the Contractor shall have five (5) working days to submit revisions.

The Contractor shall be responsible for carrying out work according to the approved Pest Management Plan. The Contractor shall receive the concurrence of the IPM Coordinator and the Facilities Manager prior to implementing any subsequent changes to the approved Pest Management Plan, including additional or replacement pesticides and changes to on-site service personnel.

The Pest Management Plan is one (1) document covering all municipal buildings and shall consist of five parts, as follows:

- A. *Proposed Methods for Monitoring and Detection:* The Contractor shall describe methods and procedures to be used for identifying sites of pest harborage and access, and for making objective assessments of pest population levels throughout the term of the contract.
- B. *Standard Operating Procedures for Non-Chemical and Chemical Pest Control Methods for Key Pests:* The Contractor shall include in the Pest Management Plan the [City or Town] of [Name of Municipality]'s standard operating procedures (SOPs) for the major pests encountered in and around structures. If the Contractor wishes to alter aspects of the SOPs, this must be discussed with and approved by the IPM Coordinator.

In addition:

- On Attachment B, Pest Control Equipment List, the Contractor shall provide an electronic list of the brand names and methods of use for pesticide application equipment, rodent bait stations, insect and rodent trapping devices, pest monitoring devices, pest detection equipment and any other pest control devices or equipment that may be used to provide service.
- On Attachment C, Proposed Pest Control Materials list, the Contractor shall provide an electronic list of the brand names, active ingredients, and method of use for all pesticides the Contractor proposes to use.

The Contractor shall also supply current labels and Material Safety Data Sheets (MSDS) for each pesticide listed.

Authorization of all potential products to be used by the Contractor will be conducted before service commences.

- C. *Service Schedule for Each Building or Site:* The Contractor shall provide complete service schedules that include the frequency of Contractor visits, specific day(s) of the week for Contractor visits, and approximate duration of each visit. The [City or Town] of [Name of Municipality] shall inform the Contractor of sites that require servicing to be performed when the building or area is vacated after regular working hours or on weekends.
- D. *Description of any Structural or Operational Changes that would Facilitate the Pest Control Effort:* The contractor shall provide a written document describing site-specific solutions for all initial observed sources of pest food, water, harborage, and access.
- E. *Name and Contact Information for Pest Control Technicians Who Will Provide Service for Each Site:* The Contractor shall provide the name(s), and cell phone number(s) of the technician(s) who will provide service to specific sites.

6. Record Keeping and Reporting

- A. **On-Site Pest Control Notebook:** The Contractor shall be responsible for maintaining a pest control notebook or file for each building or site specified in this contract. These records shall be kept on-site and maintained on each visit by the Contractor. Each notebook or file shall contain at least the following items:
- *Pest Management Plan:* A copy of the Contractor's approved Pest Management Plan for municipal buildings, including
 - Contractor's Pest Control Equipment List and the Pest Control Materials List that has been approved by the municipality;
 - Labels and MSDS for all pesticides on the Pest Control Materials List; and
 - Contractor's service schedule for the building.
- B. *Copies of Service Tickets:* A clearly legible copy of each service ticket, signed and dated by an appointed building location contact, documenting
- Identification of pest(s) found;
 - Location(s) of infestations;
 - All actions taken at the site, including
 - The number and type of non-chemical pest control methods/devices employed; and
 - The brand name, active ingredient(s), EPA Registration Number, locations, and amount of formulation of any pesticide applied; and
 - Any site-specific recommendations for structural and procedural modifications or sanitation measures to aid in pest prevention.
- C. **Pesticide and Pest Control Device Reporting:** The Contractor shall provide the IPM Coordinator with a monthly summary of pesticides and pest control devices that were used. This information shall be recorded by building and date on a form that will be provided to the Contractor when the contract is awarded. The form must be emailed to the IPM Coordinator at [Email Address] by the 15th of each month for the previous month's work, or as otherwise approved by the IPM Coordinator.

7. Posting for Pesticide Use

The Contractor shall be responsible for following the [The City or Town] of [Name of Municipality]'s Pesticide Use Posting and Notification Policy (see Attachment D).

8. Manner and Time to Conduct Service

A. Time Frame of Service Visits:

- *Routine Services:* The Contractor shall perform routine pest control services that do not adversely affect building occupants' health or productivity during the regular hours of operation in buildings.
- *After Hours Services:* As mentioned above in 4.E, there may be sites that require servicing to be performed when the building or area is vacated after regular working hours or on weekends. These service days and times will be noted in the Pest Management Plan, and there will be no additional charge for this service.
- *Work Outside of Regularly Scheduled Service:* When it is necessary to perform work outside of the regularly scheduled service time set forth in the Pest Management Plan, the Contractor shall notify the Facilities Manager and the IPM Coordinator at least one (1) day in advance.

B. Call Back Service: The Contractor shall provide all call back services at no additional charge to the [City or Town] of [Name of Municipality]. The [City or Town] will request call back service when previous treatment fails to control the pests specified herein. Service work shall be guaranteed WITH CALL BACKS, AS REQUIRED.

C. Safety and Health: The Contractor shall observe all safety precautions throughout the performance of this contract. All work shall be in strict accordance with all applicable federal, State, and local safety and health requirements. Where there is a conflict between applicable regulations, the most stringent shall apply.

The Contractor shall assume full responsibility and liability for compliance with all applicable regulations pertaining to the health and safety of personnel during the execution of work.

D. Restricted Access: Some areas of the [City or Town] of [Name of Municipality] will have limited access due to security and may require background investigations. Therefore, a schedule for a day and time must be approved by the site coordinator for EACH location receiving service. Once implemented, *no deviation will be accepted without the prior approval of the site coordinator* for the specified location. The Contractor shall adhere to these restrictions and incorporate them into the Pest Management Plan.

E. Uniforms and Protective Clothing: All Contractor personnel working in or around buildings specified in this contract shall wear distinctive uniform clothing. The Contractor shall determine the need for and provide any personal protective items required for the safe performance of work. Protective clothing, equipment, and

devices shall, at a minimum, conform to U.S. Occupational Safety and Health Administration (OSHA) standards for the products being used.

- F. Vehicles: Vehicles used by the Contractor must be clearly marked with the Contractor's name.

9. Special Requests and Emergency Service

On occasion, the [City or Town] of [Name of Municipality] may request that the Contractor perform corrective, special, or emergency service(s) that are beyond routine service requests. The Contractor shall respond to these exceptional circumstances and complete the emergency work within three (3) hours after receipt of the request. Other special services will be provided within a time frame negotiated by the [City or Town] with the Contractor. All special and emergency services shall be recorded on a service ticket to be filed at the site and with the Facilities Manager.

10. General Non-Chemical Control Methods

- A. Preferred Methods: Monitoring, preventive pest exclusion, habitat modification, and sanitation are the preferred methods of preventing and controlling an infestation and shall be part of the routine pest control service. Throughout the term of this contract, the Contractor shall be responsible for providing recommendations to the Facilities Manager and the IPM Coordinator about any structural, sanitary, or procedural modifications that would reduce pest food, water, harborage, or access. If the [City or Town] of [Name of Municipality] does not provide the repairs or sanitation that are designated as its responsibility, the Contractor will not be held responsible for the continuation of the pest problems associated with those lack of repairs or sanitation; however, the Contractor will still be responsible for management of those pest problems.
- B. Written Recommendations for Repairs or Procedural Modifications: Recommendations that require immediate attention should be conveyed via email to the Facilities Manager and the IPM Coordinator. Other, less urgent recommendations should be included in the monthly report to the Facilities Manager and the IPM Coordinator. Recommendations in the monthly report should be prioritized by their relative impact on pest prevention or control.
- C. Building Occupant Cooperation: The Contractor is to actively educate and seek the cooperation of the building management and building occupants to help prevent and reduce pest populations in and around structures. In cases where the Contractor deems such cooperation inadequate to successfully manage pests using IPM principles, the Contractor will notify the Facilities Manager and IPM Coordinator in a timely fashion.

- D. Pest Exclusion: The Contractor may make limited applications of approved sealants and other exclusion materials under sinks, around cabinets, pipe chases, windows and doors, exterior areas, etc., in lieu of or to augment other pest control methods, with approval from the Facilities Manager.
- E. Written Recommendations for Large-Scale Pest Exclusion: The Contractor must be proactive in identifying and, in some cases, correcting known or suspected problem areas that provide food, water, harborage, and access for pests in and around the building. The Contractor shall make written recommendations with photos illustrating the issues to the Facilities Manager for large-scale repairs or applications of sealants and exclusion materials (e.g., whole room or extensive exterior applications, or estimated completion time of thirty (30) minutes or more).
- F. Physical Control Methods: The use of vacuum cleaners, mechanical traps, insect light traps, and glue traps should be fully integrated into the day-to-day operations of the pest control program.

11. Use of Pesticides

The Contractor shall be responsible for application of pesticides according to the label. All pesticides used by the Contractor must be registered with the U.S. Environmental Protection Agency (EPA) and the State of California. Transport, handling, and use of all pesticides shall be in strict accordance with the manufacturer's label instructions and all applicable federal, State, and local laws and regulations.

The Contractor shall adhere to the following rules for pesticide use:

- A. Approved Products: The Contractor shall not apply any pesticide product that has not been included in the approved IPM Plan or approved in writing by the IPM Coordinator.
- B. Pesticide Storage: The Contractor shall not store any pesticide product in a municipal building.
- C. Application by Need: Pesticide application shall be according to need and not by schedule. As a general rule, application of pesticides in any inside or outside area shall not occur unless visual inspection or monitoring devices indicate the presence of pests in that specific area. Requests for preventive pesticide treatments in areas where monitoring indicates a potential insect or rodent infestation will be evaluated by the IPM Coordinator on a case-by-case basis. Written approval must be granted by the IPM Coordinator prior to any preventive pesticide application.
- D. Minimization of Risk: When pesticide use is necessary, the Contractor shall employ the least hazardous material, most precise application technique, and minimum quantity of pesticide necessary to achieve control.

- E. Pesticide Posting Policy: The Contractor shall adhere to the [City or Town] of [Name of Municipality]'s Pesticide Use Posting and Notification Policy (Attachment D).

12. Insect Control

- A. Emphasis on Non-Chemical Methods: The Contractor shall use non-chemical methods of control wherever possible. For example:
- Portable vacuums, rather than pesticide sprays, shall be the standard method for initial cleanouts of cockroach infestations, for removal of ant trails and swarming termites, and for control of spiders in webs.
 - Sanitation, physical barriers (e.g., screens, air curtains), and trapping devices, rather than pesticide sprays, shall be the standard method for indoor fly control.
- B. Application of Insecticides to Cracks and Crevices and Wall Voids: As a general rule, the Contractor shall apply all insecticides as "crack and crevice" or wall void treatments only, defined in this contract as treatments in which the formulated insecticide is not visible to a bystander during or after the application process.
- C. Insecticide Bait Formulations: Bait formulations shall be the standard pesticide technology for cockroach and ant control, with alternate formulations restricted to unique situations where baits are not practical.
- D. Application of Insecticides to Exposed Surfaces or as Space Sprays: Application of insecticides to exposed surfaces or as space sprays (i.e., fogging) shall be restricted to very exceptional circumstances where no alternative measures are practical. The Contractor shall obtain approval of the IPM Coordinator prior to any application of insecticide to an exposed surface or any fogging treatment. No surface application or space spray shall be made while staff or visitors are present. The Contractor shall take all necessary precautions to ensure staff and visitor safety and all necessary steps to ensure the containment of the pesticide to the site of application.
- E. Monitoring: Sticky traps shall be used to guide and evaluate indoor insect control efforts wherever necessary.

13. Rodent Control

- A. Indoor Trapping: As a general rule, rodent control inside buildings shall be accomplished with trapping devices only. All such devices shall be concealed out of the general view and in protected areas and/or within covers so as not to be affected by routine cleaning and other operations. Trapping devices shall be checked on a schedule approved by the Facilities Manager and the IPM Coordinator. The Contractor shall dispose of trapped rodents within 24 hours. Trapping should not be performed during periods when maintenance of traps will be delayed by holidays, weekends, etc.

- B. **Outdoor Trapping:** Trapping is the preferred method for rodent control outside of municipal buildings. To monitor for rodent activity, tamper-resistant bait stations can be used to house non-toxic feeding blocks along with unset snap traps. When rodent activity is detected, the snap trap can be set. Trapped rodents should be disposed of promptly.
- C. **Use of Rodenticides:** In very exceptional circumstances, if rodenticides are deemed absolutely essential for adequate rodent control inside or outside buildings, the Contractor shall obtain approval of the IPM Coordinator prior to making any rodenticide treatment. All rodenticides, regardless of packaging, shall be placed in locations not accessible to children, pets, wildlife, and domestic animals and in EPA-approved tamper-resistant bait stations. No second-generation anti-coagulant rodenticides may be used.
- D. **Use of Rodenticide Bait Stations:** All bait stations shall be maintained in accordance with EPA regulations, with an emphasis on the safety of non-target organisms. The Contractor shall adhere to the following six points:
- All bait stations shall be placed out of the general view, in locations where they will not be disturbed by routine operations.
 - The lids of all bait stations shall be securely locked or fastened shut.
 - All bait stations shall be securely attached or anchored to floor, ground, wall, or other immovable surface, so that the box cannot be picked up or moved.
 - Bait shall always be secured in the feeding chamber of the box and never placed in the runway or entryways of the box.
 - All bait stations shall be labeled on the outside with the Contractor's business name and address, and dated by the Contractor's technician at the time of installation and each servicing.
 - All bait stations containing rodenticide shall have a warning sign posted at eye-level on the wall above the station. See the [City or Town] of [Name of Municipality]'s Pesticide Use Posting and Notification Policy (Attachment D).

14. Program Evaluation

The IPM Coordinator and the Facilities Manager will continually evaluate the progress of this contract in terms of effectiveness and safety, and will require such changes as are necessary. The Contractor shall take prompt action to correct identified deficiencies.

Attachment A. Buildings Included in this Contract

Address	Square Footage	Building Name

Attachment B. Pest Control Equipment List

Brand Name	To be used for (e.g., sealing small holes, monitoring for crawling insects, ant baiting)	Proposed area for use

Attachment C. Proposed Pest Control Materials List

This is a list of materials that your company proposes to use in the [City or Town] of [Name of Municipality]. The final list of acceptable materials will be negotiated with the Facilities Manager and the IPM Coordinator.

Brand Name	Active Ingredient and %	EPA Reg #	Signal Word	To be used for (e.g., ant bait, cockroach control, etc.)	Proposed method of use (e.g., as a bait station, in cracks & crevices, etc.)	Proposed area/building for use (e.g., in food service areas, around the outside perimeter of the building, etc.)

Attachment D. The [City or Town] of [Name of Municipality]’s Pesticide Treatment Posting and Notification Policy

General Provisions

This policy applies only to land owned by the [City or Town] of [Name of Municipality].

Any Department that uses or authorizes the use of a pesticide shall comply with the following posting and notification procedures:

- Signs shall be posted at least three (3) days before application of the pesticide and remain posted at least four (4) days after application. In specific situations/locations, permanent signs may also be used. See provisions below under “Exemptions” and “Other Uses of Permanent Signs”.
- Application information shall be posted on the [City or Town] of [Name of Municipality]’s website pesticide posting page at least three (3) days before the application. If the application is postponed or changed, information on the website must be updated.

- If treatment is in an enclosed area, signs shall be posted at all major public and employee entry points.
- If treatment is in an open area, signs shall be posted at highly visible location(s).
- Posting signs for rat and mouse bait stations shall be posted at eye level on the wall or other structure above the bait station.
- Exceptions to these provisions are listed below under “Exemptions.”

Content of Signs

The signs shall be of a standardized design, easily recognizable by the public and municipal employees, and shall contain the following information:

- Name of pesticide product
- Active ingredient(s) in the product
- United States EPA or California State registration number
- Target pest
- Signal word on the product label indicating the toxicity category of the pesticide product
- Date of posting
- Date(s) of anticipated use; a window of time for anticipated use is acceptable
- Date of re-entry for staff and the public to the treated area, if applicable
- Name and contact number of the [City or Town] of [Name of Municipality]’s Department responsible for the application
- Website address for more information

Exemptions

Departments shall *not* be required to post signs in accordance with the provisions above:

- In rights-of-way or other areas that the general public does not use for recreation or pedestrian purposes. Recreation is defined as any activity where significant physical contact with the treated area is likely to occur.

Note: Each department that uses pesticides in such locations shall provide a public access telephone number for information about pesticide applications. The public access telephone number shall be posted in a prominent location at the department’s

main office building. Information provided shall include all items listed under “Contents of Signs”, above.

- In or around the [City or Town] of [Name of Municipality]-owned or -leased buildings, if the pesticide is on a list agreed to by the IPM Advisory Committee.

Note: Each municipal building shall post a permanent sign in a prominent location with a list of pesticides that may be used in or around the structure without individual postings. Pesticides not on this list must be posted in accordance with the provisions above. The permanent signs shall contain the following:

- Name of the pesticide product
- Active ingredient(s) in the product
- Signal word on the product label indicating the toxicity category of the pesticide product
- Areas inside or outside the building where the pesticide might be used
- Name and contact number of municipal department responsible for applications

Any pesticide granted an emergency exemption for public health emergencies or other urgent situations by the IPM Coordinator shall not be required to be posted prior to treatment. However, all other requirements for posting, as set forth above, shall be followed.

Use of any pesticide listed by the Organic Materials Research Institute or of any products on the FIFRA 25(b) list or in California Code of Regulations Section 6147 may be posted on the day of application. All other provisions listed above apply.

The IPM Coordinator may, at his or her discretion, grant necessary exemptions to the posting requirements.

Other Uses of Permanent Signs

In addition to the provisions above regarding permanent signs in and around buildings, permanent signs are acceptable in areas away from the [City or Town] of [Name of Municipality]-owned or -leased buildings where pesticide applications are a regular, periodic occurrence. The following provisions apply:

- The permanent sign must contain, at minimum, the following information
 - Target pest(s)
 - Reason for treatment
 - Name and contact number of the [City or Town] of [Name of Municipality]’s Department responsible for the application

- Website address for more information
- At least three (3) days before any pesticide application, the application information must be posted on the [City or Town] of [Name of Municipality]'s website pesticide posting page. If the application is postponed or changed, information on the website must be updated.

On the actual day of the pesticide application, a paper sign with the information listed above under "Contents of Signs" must be affixed to the permanent sign and remain for at least four (4) days.

APPENDIX A3

Model Language for Annual Certification of Contracting Pesticide Applicator

[City or Town] of [Name of Municipality]'s Policy to Require An Integrated Pest Management (IPM) Approach to Pest Control at All Municipal-Maintained Facilities and Property

Policy Statement

The [City or Town] of [Name of Municipality] will carry out its pest management operations, at municipal-owned facilities, and on property where the municipal is responsible to provide facility and landscape maintenance, using reduced-risk IPM techniques.

The [City or Town] of [Name of Municipality] recognizing that some pesticides may be potentially hazardous to human health and the environment, shall give preference to reasonably available non-pesticide alternatives, and reduced-risk pesticides, when performing pest control activities.

Departments that apply pesticides will follow an IPM policy whose goal is to ensure the long-term prevention or suppression of pest problems, while reducing or eliminating the need for chemical pest controls (to the maximum extent feasible), with minimum negative impact on human health, non-target organisms, and the environment.

The IPM policy includes pest-specific and standard operating procedures (describing the IPM approach). The municipality prepares a report each year summarizing and evaluating the pest control activities performed by municipal staff and contractors.

No products containing Clopyralid, Diazinon, Chlorpyrifos (Dursban), Chlordane, DDT, Dieldrin or other organophosphates may be used on municipal property. [Insert Name of Any Pesticides That Require Additional Authorization for Use on Municipal Property] may be used by municipal staff or a municipal contractor on municipal property or property maintained by the municipal only after all other IPM methods have been tried and with the approval of the designated municipal staff person.

Municipal staff are to report pest control problems to the [Insert Designated Municipal Staff Title] or to the [Other Designated Municipal Staff]. No unauthorized municipal staff can purchase pesticides for use at work.

Contracting Pesticide Applicators for [City or Town] of [Name of Municipality] will sign this form to acknowledge that they are aware of the [Name of Municipality]'s IPM Program.

Contracting Pesticide Applicator Printed Name

Date

Contracting Pesticide Applicator Signature

APPENDIX B: Landscape Pest Factsheets

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ANNUAL BLUEGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Annual bluegrass, *Poa annua*, (Figure 1) is one of the most common weeds of residential and commercial turfgrass, ornamental plantings, and gardens in the United States. It is native to Europe but is distributed worldwide. Commonly referred to as “Poa,” it is a particular problem in golf course greens and fairways, but it can also be a troublesome weed in vegetable and agronomic crops grown in cool climates. Though present in tree and vine crops in California, it usually isn’t a significant problem. The genus *Poa* consists of about 200 species worldwide. Their typical boat-shaped leaf tips (Figure 2), which curve up like the bow of a boat, are a distinguishing characteristic of the genus.

Three members of the genus *Poa* are commonly found in turfgrass sites in California. Kentucky bluegrass, *P. pratensis*, is a common cool-season turf species that is well adapted to cool, well-watered sites such as coastal and intermountain areas. Rough bluegrass, *P. trivialis*, is a less desirable turf species that does well in moist, shaded areas but lacks heat and drought tolerance, so it is short-lived and is generally considered a weed. Annual bluegrass is a weed species that, unlike Kentucky and rough bluegrass, is able to survive low mowing heights of less than 1 inch and still reseed. A fourth species, bulbous bluegrass, *P. bulbosus*, is sometimes found as a weed in Northern California turfgrass.

IDENTIFICATION AND LIFE CYCLE

Annual bluegrass is a misnomer because there are two plant types of annual bluegrass—a true annual, *P. annua* var. *annua*, and a perennial type, *P. annua* var. *reptans*. While the two types aren’t easy to distinguish from



Figure 1. Annual bluegrass.



Figure 2. Annual bluegrass leaf tip.

each other, the annual type is more upright in its growth habit and produces more seed than the lower-growing perennial type. The annual type also tends to produce a higher percentage of dormant seed. The perennial type produces seed that germinates readily under optimum conditions. Depending on the site, there might be a predominance of one type or a mixture of both. The perennial type is common in such sites as golf course greens, while the annual type tends to be more common in lawns and parkways, although both types can be found in either of these situations.

Annual bluegrass is a cool-season grass weed that starts germinating in late summer or fall as soil temperatures fall below 70°F (Figure 3). It continues to germinate throughout winter, allowing several flushes of germination at any one site throughout the season. An-



Figure 3. Annual bluegrass seedling.



Figure 4. Leaf blades that are crinkled part way down are a key characteristic of annual bluegrass.

nual bluegrass grows 6 to 8 inches high when left unmowed. It has light green flattened stems that are bent at the base and often rooted at the lower stem joint. Leaf blades are often crinkled part way down (Figure 4) and vary from 1 to 3 inches long with typical *Poa* boat-shaped leaf tips. The inflorescence (flowering structure) has branched seed clusters (panicles) that are 1 to 4 inches long (Figure 5). Seed clusters, also called seed heads, (Figure 6) can form as soon as plants are six weeks old; although this can occur from early fall through early summer, most seed heads are formed in spring.

PEST NOTES

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The annual form of annual bluegrass is a rapid and prolific seeder. Each small plant can produce about 100 seeds in as few as eight weeks. Viable seed can be produced just a few days after pollination, which allows the plant to reseed even in frequently mowed turf. The small seed is amber colored and about 1/16 inch long.

Annual bluegrass has a fairly weak and shallow root system and needs frequent rainfall or irrigation to survive. It grows well in moist areas in partial shade to full sun and tolerates compacted soil conditions. In coastal regions or in moderate temperature areas where turf is frequently irrigated, annual bluegrass can persist all year. In warmer areas, it usually dies in summer.

IMPACT

Annual bluegrass can be a major weed problem in home lawns and is a continual nuisance for turf and landscape managers. Because it is a grass weed growing in turfgrass, selectively removing it is very challenging. In turf it forms a weak sod that provides poor footing for athletic fields and golf courses. In addition, unsightly seed heads of annual bluegrass reduce the aesthetic quality of the turf and disrupt the smooth rolling surface of putting greens.

Because of its winter growth habit, it is more competitive than warm-season turf cultivars (e.g., common and hybrid bermudagrass, buffalograss, St. Augustinegrass, and zoysiagrass) during the cool season. This accounts for the severity of annual bluegrass invasions during winter. Although annual bluegrass can be a problem in all turf species, it visually blends into many cool-season turf species (e.g., Kentucky bluegrass, tall fescue, and perennial ryegrass) and is most obvious in closely mowed species, such as bentgrass and bermudagrass, especially the dwarf hybrids. In cool seasons, annual bluegrass grows faster than warm-season turf cultivars, which gives infested turf an undulating or irregular surface in as little as two days after mowing.

When annual bluegrass infests ornamental plantings, it forms a dense mat that lowers the vigor of desirable landscape plants by reducing available nutrients in the soil surface. In established woody shrubs and trees, annual bluegrass probably has little detrimental effect but can be aesthetically distracting.

Once a few annual bluegrass plants become established in turf or ornamental areas, spread can be rapid because of its prolific and rapid seed production. Mowing, foot traffic, birds, and cultivation all spread seed.

MANAGEMENT

A primary method of control is preventing new infestations. Maintenance gardeners frequently spread weeds from site to site when weed seeds contaminate mowers, string trimmers, and aerifiers. Cleaning landscape equipment after use in infested sites can help prevent annual bluegrass from spreading to uninfested areas.

If solitary plants of annual bluegrass are found, they should be removed before seed production starts. Isolate small areas of infestation until control can be accomplished. Hand pulling or hoeing to remove annual bluegrass can be effective as long as it is done frequently. Because dense seedling infestations are common, open areas where old plants have been removed will often have new flushes of seedling plants, hence the need for frequent attention. Controlling annual bluegrass infestations manually is very expensive in commercially maintained landscapes and usually not practical or successful. However, it can be very appropriate for home gardeners.

Maintaining turf and ornamental areas properly assures their maximum vigor, which helps these plantings become as competitive as possible and slows invasion of the weed. A dense sward of turf and closely spaced ornamentals shade the soil surface and make the establishment of annual bluegrass seedlings more difficult.



Figure 5. The annual bluegrass inflorescence is branched with three to eight flattened florets in each spikelet.



Figure 6. Annual bluegrass inflorescence emerging from the leaf sheath.

Turfgrass

No single control procedure has been successful in controlling annual bluegrass in turfgrass. Early removal of solitary infestations has been successful when practiced diligently. Open spots should be overseeded to establish a vigorous turfgrass. Removal of grass clippings might help reduce the number of seeds that reach the soil.

Overwatering, especially in shady areas, will predispose turfgrass to an-

nual bluegrass invasion. Use deep and infrequent irrigation to discourage the development of shallow-rooted annual bluegrass. Try withholding water until the desirable turf is beginning to show drought stress, rather than keeping the surface moist. Avoid fertilization and don't aerate turf during the peak of annual bluegrass germination. Also, avoid cultural practices as well as use patterns that tend to promote soil compaction.

Preemergent herbicides such as benefin, bensulide, dithiopyr, oryzalin, oxadiazon, pendimethalin, and prodiamine and their combinations such as benefin/oryzalin have been very successful in limiting germination of annual bluegrass. They should be applied a few weeks before weed seeds germinate to be most effective, as they have no effect on emerged plants (Table 1). Ethofumesate and pronamide are also available for preemergent use and have some post-emergent activity on both varieties of *Poa annua*, but these herbicides can't be used in all turf species. Although most of these products may be used on residential lawns, some of the products aren't available for homeowner purchase and can be applied only by commercial applicators. To limit bluegrass germination during winter, apply preemergent herbicides in late summer or early fall when soil temperatures drop below 70°F. Where the perennial type is a large component of the bluegrass population, pre-emergent herbicides will be of little or no benefit.

There are a few relatively new post-emergent herbicides that control annual bluegrass, and none of them can be used in all turf species. They are usually applied to warm-season turfgrass species. These herbicides can be used on residential lawns by licensed or certified applicators, but they have been of little benefit when used as the sole method of control. Foramsulfuron, sulfosulfuron, and trifloxysulfuron can be used only on warm-season turfgrass species. Ethofumesate can be used in dormant bermudagrass, creeping bentgrass, Kentucky bluegrass, tall fescue,

Table 1. Summary of Herbicides for Annual Bluegrass Control.

Herbicide	Trade name	Applied to lawns?	Applied on ornamentals?	Available to home gardeners?
Preemergents—apply before weed seeds germinate				
benefin	Balan 2.5 G	yes	yes	no
benefin/oryzalin	Amaze Grass & Weed Preventer, XL 2G, Primera One OB-2G	yes	yes	yes
benefin/trifluralin	Team	no	yes	no
bensulide	Bensumec, Pre-San	yes	no	yes
dithiopyr	Dimension, Preen Southern Weed Preventer	yes	yes	yes
ethofumesate	Poa Constrictor	yes	no	no
oryzalin	Surflan, Weed Impede	yes	yes	yes
oxadiazon	Ronstar	yes	yes	no
pendimethalin	Pendulum, Pre M, Scotts Halts	yes	yes	turf only
pendimethalin/dimethenamid	Freehand	no	yes	no
prodiamine	Barricade	yes	yes	yes
pronamide	Kerb	yes	no	no
trifluralin	Vegetable & Ornamental Weeder, Preen Garden Weed Preventer, Treflan	no	yes	yes
Postemergents—apply to young weeds				
clethodim	Envoy	no	yes	no
ethofumesate	Poa Constrictor	yes	no	no
foramsulfuron	Revolver	yes	no	no
pronamide	Kerb	yes	no	no
sulfosulfuron	Certainty	yes	no	no
trifloxysulfuron	Monument	yes	no	no
Nonselective postemergents—apply to weeds (will kill turf and ornamentals)				
diquat	Diquat, Reward	n/a	n/a	yes
glufosinate	Finale	n/a	n/a	no
glyphosate	Roundup, Kleenup, Remuda, etc.	n/a	n/a	yes
nonanoic acid	Scythe	n/a	n/a	yes

perennial ryegrass, and St. Augustine to reduce annual bluegrass infestations. Pronamide can be used in warm-season turfgrass for established annual bluegrass, but it is slow acting (15 to 21 days).

Annual bluegrass infestations often become so severe in commercial turfgrass that complete renovation is necessary. This can be done by spraying the entire area with a nonselective herbicide such as glyphosate followed

by replanting with a desirable turf species. Planting and establishment of the new turfgrass should take place during late spring and summer so that a solid cover of new turf can be obtained before the annual bluegrass germination period. Choose a species and variety that will compete well with bluegrass. Then preemergent herbicides can be used in late summer or fall to further limit annual bluegrass from establishing.

Ornamentals

Annual bluegrass can be controlled by various methods in ornamental plantings. Preventing germination and seeding is very important. Hand removal or spot spraying of solitary plants will save time and money in the long run. Cultivation or hand hoeing, although possible under some circumstances, generally isn't useful unless continued throughout the germination period because seed that is buried in the soil is brought to the surface where it germinates.

Mulching with landscape fabrics can be effective if the fabric is overlapped so no light is allowed to reach the soil. Use a polypropylene or polyester fabric or use a black polyethylene (plastic tarp) to block all plant growth. Plant-derived products (i.e., organic mulches) or rock can be used over the top of the synthetic fabrics.

When used alone, plant-derived products should be 2 to 3 inches thick, depending on the coarseness of the mulch. Finer materials can be less thick than coarser ones. If seeds of annual bluegrass get into the mulch, they can germinate and establish, just as if they were in soil. In these cases annual bluegrass plants can be easily removed by hand or with a hoe. Mulch thickness will need to be replenished periodically to maintain cover and eliminate light penetration to the soil.

Preemergent herbicides such as dithiopyr, oryzalin, oxadiazon, pendimethalin, prodiamine, and trifluralin or a combination such as benefin/oryzalin, benefin/trifluralin, or pendimethalin/dimethenamid can be used to limit seedling germination in sites where use of these materials is permitted (Table 1). Some of these products may be available only to commercial applicators. Make the application before seeds germinate in fall when soil temperatures go below 70°F. Preemergent herbicides will be of little benefit if established annual bluegrass plants or the perennial type of bluegrass is already present. However, if the existing bluegrass is removed, a preemergent herbicide can be applied to control seedlings that germinate later.

Few postemergent herbicides are registered for use in established ornamental

plantings. Clethodim, fluazifop, and sethoxydim are selective for grass weeds and safe on broadleaf ornamentals, but only clethodim has any effect on annual bluegrass. Spot treatment with diquat, glufosinate, glyphosate, nonanoic acid, or other nonselective herbicides can reduce annual bluegrass populations in ornamental beds, but extreme care is needed to prevent herbicide spray or drift onto desirable plants, or the herbicides will injure the plants. Clethodim and glufosinate are available only to licensed applicators at this time.

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University of California
Agriculture and Natural Resources

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original, labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down the sink or toilet. Either use the pesticide according to the label, or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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Arundo donax L.

Giant reed

Family: Poaceae

Range: Southern region of the U.S. In the west it can be found in California, Nevada, Utah, Arizona, New Mexico, and Texas.

Habitat: Riparian areas, floodplains, ditches, typically on sites with a low slope. Occurs in a wide range of soil types, but grows best in well-drained moist soils. Tolerates some salinity and extended periods of drought. Does not survive in areas with prolonged or regular periods of freezing temperatures.

Origin: Native to the Mediterranean region and tropical Asia. In California from the late 1700s to early 1800s, giant reed was often planted for erosion control in flood channels and as wind breaks. Since then it has been cultivated as an ornamental and to produce reeds for woodwind instruments. It is now a leading candidate for cellulosic biofuel production.

Impacts: Giant reed is primarily a problem in riparian corridors. It develops dense stands which often displace native vegetation, diminish wildlife habitat, and increase flooding and siltation in natural areas. Giant reed is also adapted to a periodic fire regime. The canes are readily flammable throughout much of the year, and the presence of giant reed increases the susceptibility of riparian corridors to fire. Large stands of giant reed can increase water loss from underground aquifers in semi-arid regions due to a high evapotranspiration rate. The rate of water loss is estimated at roughly three times more than that of the native riparian vegetation. It is also an alternate host for beet western yellows virus, sugarcane mosaic virus, and maize dwarf mosaic virus.

Western states listed as Noxious Weed: California

California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness



Giant reed is a bamboo-like perennial to 25 ft tall, with thick, well-developed rhizomes. Although plants are typically terrestrial, they can tolerate periodic flooding. The canes are erect, semi-woody, and about 1 to 2 inches thick. First year green canes have unbranched stems the same diameter as older canes, but more pliable. Older canes are often branched, sometimes with leaves only on the branches. The blades are less than 3 ft long and 1 to 3 inches wide. The ligules consist of a short, even, minutely fringed membrane about 1 to 2 mm long. The auricles and collar region are distinctly pale yellowish-green. The rhizomes are creeping, thick, scaly, often forming a dense network, firm and knotty at the stem bases. Rhizome and stem fragments with a node can develop into a new plant under suitable conditions.

Inflorescences consist of large terminal plume-like panicles, 1 to 2 ft long, and silvery cream-colored to purplish or brown. Giant reed does not appear to produce viable seed in North America, although some Asian populations produce viable seed. Plants reproduce only vegetatively from rhizomes and rhizome and stem fragments; and stem and rhizome fragments generally disperse with water, mud, and human activities.

NON-CHEMICAL CONTROL

Mechanical
(pulling, cutting,
disking)

Minor infestations can be eradicated by manual methods, especially where sensitive native plants and wildlife might be damaged by other methods. Plants less than 6 ft in height and arising from a new stem or rhizome fragment can be hand pulled. This may be most effective in loose soils and after rains have loosened the substrate. Giant reed can also be dug using hand tools, particularly when used in combination with cutting near the base of the plant.

Chopping, cutting or mowing (rotary brush cutter, chainsaw, or tractor-mounted mower) can also be used to reduce giant reed infestations, although the fibrous nature of giant reed makes using these techniques difficult. Such methods usually require tractor-mounted equipment, but on rough or rocky soils scythes can be used for smaller patches. These methods generally cause less soil disturbance compared to heavy equipment. However, they are nonselective and may damage other desirable species or open up new niches for weedy invasions. These methods usually require several cuttings before the underground parts exhaust their reserve food supply, and larger giant reed patches will have enough reserves to resprout even after years of treatment. The best timing for cutting is when the plants begin to flower, as this is when the reserve energy supply in the rhizomes is lowest.

Mechanical methods using mechanized equipment (e.g., backhoe) to remove above-ground vegetation is a

common non-chemical control method for giant reed. However, such equipment is also nonselective and can only be used on accessible terrain. Most mechanical equipment is not safe to operate on slopes over 30%. It is also of limited use where soils are highly susceptible to compaction or erosion or where excessive soil moisture is present. Site obstacles such as rocks, stumps or logs also reduce efficiency. Mechanical eradication of giant reed is extremely difficult, even with the use of a backhoe, as rhizomes buried under 3 to 10 ft of alluvium readily resprout.

Regardless of the mechanical removal method employed, it is critical to remove the entire rhizome root mass. If any of the rhizome mass is left in the ground it will resprout. In addition, stems and roots should be removed, chipped or burned on site to prevent resprouting.

Cultural

Giant reed is not very palatable to cattle, but they will feed on it during the drier months. Sheep also have potential for the management of giant reed and have been shown to survive for extended periods on a strict diet of the perennial grass. However, sheep must be properly managed to prevent soil compaction problems particularly in wet areas. The most successful grazers are goats, particularly Angora and Spanish goats. Goats can have several advantages over mechanical and chemical control methods; they are less costly and can negotiate slopes too steep to manage with machines. Angoras are preferred over Spanish goats because of their smaller size and ease of transport. Since goats will trample or browse virtually any vegetation within a fenced area, any desirable trees or shrubs must be protected.

A flame thrower or weed burner device can be used as a spot treatment to heat-girdle the stems at the base of giant reed plants. This technique is less costly than basal and stem herbicide treatments and is suitable for use during wet weather when the wildfire hazard is low. Its effectiveness is comparable to manual cutting.

Large infestations may be burned to remove standing mature plants. This may be accomplished with or without a pre-spray of herbicides to kill and desiccate plants. When burning is used alone it will not prevent resprouting from the rhizomes. Burning is best followed by herbicide treatment of resprouting plants.

Biological

Little is known about the effects of various pathogens and insects on the growth and reproduction of *Arundo donax*. However, numerous insects are known to feed on this species. In recent work, the eurytomid wasp, *Tetramesa romana*, was evaluated as a potential biological control agent in North America. The wasp was found to be specific to *Arundo* and thus unlikely to harm native or cultivated plants in the Americas. Undoubtedly, many more years will be required before this species or any other potential biological control agents are identified and released.

CHEMICAL CONTROL

The following specific use information is based on reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

AROMATIC AMINO ACID INHIBITORS

Glyphosate
Roundup, Accord XRT II, Rodeo, Aquamaster, and others

Rate: Broadcast foliar treatment: 2 to 4 qt product (*Roundup ProMax*)/acre (2.25 to 4.5 lb a.e./acre) or 2 to 4 qt product (*Rodeo* or *Aquamaster*)/acre (2 to 4 lb a.e./acre) around aquatic sites. Spot treatment: 2% v/v solution. However, the *Rodeo* product label allows up to an 8% v/v solution, depending on the equipment being used.

Timing: Postemergence. Mid-summer to fall application after flowering and before dormancy is the best timing to kill plants and protect injury on many natives. Follow-up application in subsequent spring to control germinating seedlings may be necessary.

Remarks: Glyphosate is considered the best option for control in pure stands. Two to three years of treatment are necessary. Herbicide treatment can be used after repeated mowing to reduce necessity for spring treatment to kill seedlings. Dense stands of giant reed (> 80% canopy cover) are most efficiently treated by aerial application, usually by helicopter. Helicopter application can treat at least 124 acres per day.

Undiluted glyphosate can be applied as a cut stump treatment with a paint brush within 1 to 2 minutes after stem cutting. Results have shown that glyphosate used in a cut stem treatments, regardless of time of application (May, July, or September), provided excellent control with no resprouting.

Another method of treatment includes cutting or burning plants followed by foliar treatment of glyphosate to cane regrowth to about 6 to 8 ft in height.

BRANCHED-CHAIN AMINO ACID INHIBITORS

Imazapyr **Rate:** 1 to 2 qt product/acre (0.5 to 1 lb a.e./acre)

Habitat **Timing:** Postemergence fall application timing is most effective, similar to glyphosate.

Remarks: Imazapyr has soil residual activity and may impact restoration efforts.

Imazapyr + **Rate:** 1 pt imazapyr (*Habitat*) + 1 qt glyphosate product/ acre (0.25 + 1 lb a.e./acre, respectively)

glyphosate

Timing: Postemergence fall application timing is most effective.

Remarks: The combination of the two herbicides prevents the synthesis of six amino acids, as each herbicide inhibits three amino acids. This combination is thought to provide better control at lower rates of each herbicide, thus it is more affordable compared to imazapyr alone.

WILD BLACKBERRIES

Integrated Pest Management for Home Gardeners and Landscape Professionals

Of the 11 species of *Rubus* in California, four were introduced primarily from Eurasia. Most species of wild blackberry, also called brambles, provide important sources of food and cover for many birds and mammals.

Four species, however, are considered weeds. Two of these are non-natives, cutleaf blackberry (*R. laciniatus*) (Fig. 1) and Himalaya blackberry (*R. discolor* [formerly known as *R. procerus*]) (Fig. 2). In addition, two native species also can be weeds under certain conditions. For example, thimbleberry (*R. parviflorus*) (Fig. 3) competes with conifers during establishment in reforested areas, and California blackberry (*R. ursinus* [formerly known as *R. vitifolius*]) (Fig. 4) can infest areas adjacent to streams and ditches. Of these weedy species, the most common, vigorous, and troublesome is Himalaya blackberry.

IDENTIFICATION

Of the four weedy wild blackberries, thimbleberry is the only nonvining species. It also lacks prickly stems and has a simple leaf with no leaflets. Both Himalaya and cutleaf blackberry have five-angled stems whereas thimbleberry is rounded in cross section, but Himalaya blackberry is easily distinguishable from the other wild blackberries by its five distinct leaflets, each one toothed and usually oval. By comparison, cutleaf blackberry has five very deeply lobed leaflets, and California blackberry has only three leaflets. Not all wild blackberry leaves are deciduous; many remain evergreen. This is an important feature for chemical control in late fall and winter.

Himalaya blackberry has showy flowers that form in large clusters at the end of shoots. Each flower is about 1

inch across with five white or pink petals. The fruits are black and tasty when ripe. New canes are produced each year from the crown (the base of the plant), replacing those that die naturally. New plants start from crown regrowth, rhizomes (horizontal, underground shoots), and seeds that germinate in fall and spring. Reproduction is similar for the other three species.

IMPACT

The scrambling habit of Himalaya and the other vining wild blackberries smothers existing plant growth. In addition, the tangled mass of thorny stems blocks access of humans, livestock, equipment, and vehicles to pastures and waterways. In addition, it can host Pierce's disease and serve as a vector to movement of the pathogen to other agricultural and nonagricultural areas, including riparian sites.

In forest areas, timber-logging operations create large open areas that wild blackberries often invade. When grazed, the thorny stems can injure the nasal passages of livestock. Another undesirable aspect of vining blackberry plants is they are a good source of food and shelter for rats.

BIOLOGY

Many animal species feed on wild blackberries; consequently, seeds spread easily from one area to another in animal droppings. Wild blackberry seeds have a hard seed coat and can remain dormant for an extended period. Once seeds germinate and grow and the plants become established, expansion of the thicket is almost entirely a result of vegetative growth from rhizomes. Over time a single plant can cover a very large area.



Figure 1. Cutleaf blackberry.



Figure 2. Himalaya blackberry.



Figure 3. Thimbleberry.



Figure 4. California blackberry.

PEST NOTES

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Wild blackberry plants can live for 25 years or longer. They produce vines that arise from a central crown or from buds that form along rhizomes (Fig. 5). First-year canes don't produce flowers. In the second year, the canes fruit and die. Tips of first-year canes that contact the ground form roots at the nodes, contributing to the lateral expansion of the plant.

Bumblebees and honey bees are the primary pollinators of wild blackberry flowers. The flowers can be self-pollinated, but cross pollination increases fruit set.

MANAGEMENT

Wild blackberries are able to regenerate from the crown or rhizomes following mowing, burning, or herbicide treatment. This makes them difficult to control, and control measures often require follow-up treatment. Land managers often rely on a combination of mechanical and chemical control methods followed by a prescribed burn to dispose of vegetative material.

Because of the extensive underground root system, digging out the plants in a home landscape is a difficult undertaking. Home gardeners generally must rely on foliage-applied herbicide treatments to control an infestation of wild blackberries. One nonchemical option in the home landscape is the use of a rototiller to till the ground several times after the canes have been removed.

Mechanical Control

Because **repeated tillage** easily controls wild blackberries, they aren't a problem in cultivated agricultural systems. A single cultivation, however, can fragment the rhizomes and spread the weed. **Bulldozing** also can cause resprouting and can spread the weed by fragmenting roots and stems.

Mowing isn't an effective method for controlling wild blackberries. In many cases it stimulates the formation of suckers from lateral roots and induces branching. Despite the lack of long-

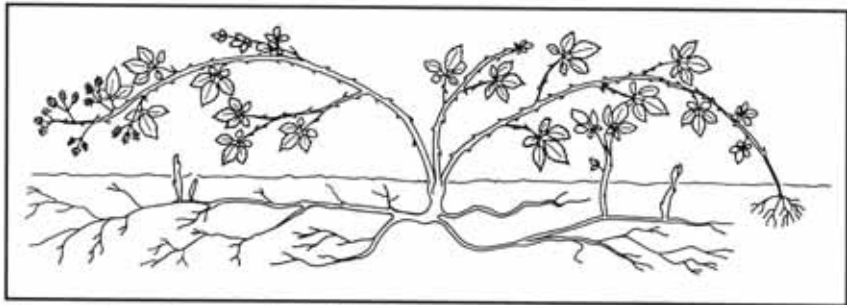


Figure 5. Vegetative growth of a blackberry plant from a central crown.

term control, mowing or chopping can provide short-term canopy reduction that will encourage the growth of grasses and broadleaf plants.

Burning, like mowing, isn't an effective long-term strategy, because wild blackberry plants vigorously resprout from rhizomes. However, like mowing, it also provides short-term canopy reduction.

Biological Control

Because many *Rubus* species are native or of economic importance, biocontrol isn't a practical control method in California. In Australia, however, blackberry leaf rust (*Phragmidium violaceum*) has been released for control of the weed. Thus far this program has not been successful, because the rust hasn't caused significant damage to its host. The rust was discovered in Oregon in the early 2000s and appeared to cause some damage to Himalaya blackberry populations. However, it has not maintained that level of injury and hasn't become widespread in California.

Chemical Control

Blackberry plants usually regrow following herbicide application; thus, repeated treatments might be necessary for effective long-term control.

Herbicides applied to the soil. In noncrop areas, tebuthiuron (Spike) is registered for use by licensed applicators for brush control. Tebuthiuron is a nonselective urea herbicide that is used for total control (i.e., it eliminates other vegetation in the treatment area) of shrubs, trees, and other weeds. It can

be applied in a pelleted formulation at the base of the plant to provide long-term control of wild blackberries.

Herbicides applied to the plant. Herbicides can be used in rangeland, pastures, noncrop areas, along roadsides, and in right-of-ways to control actively growing wild blackberry plants.

To effectively control blackberries during the growing season, an herbicide must be transported within the plant to the rhizomes and new growing points. For this to occur, the herbicide must move in the phloem with the plant sugars produced through photosynthesis. In early summer during the rapid extension of canes and expansion of foliar tissue, sugars are transported within the plant from the underground storage tissues to the shoots. After midsummer, new growth is reduced in wild blackberry first-year canes (non-flowering shoots), because these shoots are actively transporting sugars to the rhizomes. These sugars are stored for the following year's growth. In the flowering shoots (second-year canes), movement of sugars from the shoots to the rhizomes occurs later in the season than it does for first-year canes and is most active after completion of fruiting.

Time a foliar herbicide application so that it coincides with the maximum rate of sugar movement to the root system. This will depend upon whether the plants are primarily first-year canes or a combination of both first- and second-year canes. In a situation where only first-year canes are present (for example when plants have been burned or mowed), the most effective time for

optimal herbicide transport to the root system is in late summer. Herbicide application at this time reduces the likelihood of regrowth in subsequent years. Where the bramble infestation consists primarily of second-year canes or a combination of first- and second-year canes, apply an herbicide in early fall, before plants become dormant. Herbicides applied too early generally result in good kill of the top growth but very little movement of the chemical to the root system. Consequently, the plant regrows.

Plants stressed from drought or grazing don't translocate sugars as rapidly as do actively growing plants. Thus, chemical control of wild blackberry plants under stress is difficult and not recommended.

Foliar-applied herbicides. Herbicides used to control wild blackberry during the growing season include glyphosate, dicamba, dicamba/2,4-D combinations, and triclopyr. Of these, glyphosate (Roundup and other products containing glyphosate) and triclopyr (Brush-B-Gon, Blackberry and Brush Killer) are registered for use by home gardeners.

- Glyphosate formulated into a product with 41% active ingredient (a.i.) can provide good to excellent control of wild blackberries when applied in a 0.5 to 1.5% solution (i.e., about 0.6 to 2 ounces of product per gallon of water). One product available for use in the home landscape with this concentration of active ingredient is Roundup Super Concentrate. In natural areas, Roundup Pro is commonly used, and in riparian sites near water, the formulations Aquamaster and Rodeo are registered. Glyphosate products that have a lower concentration of active ingredient, such as Roundup Concentrate (18% a.i.), will require a 1.5 to 3.5% solution (i.e., about 2 to 4.5 ounces per gallon of water) for effective control. Late summer or early fall treatments give better control than treatments before or during flowering. To obtain good control, however, complete foliage coverage (spray-to-wet) is essential; spray the plant

until it is thoroughly wet but not to the point of runoff. Burning or mowing 40 to 60 days after spraying with glyphosate increases the level of control and also contributes to good pasture establishment by removing stem debris. Shoots recovering from sublethal glyphosate treatment tend to die more quickly when subjected to heavy grazing. Be sure to wait at least two weeks before grazing after treatment if less than 10% of the area was treated. If more than 10% of the area was treated, animals can't be grazed on the land until eight weeks following treatment.

- Dicamba alone (Banvel, Vanquish) or plus 2,4-D applied in late summer gives good control of wild blackberries. However, 2,4-D alone provides only fair control and will result in resprouting.
- Triclopyr is available to licensed applicators for commercial use in either amine (Garlon 3A) or ester (Garlon 4) formulations. Triclopyr ester (0.75 to 1% solution) is the most effective formulation of triclopyr on thimbleberry and the other three species of wild blackberries. Absorption of the herbicide into the foliage isn't as good with the amine form. Nevertheless, it also provides good control when applied at a 1% solution. The best time to apply either form of the herbicide is midsummer. When air temperatures are higher than 80°F, it is best to use the amine formulation, because the ester form is subject to vaporization. The timing for control of wild blackberries with triclopyr is somewhat earlier than that recommended for glyphosate. Like glyphosate, apply triclopyr spray-to-wet on the foliage. Sometimes glyphosate and triclopyr (1% solution each) are used in combination to achieve better control. Triclopyr is available in retail stores for use in the home landscape in products formulated at a lower concentration than those available to licensed applicators. Carefully read and follow the label of these products (Brush-B-Gon Concentrate, Blackberry and Brush Killer) to apply the correct amount to plants.

Basal bark treatment. Concentrated forms of triclopyr (often mixed with commercially available seed oils for better penetration) can be applied to basal regions of wild blackberries with a backpack sprayer using a solid cone, flat fan, or a straight-stream spray nozzle. Thoroughly cover a 6- to 12- inch basal section of the stem with spray but not to the point of runoff. Basal bark applications can be made almost any time of the year, even after leaves have senesced (aged, dried, and fallen from plant). In areas where people frequently harvest the fruit of wild blackberries, a midfall basal bark treatment might be desirable to avoid human contact with the chemical.

Dormant stem and leaf treatment. As an alternative to basal bark treatments, a 1% solution of triclopyr ester can be applied to dormant leaves and stems in late fall and winter in a 3% crop oil concentrate mixture; see product labels for the rate to use to obtain the desired concentration. As with other herbicide applications, spray the plant until it is thoroughly wet but not to the point of runoff. Like basal bark treatments, the timing of this technique prevents human contact with the herbicide during berry-picking season.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original, labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down the sink or toilet. Either use the pesticide according to the label, or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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Picris echioides L.

(= *Helminthotheca echioides* (L.) Holub [Jepson Manual 2012])

Bristly oxtongue

Family: Asteraceae

Range: Primarily in California, but also found in Nevada, Oregon, Washington, Montana, and North Dakota.

Habitat: Roadsides, waste places, fields, pastures, crop fields, orchards, vineyards, landscaped areas, gardens, and other disturbed open places. Most common in seasonally wet places.

Origin: Native to the Mediterranean regions of Europe.

Impacts: Can form dense stands in rangelands and other areas near coastal grasslands.

California Invasive Plant Council (Cal-IPC) Inventory: Limited Invasiveness

Bristly oxtongue is an erect winter, or sometimes summer, annual or biennial to nearly 3 ft tall. It has milky sap, stiff-bristly foliage, and yellow dandelion-like flowerheads. Young plants overwinter as rosettes before bolting in late spring. The leaves are alternate and covered with stiff, coarse, papilla-based hairs that are minutely branched at the tips.

The flowerheads are both terminal and axillary, mostly 1 to 2 inches wide, and consist only of yellow ligulate flowers. The achenes have a white bristly to plumose pappus on a stalk. Plants reproduce only by seed. Seeds probably disperse short distances with wind. Some seeds disperse greater distances by clinging to tools, vehicle tires, and landscaping and agricultural machinery. No studies have determined the seed longevity in the soil, but seeds would be expected to persist for a couple of years.



NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, diking) Control can be achieved by hand pulling, string trimming, or hoeing when soil is moist. Roots should be removed to 2 inches below the soil surface. Mowing repeatedly will suppress plants, but basal leaves may result in some recovery.

Cultural It is not known whether plants are palatable to livestock. Burning may be an effective control option, but there are no studies to support this. However, bristly oxtongue often occurs in areas with annual grasses, and it is a late season plant. As such, there is likely a window of opportunity for burning after grasses have dried to provide fuel, but before bristly oxtongue has produced viable seed.

Biological There are no biological control agents available for the control of bristly oxtongue.

CHEMICAL CONTROL

There is very little information available for the control of bristly oxtongue, but control measures for other members of the Asteraceae are expected to be effective. In particular, the chemical control options for yellow starthistle are likely to also be effective on bristly oxtongue.

The following specific use information is based on reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

GROWTH REGULATORS

2,4-D	Rate: 1 to 4 pt product/acre (0.48 to 1.9 lb a.e./acre)
Several names	Timing: Postemergence to seedlings or plants no later than the bolting stage. Remarks: 2,4-D is a broadleaf herbicide with no soil activity. Older plants are expected to require a higher rate compared to seedlings or plants in the early rosette stage.
Aminocyclopyrachlor + chlorsulfuron <i>Perspective</i>	Rate: 3 to 4.5 oz product/acre Timing: Postemergence in spring and early summer to rosettes or bolting plants, or in fall to seedlings and rosettes before the ground freezes. Remarks: Higher rates are necessary after plants bolt. Aminocyclopyrachlor has similar activity as aminopyralid and is expected to provide similar control of bristly oxtongue. <i>Perspective</i> provides broad-spectrum control of many broadleaf species. Although generally safe to grasses, it may suppress or injure certain annual and perennial grass species. Do not treat in the root zone of desirable trees and shrubs. Do not apply more than 11 oz product/acre per year. At this high rate, cool-season grasses will be damaged, including bluebunch wheatgrass. Not yet labeled for grazing lands. Add an adjuvant to the spray solution. This product is not approved for use in California and some counties of Colorado (San Luis Valley).
Aminopyralid <i>Milestone</i>	Rate: 5 to 7 oz product/acre (1.25 to 1.75 oz a.e./acre) Timing: Postemergence in spring and early summer to rosettes or bolting plants, or in fall to seedlings and rosettes before the ground freezes. Remarks: Higher rates are necessary after plants bolt.
Clopyralid <i>Transline</i>	Rate: 6 to 10 oz product/acre (2.25 to 3.75 oz a.e./acre) Timing: Postemergence in spring and early summer to rosettes or bolting plants, or in fall to seedlings and rosettes before the ground freezes. Remarks: Higher rates are necessary after plants bolt. See recommendations for yellow starthistle; control is expected to be similar for bristly oxtongue.
Picloram <i>Tordon 22K</i>	Rate: 1 pt product/acre (4 oz a.e./acre) Timing: Preemergence in winter, or early postemergence in late fall or spring. Remarks: Picloram has a very long soil residual activity and should provide 2 years of control. It is selective on broadleaf species and does not generally injure grasses. <i>Tordon 22K</i> is a federally restricted use pesticide. Picloram is not registered for use in California.

AROMATIC AMINO ACID INHIBITORS

Glyphosate <i>Roundup, Accord XRT II, and others</i>	Rate: Broadcast foliar treatment: 2 to 4 pt product (<i>Roundup ProMax</i>)/acre (1.1 to 2.25 lb a.e./acre). Spot treatment: 1% v/v solution Timing: Postemergence to seedlings or plants no later than the bolting stage. Remarks: Glyphosate is a nonselective herbicide. Studies with yellow starthistle show good control with glyphosate, and it is expected that similar results would occur with bristly oxtongue.
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BROOMS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Brooms are a group of shrubs introduced into North America from Europe in the mid-1800s. The four most common species are Scotch broom (*Cytisus scoparius*), French broom (*Genista monspessulana*), Spanish broom (*Spartium junceum*), and Portuguese broom (*Cytisus striatus*). Brooms initially were introduced as ornamentals, but the United States Department of Agriculture's Natural Resources Conservation Service used them extensively for erosion control along roadsides and in mined areas.

These highly competitive shrubs grow rapidly and form dense stands that most wildlife find impenetrable and unpalatable. Their dense stems make regeneration of most other plant species difficult or impossible, and they create a dangerous fire hazard. In addition, brooms are able to fix atmospheric nitrogen, which increases soil fertility and gives a competitive advantage to other non-native weeds that, unlike the

local natives, thrive on high nitrogen levels. Although some retail nurseries still sell a variety of broom species, homeowners should avoid planting it in their personal landscapes. Depending on your climate, a number of alternate plant species have similar attributes but are not invasive. Contact your county UC Master Gardener for a list of recommendations.

IDENTIFICATION

Brooms are upright shrubs that grow 3 to 10 feet tall (Figs. 1 and 2). They generally produce bright yellow, pea-shaped flowers on green stems from April to June.

Scotch and Portuguese brooms produce their flowers in the leaf axils, while French and Spanish brooms have flowers at the branch tips. In some areas Scotch broom flowers can be multicolored, typically with red or purple petals along with yellow ones.

Another distinguishing characteristic between the species is stem shape. Scotch broom has a five-angled stem (star shaped when viewed from a cross section), French and Portuguese have an eight- to ten-angled stem, and Spanish broom has a finely ribbed stem making it nearly round.

Leaf characteristics also identify the species. Spanish broom produces simple leaves while the other three species have mostly trifoliate leaves. For most species, new leaves produced in spring often are lost during hot, dry summer months or periods of stress, giving the plants their characteristic whisk broom appearance. Scotch, Portuguese, and Spanish brooms are deciduous while French broom is an evergreen.

All four brooms produce brownish-black pea pods in mid- to late summer that contain shiny, dark greenish-brown seeds. Table 1 shows identifying features of these four broom species.

Figure 1. Brooms are upright shrubs that produce yellow flowers in spring. Most species also generate new leaves in the spring but often lose them during hot, dry summer months, creating a whisk broom appearance. Shown here is Scotch broom, *Cytisus scoparius*.



Figure 2. Spanish broom, *Spartium junceum*.












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Table 1.
Distinguishing Features of Four Common Broom Species in California.

<p>Scotch broom (<i>Cytisus scoparius</i>)</p>	<p>French broom (<i>Genista monspessulana</i>)</p>	<p>Spanish broom (<i>Spartium junceum</i>)</p>	<p>Portuguese broom (<i>Cytisus striatus</i>)</p>
 <p>Stems: 5-sided; star-shaped cross section Leaves: compound, 3 leaflets, deciduous, sometimes single on new twigs</p>	 <p>Stems: 8 to 10 ridges; round cross section Leaves: compound, 3 leaflets, evergreen, usually dense</p>	 <p>Stems: smooth or finely ribbed; round cross section Leaves: simple, deciduous, sparse</p>	<p>No photo available.</p>
 <p>Flowers: single or paired in leaf axils Petals: yellow or partially red</p>	 <p>Flowers: 4 to 10 in clusters at end of short branches Petals: yellow</p>	 <p>Flowers: several in open racemes at stem ends Petals: yellow</p>	 <p>Flowers: single or paired in leaf axils Petals: yellow</p>
 <p>Seed pods: flattened, only margins hairy</p>	 <p>Seed pods: slightly flattened, entirely covered with long hairs</p>	 <p>Seed pods: slightly flattened with few, if any, long hairs</p>	 <p>Seed pods: slightly inflated, entirely covered with long hairs</p>

BIOLOGY

You'll often find brooms in disturbed places such as riverbanks, road cuts, and forest clear cuts, but they also can colonize undisturbed grassland, shrubland, and open canopy forests. Invasion and spread typically are by seed dispersal. The pods ripen during the dry summer months then explosively eject their seeds a few feet away, mak-

ing a popping noise you can hear for some distance. All of the brooms are prolific seed producers with a single shrub producing as many as 2,000 to 3,500 pods containing up to 20,000 seeds. About 40% of the newly produced seeds germinate immediately after dispersal, and another 25% germinate the second year. The seeds have an impervious seed coat, enabling some seeds to remain dormant in the soil for

up to 50 years and making long-term management difficult.

After germination, stem growth is rapid—as much as 3 to 4 feet the first year. After continuing to grow quickly for another 3 to 4 years, the plant experiences 6 to 8 years of relatively slow growth. Next is a period of senescence with more dead, woody tissue than green. Plants typically live 12 to 17

years but can survive for as long as a quarter century.

Although brooms usually don't reach flowering maturity until the second or third year of growth, under the right conditions—including prevalent moisture—broom species can produce flowers and seeds their first year, making early removal important.

MANAGEMENT

The two primary methods for managing brooms are mechanical removal and treatment with herbicides. Broom establishment is mainly through seed dispersal, so maintaining a healthy cover of desirable vegetation and reducing soil disturbance will minimize the potential of broom invasion.

Mechanical Control

You can use hand pulling or mechanical grubbing—using a shovel, pick, or Weed Wrench—to physically remove smaller infestations in wildlands or urban areas. Remove plants in early spring or late fall when the soil is moist and it is easy to dislodge roots. Some tools, however, are difficult to use in soils that are too moist, and hand pulling can create soil disturbance that can lead to rapid reinvasion. Grubbing when the soil is dry and hard usually will break off the stems, leaving rootstalks that will vigorously resprout.

Other forms of mechanical control have not proven successful. Brush rakes and bulldozers often leave pieces of rootstalks that readily can resprout. In some cases, brush removal in late summer, when plants experience moisture stress, can slow their ability to recover. However, using large equipment to clear land creates a perfect environment for new seedling establishment, making follow-up control essential.

Mowing broom plants gives poor control, unless you perform it repeatedly throughout the growing season. Within a couple months of germination, young plants usually have produced underground rootstalks large enough to recover from a single mowing. Use extreme caution when mowing during spring and summer because of the

potential for wildfires. Mowing later in the season also can spread seeds.

Lopping mature plants near the base will provide some control; you'll want to do this when plants are moisture stressed in late summer or in late spring following a winter with little rainfall. Lopping at other times can lead to vigorous resprouting.

Cultural Control

Burning alone is not an effective method for controlling brooms. Although burning can remove large amounts of debris, in many cases it can increase the population as it removes competitive vegetation, releases nutrients into the soil, and stimulates the germination of broom seeds left in the soil.

Cutting the above-ground vegetation of French or Scotch broom and allowing it to dry on site, followed by burning, can effectively control resprouting. Burning is more effective if you follow it with an herbicide application, subsequent burnings, and/or revegetation using desirable species. It is important to employ a control strategy following a burn, otherwise the broom population in subsequent years may become worse than before.

Grazing can provide control in small areas if the grazing pressure is high enough to continually suppress growth. Goats have been shown to vigorously feed on resprouting vegetation and shrubs, including brooms. You can train goats to selectively feed on brooms or other undesirable species, but overgrazing can lead to nonselective damage to desirable vegetation.

Biological Control

In the 1960s, three insects were introduced as biological control agents on brooms—the Scotch broom seed beetle (*Bruchidius villosus*), the Scotch broom seed weevil (*Apion fuscirostre*), and the Scotch broom twig miner moth (*Leucopetera spartifoliella*). The latter two species are specific to Scotch broom, while the seed beetle also attacks Portuguese broom, Spanish broom, and French broom. Because brooms are serious problems in many countries, the Inter-

national Broom Initiative is evaluating other insects and pathogens in their native countries to determine their control potential.

Chemical Control

California homeowners can purchase the post-emergent herbicides triclopyr and glyphosate, the most effective chemicals for controlling brooms. You can use these herbicides either alone or as a combination of glyphosate with triclopyr or imazapyr. In areas near rivers or streams, it is important to use the proper formulation of these herbicides. Ester formulations of triclopyr or imazapyr, for example, are not registered for use near water, and some glyphosate formulations cannot be used near water either.

Depending on the compound, you can apply these herbicides as foliar sprays, a cut-stump treatment, or a basal bark application. When using herbicides, be sure to prevent them from getting on desirable plants. Because glyphosate is a nonselective compound, it will damage or kill other vegetation. Triclopyr is a broadleaf herbicide that will not injure grasses but will damage or kill other broadleaf plants. Homeowners and professional applicators should wear appropriate protective equipment as stated on the herbicide label.

Foliar Sprays. The effectiveness of herbicides depends on three factors—timing, achieving good coverage, and using a proper concentration.

Timing. Foliar application of herbicides to brooms is most effective after leaves are fully developed and when the plant is actively growing. This period normally is from April into June or July, when soil moisture remains adequate. The flowering stage is the optimum time to treat. Don't apply herbicides before plants begin their spring growth or in mid-summer when plants are stressed. Although not typically a problem, dust can cover plants growing near roadsides. Herbicides, particularly glyphosate, can readily attach to dust or soil particles, thus reducing their effectiveness.

Coverage and Concentration. You can apply herbicides as a foliar spray using one of two methods. The first is spray-to-wet, where all leaves and stems should glisten following an application. Coverage, however, should not be to the point of runoff.

The other method is a low-volume foliar application called drizzle. This technique uses a higher concentration of herbicide, but you spray it at a lower volume. This method is advantageous in dense shrubbery or where access is limited. To achieve proper coverage, spray the herbicide uniformly over the entire canopy in a "drizzle" pattern, using a spray gun.

For spray-to-wet applications, products containing 41% glyphosate as the active ingredient can provide good to excellent control of brooms when applied at 2.5 ounces of product per gallon of water (2% of the total solution). Some products available for use in the home landscape with this concentration of active ingredient are Clearout 41 Plus, Honcho Herbicide, and Honcho Plus Herbicide. Glyphosate products that have a lower concentration of active ingredient, such as Roundup Concentrate (18% active ingredient), will require about 6 ounces of product per gallon of water (4.7% of the total solution) for effective control.

Triclopyr is available in either amine or ester formulations, with triclopyr ester being more effective on brooms, since absorption of the herbicide into the foliage is not as good with the amine form. One product available for use by licensed applicators—and for homeowners that acquire an operator identification number from their county Department of Agriculture—is Garlon 4. This and other similar products formulated with a minimum of 61% active ingredient can provide good to excellent control when applied at 1 to 1.25 ounces of product per gallon of water (0.75% to 1.5% of the total solution).

Mixing triclopyr ester with commercially available seed oils can offer better penetration. One available product is Hasten Spray Adjuvant; mix this at

1.25 ounces of product per gallon of herbicide solution (1% of the total solution).

The best time to apply either form of the herbicide is late spring. When air temperatures are higher than 80°F, it is better to use the amine formulation, because the ester form is subject to vaporization. More than one ester formulation of triclopyr is available, with differing degrees of volatilization at high temperatures.

You can use glyphosate and triclopyr in combination to achieve better control. Triclopyr is also available in retail stores for use in the home landscape in products formulated at a lower concentration than those available to licensed applicators. Carefully read and follow the label of these products—such as Brush-B-Gon Poison Ivy and Poison Oak & Brush Killer—to apply the correct amount.

The drizzle application method is good in situations of dense planting or when it is difficult to cover an entire area due to topography. Glyphosate formulated into a product with 41% active ingredient can provide good to excellent control of brooms when applied at 19 ounces of product per gallon of water (15% of the total solution). You also can apply triclopyr using a drizzle application. If you are using triclopyr ester formulated into a product with 61% active ingredient, apply it using 13 ounces of product (10% of the total solution) and 25 ounces of seed oil (20% of the total solution) per gallon of water.

Remember that although the drizzle technique uses a higher concentration of herbicide, you are applying it at a lower volume. One gallon of mixed herbicide solution should adequately treat one-half acre of densely populated broom.

Cut Stump Application. Cut stump treatments are most effective in spring during active plant growth or in the fall. Immediately after cutting, apply the herbicide to the cut surface with a paint brush, spray bottle, or plastic squeeze bottle. Delaying application

will result in poor control, because the cut surface quickly will develop an air interface between the water in the vascular tissue and the herbicide solution, preventing movement of the chemical into the plant.

For small stumps, completely cover the cut surface. For large stumps, it is necessary to wet only the cambium, the outer ring of wood next to and including the bark. For small-stemmed shrubs, cut the stems with loppers or clippers and paint or sponge the herbicide solution onto each cut end.

For triclopyr products containing 61% active ingredient, use 1 part product and 4 parts water. The 8% material available to homeowners in nurseries and other stores will work well undiluted. You also can apply glyphosate as a cut-stump application. If using a brand that has 18% glyphosate listed in the active ingredients, make a 1:1 solution of the product and water. If the product contains 41% glyphosate, use 1 part product and 3 parts water.

Basal Application. You can apply concentrated forms of triclopyr ester to basal regions of brooms using a backpack sprayer with a solid cone, flat fan nozzle, straight-stream spray nozzle, or even a wick applicator. Thoroughly cover a 6- to 12-inch high basal section of the stem with spray but not to the point of runoff. You can make basal bark applications almost any time of the year, even after leaves have senesced. For triclopyr ester formulated into a product with 61% active ingredient, the application ratio is 13 ounces of product (10% of the total solution) and 25 ounces of seed oil (20% of the total solution) per gallon of water. Glyphosate and the amine formulation of triclopyr provide poor control using this technique.

One application of an herbicide does not always completely control brooms. Retreat when new, sprouting leaves are fully expanded, generally when the plants are about 2 feet tall. Watch treated areas closely for at least a year, and retreat as necessary.

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Delairea odorata Lem.

Cape-ivy

Family: Asteraceae

Range: Mainly along the coast of California and Oregon.

Also invasive in Hawaii.

Habitat: Riparian corridors, seasonal wetlands, coastal habitats, coastal bluffs and scrub, moist canyons, coastal grassland, oak woodlands, and disturbed sites such as roadsides, urban waste places, or other areas. Requires some moisture year-round. Grows in deep shade or under cloudy conditions and does not tolerate full sunlight. Tolerates serpentine soils, and established plants can survive drought conditions.

Origin: Native to the moist mountain forests of South Africa and introduced to the United States in the late 1800s as a houseplant. Also considered an invasive weed problem in Australia.

Impacts: Under favorable conditions, plants spread invasively and can develop a dense cover that outcompetes other vegetation in natural areas.

Vines grow over trees and shrubs and can form dense mats that smother underlying vegetation. Such problematic infestations also reduce native species richness and seedling recruitment in the community. Cape-ivy contains pyrrolizidine alkaloids (liver toxins) and can be toxic to animals when ingested; fish can be killed when plant materials are soaking in waterways.

Western states listed as Noxious Weed: California

California Invasive Plant Council (Cal-IPC) Inventory: High Invasiveness



Cape-ivy is a fleshy perennial vine, with stems to about 30 ft long. The leaves are glossy green, glabrous, alternate, broadly deltate to "ivy-shaped", 1 to 4 inches long, 1.5 inches wide with 5 to 9 lobes. The foliage is evergreen in mild climates and the leaves and stems are deciduous elsewhere.

The flowers are yellow, grouped on terminal and axillary corymbs, with disk flowers approximately 5 mm long arranged in clusters. The fruits are achenes about 2 to 3 mm long, often with a pappus or a crown of hairs. Plants reproduce primarily vegetatively, from fragments of rhizomes, stolons, and stems. A stem fragment as small as one inch, if it has a node, can generate a new plant. Even small fragments of dying stems can resprout, although the regeneration rate is reduced by about one-third. While most seeds produced are not viable, some viable seeds develop in sites throughout California and Oregon. When viable seed are produced, they can disperse long distances by wind.

NON-CHEMICAL CONTROL

Mechanical
(pulling, cutting,
disking)

Manual removal of plants, including roots and rhizomes, before viable seed develops can help control infestations in areas where plants are accessible. Removing all plant material from the site will help prevent rerooting of rhizomes, stolons, or stem fragments. Follow-up removal of resprouts is essential. In some large patches, all stems can be cut at ground level and Cape-ivy rolled up like a rug. Although the below-ground reproductive tissues will resprout, this strategy makes it possible to detect and spot-treat new sprouts while avoiding contact with desirable vegetation.

Because Cape-ivy can resprout and establish from stem fragments, mowing is not recommended.

Cutting off Cape-ivy before it flowers will reduce seed production and deplete the plant's energy reserves. Resprouts are common after treatment. Cutting should be combined with an herbicide treatment or with multiple cuttings over a period of years. All plant parts should be bagged and properly disposed of.

Cultural

Grazing and burning are not considered effective control options. The leaves and stems can be toxic to livestock.

Biological

To date, no biological control agents have been released. However, extensive research by USDA-ARS has been ongoing since 1998. Several species of insects are being examined as potential controls, including a gall-forming fly (*Parafreutreta regalis*), a leaf-mining moth (*Acropelia* spp.), a defoliating moth (*Diota rostrata*), and a stem-boring moth (*Digitivalva delaireae*). The two most promising, the stem-boring moth and the gall-

forming fly, are going through the final stages of testing.

CHEMICAL CONTROL

The following specific use information is based on published papers and reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

GROWTH REGULATORS

Clopyralid <i>Transline</i>	Rate: Spot treatment: 0.5% v/v solution plus 0.25 v/v surfactant to thoroughly wet all leaves. Timing: Postemergence when plants are growing rapidly. Remarks: Clopyralid is a selective herbicide for broadleaf species. This compound has been shown to be successful in controlling Cape-ivy in Australia.
Triclopyr <i>Garlon 4 Ultra,</i> <i>Pathfinder II</i>	Rate: Spot treatment: 0.5 to 1% v/v solution of <i>Garlon 4 Ultra</i> and water plus 0.25 to 0.5% v/v surfactant to thoroughly wet all leaves. Timing: Postemergence when plants are growing rapidly. Remarks: Triclopyr is a selective herbicide for broadleaf species. In areas where desirable grasses are growing under or around Cape-ivy, triclopyr can be used without non-target damage.

AROMATIC AMINO ACID INHIBITORS

Glyphosate <i>Roundup, Accord</i> <i>XRT II, and others</i>	Rate: Spot treatment: 1 to 2% v/v solution of <i>Roundup ProMax</i> (or other trade name with similar concentration of glyphosate) in water, or 1% <i>Roundup</i> (or other trade name) plus 0.5% <i>Garlon 4 Ultra</i> v/v plus silicon surfactant in water to thoroughly wet all leaves. Wiper treatment: 33 to 50% of concentrated product. Timing: Postemergence when plants are growing rapidly. Best results when treated in late summer or early fall. Remarks: Glyphosate is a nonselective systemic herbicide. It gives good control with some resprouts. In many situations, it may be more appropriate to use a wiper application to achieve selectivity. Glyphosate can be combined with triclopyr for more effective control. Use a surfactant when applying this combination.
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CLOVERS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Clover is a broad term that refers to plants in three genera: *Trifolium*, *Medicago*, and *Melilotus*. Each contains clover species that are troublesome in turfgrass and ornamental areas. They are in the legume family (Fabaceae) and have distinctive "pealike" flowers that are arranged in various types of heads.

Clover plants have a symbiotic relationship with a bacterium in the *Rhizobium* genus that allows them to fix atmospheric nitrogen and provide for their own nitrogen needs, which is why clover can maintain a dark green color even under low nitrogen fertility. Turfgrass growing in soil that is low in nitrogen may receive supplemental nitrogen from old clover plants as their roots die and decay.

IDENTIFICATION AND BIOLOGY

Depending on the species, clovers may have an annual or perennial life cycle. Both annual and perennial clovers begin to germinate in fall when soil temperatures are in the 50° to 60°F range. Germination continues throughout the winter and early spring months. Winter rainfall will sustain the annual clovers, but irrigation is required for survival of the perennial species during the dry summer months. A weed commonly confused with clovers is *Oxalis*. *Oxalis* leaves look similar to those of clovers, but lack a stipule and generally have a more pronounced indentation at the top of each leaflet. Once *Oxalis* matures it has small yellow flowers that have five regular petals that are readily distinguished from clover flowers. For more information on *Oxalis* species, see *Pest Notes: Creep-*

ing Woodsorrel and Bermuda Buttercup listed in References.

Annual Clovers. Annual clovers that typically cause problems in turfgrass include black medic (*Medicago lupulina*) and California burclover (*Medicago polymorpha*). Another of the annual clovers, little hop clover or shamrock clover (*Trifolium dubium*), is sometimes planted as part of a turfgrass mixture.

Annual clovers grow mostly in a prostrate manner, even without mowing (Fig. 1). Black medic and burclover have trailing stems that branch from the base and radiate out from a single taproot. The compound leaves have three oval-shaped leaflets that are finely toothed with prominent veins (Fig. 2). The central leaflet has a short stem whereas the other two are almost stemless. Flowers are small, bright

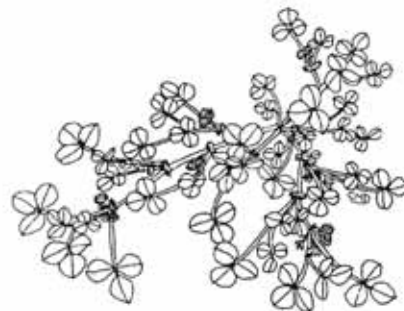


Figure 1. California burclover plant.

yellow, and borne in clusters at the end of a stem. In black medic, a single seed is produced in a smooth, small brown to black pod. The burclover seedpod is light brown and curls into a tight bur that is typically spiny. The burs contain several seeds.

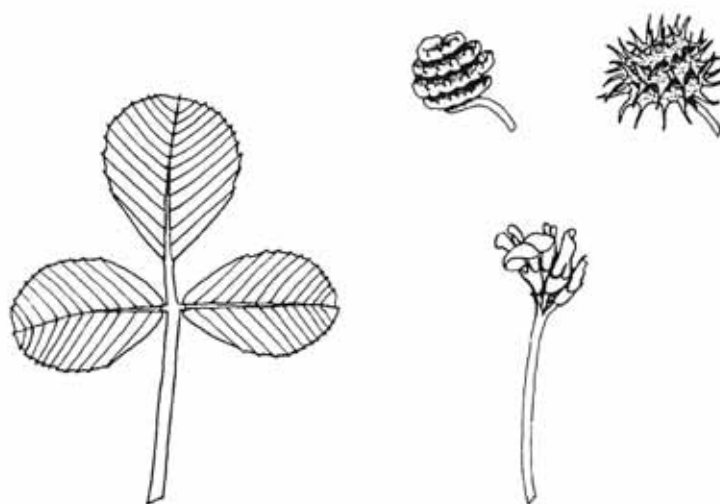


Figure 2. Leaf, seedpods, and flowers of California burclover.

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Figure 3. Yellow sweetclover plant.

Sweetclovers. Sweetclovers, including white sweetclover (*Melilotus alba*) and yellow sweetclover (*Melilotus officinalis*), are erect annuals or biennials that are more problematic in ornamental areas than in turfgrass. They grow from 2 to 5 feet tall (Fig. 3) and have a trifoliate leaf arrangement with the leaf margins toothed more than halfway back from the tip (Fig. 4a). The flowers are small, yellow or white (depending on the species), and are produced in a many-flowered terminal and in leaf axils (Fig. 4b). The small pods have one seed.

Perennial Clovers. The perennial white clover, *Trifolium repens*, is most often found as a turfgrass weed, but it and strawberry clover, *Trifolium fragiferum*, are sometimes planted in a mixed stand with turfgrass to reduce the need for nitrogen fertilizer application.

White and strawberry clovers have a creeping stem system that roots at the nodes (joints in the stem), forming large clumps (Fig. 5). White clover leaves are trifoliate with 1/4- to 1/2-inch-long leaflets (Fig. 6). The flowers of



Figure 4a. Leaf of yellow sweetclover.

white clover are formed in heads that are white to pale pinkish. Strawberry clover is a more robust plant than white clover and thus more aggressive. The leaves mostly form from the base of the stem with the leaflets longer and narrower than white clover. The pink flowers are borne in heads that are less showy than white clover.

IMPACT

Clover can be a concern in turfgrass or landscaped areas for at least three reasons. First, during the flowering period bees are attracted to the clover blooms and people playing or using the turfgrass may be stung. Second, clovers reduce the uniformity of the turfgrass because its texture, color, and growth rate are different from that of grasses. And third, the mature burs of burclover are a problem for people walking barefoot and when they become attached to clothing or pets.

MANAGEMENT

Clovers are relatively easy to control in the home garden by hand-pulling, cultivation, and the application of mulch. In large, landscaped areas herbicides may also be necessary. Because clover seed has a hard seed coat that is very heat tolerant, composting and solarization are not as effective in reducing clover's seed viability as they are with other weed species. The



Figure 4b. Flowers of yellow sweetclover.

hard seed coat also allows the seeds to survive longer in the soil than many other weed seeds; clover seeds can germinate over many years, making the control of these plants an ongoing effort.

Once clovers are controlled, change cultural practices in the landscape and turfgrass to reduce the chance of reinfestation. Insuring a thick stand of grass can help exclude clovers in turf. Fertilization can also influence clover growth. For instance, adjust the fertilizer program to include more nitrogen and less phosphorus in turfgrass. Mulches can be effective in excluding clovers and other weeds in landscapes.

Landscaped Areas. Annual clovers can be easily controlled by hand-pulling, hoeing, or cultivation. Mulching, depending on the size and depth of the mulch, can prevent seedling establish-



Figure 5. White clover plant.

ment. Before seeds germinate, a 4-inch thick organic mulch (e.g., compost, wood chips, etc.) can prevent establishment of clovers. Organic mulch can also be applied after the seedlings have germinated but must be applied more thicker layer (4 to 6 inches) and must cover the plants completely to block out all light. Organic mulches need to be reapplied each year to maintain the 4-inch-thick layer because they decompose and the thickness of the mulch declines over time. Woven black landscape fabric can exclude weeds over a number of years. Larger plants are more difficult to control with mulching, but they can be hand-pulled or hoed.

Preemergent Control. Preemergent herbicides available for landscape use are effective but generally unnecessary in the home landscape where annual clovers are easily controlled by the methods mentioned. For landscape professionals, herbicide formulations that contain isoxaben are effective for controlling annual clovers and can be used around many woody shrubs and trees. Most established annual flowers tolerate this herbicide. Herbicide formulations containing oryzalin, trifluralin, or pendimethalin will control most grass species and some broadleaf weeds but will miss many other broadleaf species (mustard, aster, legume, and cheeseweed families).

Postemergent Control. Postemergent control of clover is difficult. If the seedlings are small, glyphosate can be used in open areas provided desirable plants are not sprayed. Once annual clover plants reach 3 to 4 inches in

height, control with herbicides is more difficult. The top may be burned, but the plants often regrow. None of the herbicides used in turfgrass for clover control is safe to use in ornamental plantings because they can damage desirable plants.

Perennial clovers can also be controlled with glyphosate when the plants are seedlings, but once the clover is established, it cannot be controlled except by digging it out. Glyphosate at high rates will suppress some clovers.

Turfgrass Areas. Yellow turf and green clover is a good indication of low nitrogen fertility. The invasion of clover into turfgrass can be reduced by using levels of nitrogen fertilizer that will promote grass growth but not the growth of clover; this can be achieved by applying 1 pound of active nitrogen per 1,000 square feet of turfgrass during each month of active turfgrass growth (not to exceed 4 lb active nitrogen/1,000 sq ft/year). Also, high phosphorus in the soil promotes the invasion of clovers. However, nitrogen applications should be carefully calculated and applied to avoid runoff of excess fertilizer to municipal drainage systems. Clover in established turfgrass cannot be controlled by fertilization or mowing of the grass. Once clover is established, the annual clovers can be controlled by hand-pulling before seeds are formed. Hand-pulling will need to be repeated as new germination occurs and desirable turfgrass is planted in weeded areas.

Herbicide. Both established annual and perennial clovers can be controlled with postemergent herbicides. The best herbicide to use depends upon the species of turfgrass. Warm-season turfgrasses such as bermudagrass, zoysiagrass, and kikuyugrass will tolerate products containing mecoprop and dicamba but not triclopyr. Cool-season turfgrasses will tolerate all of the herbicides that control clover. The herbicide 2,4-D is not effective for clover control; it will injure the plant but does not control it.

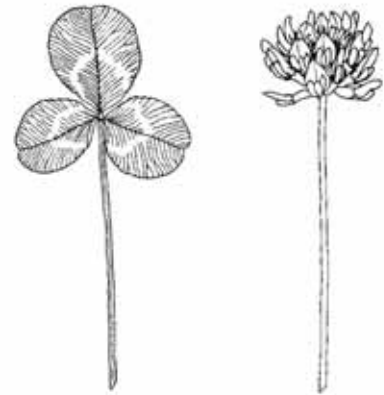


Figure 6. White clover leaf and flower.

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CRABGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Crabgrass is a weed almost everyone is familiar with. Two species are common in California—smooth crabgrass, *Digitaria ischaemum*, (Fig. 1) and large or hairy crabgrass, *D. sanguinalis*, (Fig. 2). Both were introduced from Eurasia and are widespread throughout the United States. As annuals, they germinate, set seed, and die within one year.

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

IDENTIFICATION AND LIFE CYCLE

Smooth Crabgrass

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

Seedling leaves are light green and smooth (Fig. 3). They are very conspicuous in the lawn with their lighter green color. True leaves are dark green but still smooth, and the leaf blade is from $\frac{1}{4}$ to $\frac{1}{3}$ inch across, up to 5 inches long, and pointed. Crabgrass often forms patches in lawns, and plants can grow together to form large clumps. The projection at the base of the leaf blade, known as the ligule (Fig. 4), is small



Figure 1. Smooth crabgrass.

and inconspicuous, and the collar region lacks the clasping, prominent outgrowths or auricles present on some grasses. The leaf sheath and upper leaf surface are smooth, but a few hairs can be present on the lower leaf surface. Sometimes a reddish tint is visible at the base of the leaf.

The inflorescence, or flower stalk, (Fig. 5) has branches that originate from the main stem at $\frac{1}{8}$ - to $\frac{1}{4}$ -inch intervals. The branches are $\frac{1}{2}$ to $2\frac{1}{2}$ inches long at the end of the stalk.

Large Crabgrass

When found in turf, large crabgrass is a low-growing, summer annual that spreads by seed and from rootings of nodes that lie on the soil. Unmowed, it can grow 2 feet tall. It won't tolerate close mowing as well as smooth crabgrass. As a result, smooth crabgrass is a more common weed in lawns.

Seedling leaves are light green and hairy. True leaves are generally 3 inches long and hairy on the upper surface of the leaf and leaf sheath. The collar region and flower stalk are similar to that of smooth crabgrass, but the branches are longer—about 2 to 5 inches—at the end of the stalk. One source reports seed production from a single, large crabgrass plant can be as high as 150,000.



Figure 2. Large crabgrass in a lawn.



Figure 3. Smooth crabgrass seedling.



Figure 4. Smooth crabgrass collar region and sheath. The ligule at the base of the leaf blade is a short projection, and there are no auricles.



Figure 5. Flowering stem of smooth crabgrass.

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Lifecycle

The flowering stems of both species of crabgrass are similar to those of bermudagrass and goosegrass, but the panicle-like branches (whorls) on the flowering stems of these other grasses originate at the same point while those on crabgrass originate about $\frac{1}{8}$ to $\frac{1}{4}$ inch apart at the end of the stem.

Dallisgrass, another common grass in lawns, has panicle branches that are widely separated on the flowering stem (Fig. 6). Dallisgrass and bermudagrass can be readily distinguished from crabgrass by their characteristic vegetative reproductive structures that allow rapid spread in the garden. Dallisgrass has short, thick, underground rhizomes, and bermudagrass spreads with slender, belowground rhizomes and aboveground rooting stems called stolons. As an annual weed, crabgrass spreads primarily by seed and doesn't have rhizomes or stolons.

In Southern California, the major germination period for both crabgrass species is from mid-January to early April, depending on the temperature; however, seeds can germinate throughout spring and summer. Although germination is early in areas with mild winters, growth is slow during spring months until mid-May. In June and July the plants produce primarily leaves and stems and typically flower in late July and August. In the absence of a frost, crabgrass can overwinter in warm areas or during warm winters and produce new growth and a second crop of seed in spring or early summer.

In central and northern parts of the state, crabgrass begins to sprout early to mid-March when soil temperatures reach 50° to 55°F for at least 3 consecutive days. Growth and germination will continue throughout summer and into fall.

MANAGEMENT

Crabgrass is easy to manage using a variety of cultural and chemical controls. Controlling crabgrass before it sets seed is important, because the seeds can remain viable for at least 3 years in soil.

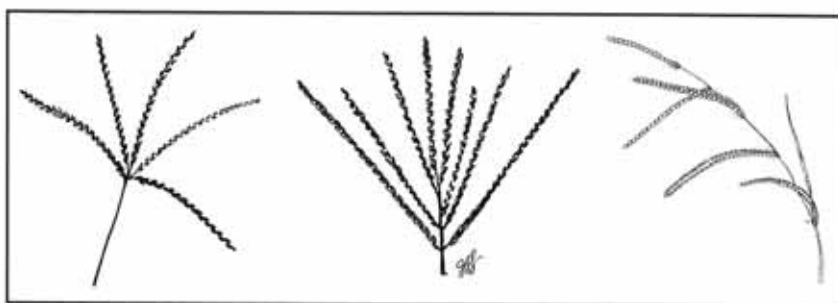


Figure 6. Flowering stems of bermudagrass (left), crabgrass (center), and dallisgrass (right).

Cultural Control in Turfgrass

Because crabgrass spreads and reproduces primarily by seed, any cultural efforts that reduce seed production will decrease occurrences of this weed. Cultural activities that increase the vigor of turfgrass also decrease the potential of crabgrass invasion. These include using the proper mowing height for your specific turf, selecting the best turf species for your area, overseeding to keep turfgrass thick, applying fertilizer at the correct time of year, and proper irrigation. For more information on maintaining vigorous lawns that out compete weeds, see The UC Guide to Healthy Lawns at www.ipm.ucdavis.edu/TOOLS/TURF/TURFSPECIES/.

Mowing at the optimum height for turf increases turfgrass vigor and reduces the germination and establishment of crabgrass. Select the proper mowing height from Table 1 for the dominant turfgrass species in your lawn. After mowing crabgrass-infested turf, thoroughly rinse the mower to remove seeds and avoid transferring them to uninfested sites.

Selecting a turfgrass that is adapted to your local conditions also will help produce vigorous turf. Cool-season species (bentgrass, Kentucky bluegrass, tall fescues, and perennial ryegrass) are most competitive in coastal and northern regions of California. Some of the newer cultivars of Kentucky bluegrass, tall fescue, and perennial ryegrass are even more competitive and grow better than the older cultivars. For example, tall fescue cultivars used

Table 1.

Proper Mowing Height for Turfgrass Species.

Turf species	Mowing height (in inches)
bentgrass, colonial	0.5–1
bentgrass, creeping	0.5 or less
bermudagrass, common	1–1.5
bermudagrass, hybrid	
Santa Ana	0.5–0.75
tifgreen	0.25–0.5
tifway II	0.5–0.75
bluegrass, Kentucky	1.5–2.5
dichondra	0.5–0.75
fescue, fine	1.5–2.5
fescue, tall	2–3
kikuyugrass	1–1.5
ryegrass, annual	1.5–2
ryegrass, perennial	1.5–2.5
St. Augustinegrass	1–2
zoysiagrass	.5–1

for turf vary in their ability to compete with both smooth and large crabgrass. Crabgrass tends to invade the older fescue varieties (Fawn and Kentucky 31), which grow in an open, upright manner. The slower-growing, dwarf-type tall fescue varieties, especially Bonsai, also are susceptible to crabgrass invasion. A newer Bonsai variety (2000) claims a more vigorous growth habit.

Warm-season species (bermudagrass, dichondra, St. Augustine grass, and zoysiagrass) are most competitive with weeds in interior valleys and desert regions. Kikuyugrass is more competitive in south coastal regions.

In the turf selection process it is important to consider the amount of foot traffic, pest problems, and/or shade, as these factors can significantly impact the vigor of the lawn. For example, hybrid bermuda can be very competitive, but only if it receives adequate sunlight. If it receives fewer than 6 hours of sun during the day, it will grow poorly and weeds can easily invade. Tar Heel tall fescue withstands more foot traffic on the lawn than does the variety Justice. Other newer tall fescue varieties include Barlexas, Coyote, Greenkeeper, and Innovator.

Fertilizers can increase turfgrass vigor and reduce the possibility of a crabgrass invasion. The best time to fertilize is when the turf is actively growing, which depends upon your turf species (Table 2). Because seedling crabgrass isn't very competitive, a vigorously growing turf will crowd out new seedlings.

Irrigation timing and amount also can affect crabgrass germination and growth. Overwatered turf or turf that receives daily, light irrigation becomes weak and vulnerable to invasion by this weed. Irrigating once a week will improve turf vigor. Often, crabgrass first appears in open areas with no turf, along sidewalks where the soil can be warmer, or around sprinkler heads where turf is mowed more closely.

Cultural Control in the Landscape and Garden

In the landscape, you easily can control crabgrass by mulching, hoeing, and hand pulling when the plants are young and before they set seed. You also can control this weed with solarization. Several chemical herbicides are available but often aren't necessary.

Mulching with wood products (e.g. wood chips or nuggets), composted yard waste, or synthetic landscape fabrics covered with mulch will reduce crabgrass in shrub beds and bedding plants and around trees by blocking sunlight needed for its germination, establishment, and growth. Mulch depth depends on the size of the particles; coarse mulch might need to be 3 to 6 inches deep to control all weeds, while

a finer mulch might need to be only 2 to 3 inches deep. Plan to replenish landscape mulches periodically because of decomposition, movement, or settling.

Organic mulches that have been on the soil for a while decomposing can provide an adequate growth medium for weeds to germinate and grow in. If crabgrass is germinating in the mulch, move it about with a rake to reduce seedling establishment. Hand pull escaped crabgrass plants before they set seed. Flaming with a hand-held burner will control crabgrass seedlings, but be careful not to set fire to the mulch if it is wood chips, compost, or another flammable material.

Soil solarization with clear plastic prior to planting is effective for eradicating crabgrass plants and seed if you apply it during periods of high solar radiation. For more information about this process, see *Pest Notes: Soil Solarization for Gardens & Landscapes* in References.

Chemical Control

Crabgrass is easy to control in both turfgrass and ornamental beds if you apply preemergent herbicides before it germinates or postemergent herbicides after it germinates. Avoid using chemical herbicides in vegetable gardens because of the variety of crops grown and planted there.

Read the label to make sure the product is safe to use on your turf type and around the ornamentals in your landscape. The active ingredients listed below can be found under different brand names; for a partial list, see Table 3.

Table 2.
Periods of Active Growth for Cool- and Warm-season Turf Species.

Turfgrass species	Period of active growth
Cool-season turf	
bentgrass	March–June, September–November
bluegrass, Kentucky	late February–late May, October–December
fescue, fine	March–June, October–December
fescue, tall	March–June, October–December
ryegrass, annual (for overseeding)	October–May
ryegrass, perennial	February–June, October–December
Warm-season turf	
bermudagrass	April–late September
dichondra	April–October
kikuyugrass	February–November
St. Augustinegrass	March–October
zoysiagrass	April–October

Table 3.
Examples of Preemergent and Postemergent Herbicides with Brand Names.

Herbicide	Brand name	Homeowner or professional use?	For use on turf?
Preemergents			
bensulide	Bensumec, Pre-San	homeowner	yes
dithiopyr	Dimension, Preen	professional	yes
oryzalin	Surflan, Weed Impede	homeowner	yes
oxadiazon	Ronstar	professional	yes
pendimethalin	Pendulum, Pre-M, Scotts	homeowner	yes
prodiamine	Barricade	professional	yes
trifluralin	Vegetable and Ornamental Weeder	homeowner	no ¹
Postemergents			
dithiopyr	Dimension, Preen	professional	yes
fluazifop	Poast, Grass Getter, Ornamec	homeowner	no
quinclorac	Drive, Momentum, Trimec Crabgrass	homeowner	yes
sethoxydim plus oil	Fusilade	homeowner	no

¹ Warm-season turf (bermudagrass and St. Augustine only). Will injure cool-season species.

Preemergent herbicides available for home gardeners for crabgrass control in warm-season grasses (bermudagrass and zoysiagrass) and cool-season grasses (Kentucky bluegrass, fine fescue, tall fescue, and perennial ryegrass) include benefin, bensulide, pendimethalin, and trifluralin.

Professional pesticide applicators also can use dithiopyr, oxadiazon, and prodiamine. Oryzalin also is available for home gardeners, but it is for use in warm-season turf (bermudagrass and zoysiagrass) only.

Apply preemergent herbicides before crabgrass germinates, usually around the first of March. Many fertilizers contain a preemergent herbicide (weed and feed) so that the spring fertilization and preemergent treatments can be done at the same time. However, timing is critical, and weed and feed products often are applied at the wrong time.

Crabgrass has germinated as early as Jan. 30 in Bakersfield and Fresno on warm days. If a preemergent were applied at that time it could start to break down in 4 to 5 months, and a second application could be required. Follow label directions during application and make sure there is adequate overlap, as the herbicide is applied in the lawn to prevent strips of weeds from coming up.

There are few **postemergent herbicides** available for crabgrass control in lawns. Dithiopyr currently can be applied to home lawns but only by professional applicators. Dithiopyr provides good preemergent control of seeds and con-

trols emerged crabgrass plants up to the third leaf stage.

Quinclorac often is sold in a ready-to-use spray bottle for the homeowner; however, crabgrass control is only partial, and some species have shown resistance to this product. Companies have stopped making products containing the active ingredients MSMA and DSMA, which have been used since the 1950s, and some companies are substituting quinclorac.

Use postemergent herbicides when crabgrass is small (in the 1- to 3-leaf stage). If the crabgrass is larger, it takes more herbicide to control it, and there is a greater chance of injury to the turfgrass.

In **ornamental beds**, home gardeners can use the preemergent herbicides benefin, oryzalin, and trifluralin to control crabgrass. Landscape professionals also can use oxadiazon, pendimethalin, and prodiamine. You can use these chemicals either before crabgrass has germinated or after you've removed the weed by hoeing or hand pulling but before another flush of germination.

Use a postemergent selective herbicide (fluazifop, quinclorac, or sethoxydim plus oil) to control crabgrass over or around most broadleaved ornamentals. You also can use nonselective herbicides such as glufosinate-ammonium, glyphosate, or pelargonic acid. Use nonselective herbicides with care to prevent them from harming desirable shrubs. All of these herbicides are available for use for home gardeners.

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

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Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original, labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down the sink or toilet. Either use the pesticide according to the label, or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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DALLISGRASS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Dallisgrass, *Paspalum dilatatum*, is a tufted perennial grass that was introduced into the United States from Uruguay and Argentina. It is now naturalized in much of the southern United States. In California dallisgrass is found throughout the state except at high elevations, such as the Great Basin and Sonoran Deserts. It has been used as a pasture grass in wet areas or irrigated sites, but it is less commonly used as forage in California because of its weedy character. The seed heads are susceptible to an ergot fungus that is toxic to livestock when ingested. Dallisgrass is primarily a weed in turfgrass, wet roadside areas, irrigation ditchbanks, and in some orchards and vineyards. It is closely related and similar in appearance to knotgrass, *Paspalum distichum*, which is a mat-forming perennial grass with good forage qualities and more desirable attributes for natural areas. Bahiagrass, *Paspalum notatum*, is also a warm-season tufted perennial with short rhizomes that could be confused with dallisgrass.

IDENTIFICATION AND LIFE CYCLE

Dallisgrass is a coarse-textured grass that grows in a clump and slowly increases in diameter as its shallow, underground stems (short rhizomes) grow outward. The rhizomes have short internodes (the length of stem between the joints) that look like concentric rings on its surface (Fig. 1). The presence of these distinctive rhizomes is a good way to distinguish dallisgrass from other common clumping grasses in lawns, such as crabgrass. As the clump matures, the center may die and a different grass or weed may be growing in its center. Where large

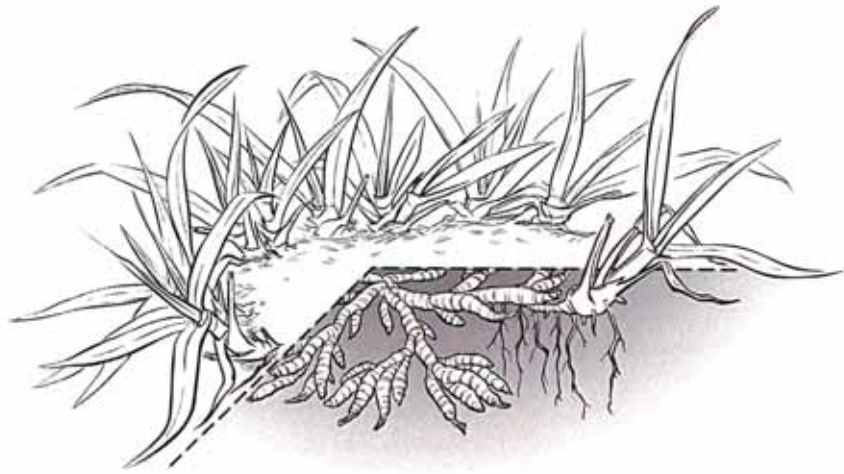


Figure 1. Dallisgrass grows in a clump and increases in diameter as its shallow, underground stems (rhizomes) grow outward.

numbers of dallisgrass plants grow together they can form almost a solid planting with uneven texture and poor turfgrass qualities.

The leaf blades of dallisgrass are fairly wide ($\frac{1}{4}$ – $\frac{1}{2}$ inch) compared to desirable thinner turf grasses. If left unmowed, blades will grow 4 to 10 inches long. At the base of each leaf blade is a collar with a membranous ligule about $\frac{1}{4}$ inch long and no auricles or projections. At the base of the collar is the leaf sheath, which is slightly flattened. Frequently there is purplish coloration at the base of the grass stems (technically called culms). The flowering stalk (raceme) grows 14 to 65 inches tall and the flower head (inflorescence) consists of 2 to 10, often drooping, spikelets (delicate branches) that arise from different points at the top of the flower stalk. Each spikelet has two rows of flat, egg-shaped seeds along its entire length and is pale green to purplish in color. (Fig. 2).

For information on other troublesome species of grasses or grasslike weeds, see *Pest Notes on Annual Bluegrass, Bermudagrass, Crabgrass, Kikuyugrass, Nutsedge, and Green Kyllinga* listed in Suggested Reading.

Dallisgrass produces abundant amounts of seed, which are its primary means of dispersal. Water, lawn mowers, and humans or pets spread the seed to new places. Seeds usually germinate in spring and summer when soil temperatures are in the 60° to 65°F range and grow to form new clumps. The optimum air temperature range for growth is 80° to 90°F and when temperatures are in this range, plants grow very rapidly. This weed is often found growing in wet areas such as drain ditches, low places, and in heavily irrigated turfgrass. It tolerates both sandy and heavy clay soils and, once established, is drought-resistant and frost-tolerant. Dallisgrass does not become off-color in winter like many

warm-season grasses. It responds to nitrogen fertilizer and competes well against turfgrasses in fertilized sites.

IMPACT

Dallisgrass creates an unsightly clump in turfgrass that can be a problem in golf courses, sports playing fields, and home landscapes. The stiff clumps are much coarser in texture than other grasses common in developed recreational areas such as lawns, golf courses, or parks and can present a hazard in sports fields and play areas, causing people to fall. It has a faster growth rate than turfgrasses. The flower stalks (racemes) often escape mowing and spring back up above the rest of the turfgrass, causing problems in golf courses and sports fields as well as lending a rough, uneven appearance to lawns (Fig. 3).

MANAGEMENT

A major component of dallisgrass management is preventing establishment of new plants. In home landscapes, removing young plants by digging them out before they form rhizomes or set seed is the best strategy for control. Mature plants can also be dug out, but they sometimes grow back if rhizomes are left behind. In professionally managed turfgrass areas, prevention is an important component in managing this weed. When dallisgrass is abundant or the plants are located over a large area, it may be necessary to supplement cultural practices with herbicides.

Prevention

Dallisgrass can be introduced into lawn areas with new turfgrass seed or sod, but often the seed is introduced on mowers that have been used in contaminated sites and then moved to weed-free sites. Cleaning a mower after mowing a contaminated site should reduce the chance of invasion into new areas. Inspect sod before taking delivery to make sure dallisgrass is not present. Don't use soil from dallisgrass-contaminated areas to repair low or bare spots in lawns. In dallisgrass infested areas delay or minimize the amount of aeration performed on the turfgrass in spring when new

seedlings germinate to avoid small open areas where dallisgrass plants might become established.

Cultural Control

Because dallisgrass is a perennial plant, persistence is required to kill it with cultural practices. In lawn areas the clumps can be removed by digging. Mowing the turfgrass will not remove dallisgrass, but when turfgrass is mowed at its optimum height, it is better able to resist an invasion of this weed.

When dallisgrass has been established for some time in the turfgrass, seed will be abundantly present in the soil. In well-established turfgrass, seedlings may not be able to establish, but if there are open areas in the turf, seed will germinate in these areas. If bare areas are present, overseed them with desirable turfgrass species to reestablish the turf.

Dallisgrass is not normally a problem in ornamental beds, but if it does occur, the plants can be dug out and a thick layer of mulch laid over the area to control the seedlings. Along roadsides and fences or in orchards and vineyards, the plants can be dug out during summer and left in place for the clumps of rhizomes to dry. As long as all the rhizomes are dug up and dried, the plant will not regrow. New seed will continue to germinate and establish unless the seedlings are removed.

Mulching with organic materials is not very effective for the control of mature dallisgrass. However, if the tops of the plants are removed down to the soil line, laying black plastic or landscape fabric over the area will control the remainder of the plant as well as any new seedlings. Summer solarization with clear plastic significantly helps control dallisgrass seed and reduces rhizome regrowth. For information on solarization, see the publication *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds* listed in References.



Figure 2. Dallisgrass flower head.



Figure 3. Dallisgrass creates unsightly clumps in turfgrass and the flower stalks often escape mowing causing hazards in recreational areas.

Chemical Control

Where digging out clumps of dallisgrass in turfgrass is not practical, herbicides may be used. Herbicides to control established plants are referred to as *postemergent* herbicides. These herbicides are either selective and kill only specific weeds, or they are nonselective and kill any plant they come in contact with. To control germinating seed, *preemergent* herbicides are used. In order to obtain complete control of this perennial grass weed, it is necessary to control both the established dallisgrass plant and the germinating seed.

Established Plants in Turfgrass. The postemergent herbicides MSMA or CMA (such as Weed-Hoe or Weed-B-

Gon Crabgrass Killer for Lawns) can be used by home gardeners to control clumps of dallisgrass growing in lawns. These herbicides are relatively selective and must be applied two to three times at 3-week intervals in the summer. The turfgrass and dallisgrass should be in good growing condition before application. Also, it is best if the turf is left unmowed for 2 weeks before the first application to create the maximum amount of leaf area for coverage by the herbicide spray. Withhold irrigation for 24 hours after application. Don't apply these herbicides during extremely hot weather and check the label for rate adjustments during warm weather to minimize the risk of injuring the turfgrass. There are some restrictions on turfgrass types where these products can be used, such as on St. Augustinegrass.

Foramsulfuron (Revolver) is a new postemergent herbicide for control of cool-season grass weeds and turf species in warm season lawns. It can only be used in bermudagrass and zoysiagrass lawns and has good weed control activity on dallisgrass, but be aware that it is harmful to most cool season turfgrasses. This product is only available to professional applicators at this time, but may be used on residential lawns.

Some turf managers and home gardeners use the nonselective herbicide glyphosate (Roundup) to control dallisgrass in turf. Glyphosate kills both the dallisgrass and the turfgrass, leaving an area of dead turf. To keep the turf vigorous and growing well enough to out compete germinating dallisgrass seed, the spot needs to be overseeded or a preemergent herbicide needs to be applied. Sometimes dallisgrass is not entirely killed after an herbicide treatment, even though the turf is severely damaged or killed, and retreatment may be required. Other nonselective postemergent herbicides are not as effective as glyphosate.

Seed in Turfgrass. Preemergent herbicides can be used in established turfgrass to control germinating dallisgrass seed. Apply preemergent her-

bicides in late winter or early spring before dallisgrass seed germinates. Herbicides that control crabgrass such as benefin + oryzalin, bensulide, DCPA, dithiopyr, oryzalin, oxadiazon pendimethalin or prodiamine, are also effective on dallisgrass. (Bensulide, DCPA, and oxadiazon are for professional use only and may have some restrictions for use on residential lawns.) Preemergent herbicides used on lawns need to be irrigated into the soil with about ½ inch of water relatively soon after application in order to become effective. Consult the label for application details.

Ornamental and Noncrop Areas. In ornamental or noncrop areas, glyphosate can be used as a nonselective treatment to control established plants. Apply glyphosate when dallisgrass is flowering but before seed has been produced.

The preemergent herbicides napropamide, oryzalin, pendimethalin, or combinations of benefin plus oryzalin are effective to prevent dallisgrass seed from germinating. Benefin plus trifluralin is also available, but only for use by commercial pest controllers. Once seedlings appear, then postemergent herbicides may be necessary to control them chemically.

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SUGGESTED READING

For information on other troublesome species of grasses or grasslike weeds, see these additional *Pest Notes* on Annual Bluegrass, Bermudagrass, Kikuyugrass, Nutsedge, and Green Kyllinga. Available online, <http://www.ipm.ucdavis.edu/PMG/PESTNOTES>.

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DANDELIONS

Integrated Pest Management for Home Gardeners and Landscape Professionals



Figure 1. Dandelion.

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

Dandelion was introduced from Europe and has been used as a pot-herb and medicinal plant since Roman times. It has a high vitamin and mineral content. Mature leaves are often dried and used to make a mild tea. Roots are often used to make stronger tea or dried and used for various medicinal purposes including a mild diuretic. Salads, beer, and wine are also made from the leaves and flowers.

IDENTIFICATION AND LIFE CYCLE

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

Flowering stalks are 6 to 24 inches in length and terminate in a compound inflorescence or head that contains 100 to 300 ray flowers and looks like a characteristic puffball. Each ray flower has a strap-shaped yellow petal with five notches at the tip. Dandelion flowers are not normally pollinated but develop asexually. Flowering occurs nearly year round in the temperate climatic regions of California. The seeds are achenes and are about 1/8 inch in length with five to eight ribs. At the apex of the achene there is a slender stalk (about two to four times the length of the achene) that



Figure 2. Deeply serrated dandelion leaf margin.

terminates in a parachute-like structure (pappus), allowing the seed to be transported via wind currents for miles (Fig. 3).

Seed germination occurs at or very near the soil surface. Light increases germination. The seed germinates when soil is moist and soil temperature is at least 50°F; however, germination is more rapid when the soil temperatures are closer to 77°F. Germination occurs throughout the growing season. The seedling stage can last 8 to 15 weeks, depending on temperature and growing conditions.

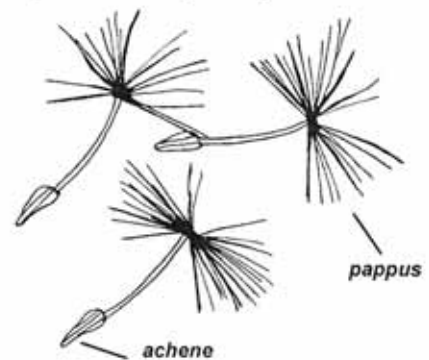


Figure 3. Dandelion seed.

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Seedling growth is slower in cold weather.

Flowering begins soon after the seedling stage and continues throughout the life of the plant. Dandelion plants can survive for many years, developing massive, thickened crowns 6 to 10 inches across. These perennial plants are well adapted to irrigated areas such as in turfgrass, pastures, or alfalfa where frequent mowing or grazing is practiced.

IMPACT

Dandelion can be a major weed problem for turf and ornamental managers. In turf, it forms clumps that cause poor footing for athletic fields and golf courses. Dandelion's texture and color vary from that of normal turfgrass and the yellow flowers reduce the aesthetic quality of the turfgrass.

When dandelion infests turfgrass and ornamental plantings, it forms dense circular mats of leaves (6 to 14 inches in diameter) that crowd out desirable species and reduce the vigor of those plants that survive. Because of the extensive root system of established plants, hand-pulling or hoeing to remove dandelion is usually futile unless done repeatedly over a long period of time. Thus, control by this means is most successful in areas such as home lawns and gardens. Once a few plants become established in turfgrass or ornamental areas, their seed can be spread by wind or equipment.

Dandelion is also found in nontilled orchards where mowing is used for weed control. It can be a problem in spring when trees are in bloom because it is very attractive to bees. The pappus on the seed frequently clogs up tractor radiators, and roots of dandelion are attractive to gophers. As a weed in irrigated pastures and alfalfa, dandelion is usually most serious in the intermountain regions of

California where these sites remain in production for long periods of time (more than 5 years). Although it is slow to establish, once established it is difficult to control because of its extensive root system.

MANAGEMENT

Because dandelion seed can be wind-borne for several miles, prevention of new infestations is difficult. Solitary new dandelion plants along fence rows, roadsides, flower beds, and in turfgrass should be grubbed out (digging out the entire plant, taproot and all) before they produce seed. Monitor the area for several months to make sure that removal was complete. Areas with infestations should be isolated and seed heads removed until control can be accomplished. Turfgrass and ornamental areas should be well maintained to assure maximum vigor. Making these plantings as competitive as possible will slow invasion of the weed. Dense stands of turfgrass and ornamentals shade the soil surface, making the establishment of new dandelion seedlings more difficult.

Home Landscapes

In the home landscape, dandelion plants can easily be grubbed out, especially when they are young. Dandelion knives and similar specialized tools are available for removing in-

dividual weeds and their roots while minimizing soil disturbance. Control dandelion plants before they set seed to reduce the potential for further invasion by this weed. Also, landscape fabrics (see "Ornamentals" below) can be used to control this weed.

Turfgrass

No single control procedure has been successful in controlling dandelion in turfgrass. Early grubbing of new seedlings has been successful when practiced diligently. These plants must be dug up regularly for several years to be successfully eliminated. Spot spraying isolated plants with glyphosate can be helpful, but the turfgrass is killed, leaving open areas. Overseed the open spots to establish a vigorous turf sod.

The preemergent herbicides commonly used to control crabgrass in turfgrass have not been successful in limiting germination of dandelion. However, a relatively new broadleaf preemergent herbicide, isoxaben, has been effective but, like all preemergent herbicides, must be applied to the soil before the dandelion seed germinates (Table 1).

Postemergent herbicides that control broadleaf weeds (2,4-D, triclopyr, MCPA, and mecoprop) can control dandelion seedlings. Control of es-

TABLE 1. Summary of Herbicides for Dandelion Control.

Site	Material	Applied to soil before germination	Applied to young plants	Readily available to home gardeners
Turfgrass	glyphosate	—	x	yes
	isoxaben	x	—	yes
	2,4-D	—	x	yes
	triclopyr	—	x	yes
	MCPA	—	x	yes
Ornamentals	mecoprop	—	x	yes
	isoxaben	x	—	no
	oxyfluorfen	x	—	no
Orchards	glyphosate	—	x	yes

x = yes
— = no

established plants with a postemergent treatment is much more difficult; 2,4-D works best for established dandelion control while triclopyr, MCPA, and mecoprop reduce dandelion vigor but do not kill it.

Ornamentals

There are few options for the control of dandelion in ornamental plantings. Prevention is very important. Hand removal or spot treatment of solitary plants with glyphosate will save time and money in the long run. Pulling or hand-hoeing is helpful if done periodically during the year; however, regrowth from the extensive perennial root system limits the effectiveness of this method.

Mulching with landscape fabrics can be particularly effective for controlling seedlings if the fabric is overlapped and no light is allowed

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to penetrate to the soil. Use a polypropylene or polyester fabric or black polyethylene (plastic tarp) to block all plant growth. Fabric mulches should be covered with an organic mulch to improve aesthetics and to reduce photodegradation. Organic mulches such as wood chips or bark may also be effective in controlling dandelion seedlings if they are at least 3 inches deep and are managed in such a way as to not provide a growth medium for new dandelion seedlings.

Isoxaben and oxyfluorfen have been useful in limiting dandelion infestations when they are applied to the soil before the seed germinates. These materials can only be applied by a licensed pesticide applicator, and control may be difficult because of dandelion's extended germination period. If isoxaben is used, lightly hoe any dandelion seedlings that escape the treatment; if oxyfluorfen is used, do not disturb the soil after application.

Few postemergent herbicides are registered for use in established ornamental plantings. Spot treatment with glyphosate can control existing dandelion plants, but do not allow the spray or drift to contact desirable plants or injury will result.

Orchards

Dandelion can be managed in commercial orchards through summer cultivations or by maintaining a competitive cover crop. Glyphosate is often used to spot treat individual plants.

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Invasive Plants of California's Wildland

Foeniculum vulgare

Scientific name *Foeniculum vulgare*

Additional name Miller

information:

Common name fennel, anise, sweet fennel, aniseed, sweet anise, sweet fennel

Synonymous scientific names *Anethum foeniculum*, *Foeniculum officinale*

Closely related 0

California natives

Closely related 0

California non-

natives:

Listed

CalEPPC List A-1, CDFA nl

Distribution



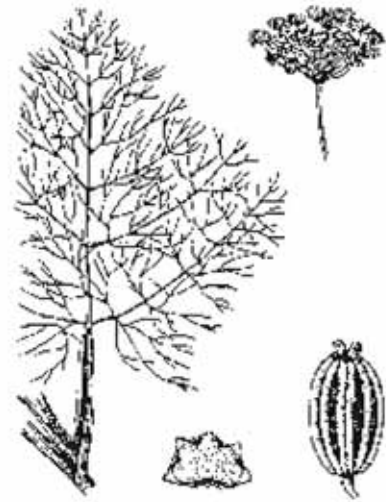
HOW DO I
RECOGNIZE IT?

*Distinctive
features:*

Fennel (*Foeniculum vulgare*) is an erect perennial herb, four to ten feet tall, with finely dissected, almost feathery leaves and characterized by a strong anise scent originating from stems and leaves. The flowers are yellow and small (one-quarter inch across), and are clustered in large, rounded, umbrella-like groups (compound umbels), roughly four inches across, that are conspicuous from April through July. During the growing season plants usually include a mixture of living and dead hollow stems (canes). Branches arise from the stems at conspicuously jointed nodes, and leaves arise both from the root crown and from the stems. Leaves sheath the stems where they meet. Seeds of wild fennel look like the fennel seed commonly used as a flavoring in foods: they are oblong, dorsally compressed, and ribbed.

Description:

Apiaceae. Perennial herb, 3.3-12 ft (1-3.5 m) high with a characteristic anise or licorice scent. Roots: mature plants have a thick, deep taproot from which erect, solid glaucous-green stems arise. Stems: 10-20 stems originate from a basal cluster in late winter, then die back the following September-November. Leaves: petioles 2.8-5.6 in (7-14 cm) long sheaths hug the stem; leaf blades triangular-ovate in outline and 0.3-2 ft (10-60 cm) long, 1-1.3 ft (30-40 cm) wide, finely dissected into nearly thread-like segments. Inflorescence: compound umbel with 15-40 spreading-ascending rays, each 0.4-1.6 in (1-4 cm) long.



Flowers: no sepals, yellow petals with narrowing tips, 5 small stamens, inferior ovary topped by two short styles. Fruits: 0.1-0.2 in (2.5-4.5 mm), oblong-ovate, dorsally compressed, with thick, prominent ridges.

WHERE WOULD I FIND IT?

In California fennel is found in mesic locations with a Mediterranean climate from sea level to 2,000 feet. It usually colonizes disturbed areas, especially weedy sites adjacent to fresh or brackish water, and pastures, abandoned lots, and roadsides. Common in open habitats such as grasslands, coastal scrub, savannas, and the banks of creeks, estuaries, and bays. Dense local populations have been reported from Santa Cruz Island, in fields around the San Francisco Bay region, Palos Verdes Peninsula (Los Angeles County), and Camp Pendleton (San Diego County). It is widely scattered in fields and ditches throughout the Sacramento, Salinas, and San Joaquin valleys and foothills, and in hillside pastures of most coastal counties from Mendocino south to San Diego. Fennel is particularly aggressive in areas subjected to plowing or medium-heavy grazing and recently abandoned (Beatty 1991).

Fennel occurs in soils with pH ranging from 4.8 to 8.3, but appears to prefer more acidic than alkaline conditions. The preferred soil type appears to be well drained, sandy soils, but it has been observed to thrive in sites with a high clay content (pers. observation). Fennel forms dense stands in localized areas (Beatty 1991, Beatty and Licari 1992, R. Klinger, unpubl. data).

WHERE DID IT COME FROM AND HOW IS IT SPREAD?

Fennel is native to southern Europe and the Mediterranean region, where it has been used for centuries as a spice and for medicinal purposes (Garland 1979). Although details about its introduction are unknown, it has occurred in California for at least 120 years and is presumed to have escaped from cultivation repeatedly (Robbins et al. 1941).

Fennel will reproduce from both root crown and seed. Seeds are dispersed by water and on vehicles and clothing. Birds and rodents eat the seeds and may disperse them as well.

WHAT PROBLEMS DOES IT CAUSE?

Fennel will invade areas where the soil has been disturbed and can exclude or prevent reestablishment of native plant species. It can drastically alter the composition and structure of many plant communities, including grasslands, coastal scrub, riparian, and wetland communities. It appears to do this by outcompeting native species for light, nutrients, and water and perhaps by exuding allelopathic substances that inhibit growth of other plants (Granath 1992, Colvin 1996, Dash and Gliessman 1994). It develops dense, uniform stands. On Santa Cruz Island fennel can

achieve 50 to 90 percent absolute cover and reach heights of ten feet (Brenton and Klinger 1994). Once established, fennel is tenacious and difficult to control. Because of its prolific seed production and seed viability, a long-lived seedbank can build up rapidly.

Most impact assessment for fennel has focused on native plants, but fennel's value to animals is unknown. Grazers will feed on early-season regrowth, and feral pigs will seek out and eat the roots, but mature stems are generally not used as food. Birds and rodents eat the seeds.

Fennel stand development and successional patterns are poorly understood, especially with regard to persistence. It is unclear whether fennel stands are an edaphic climax, or whether another plant community will replace them after several decades. In parks and preserves where fennel removal is part of a restoration program, transitional communities will occur after fennel is removed, but these may be dominated by other non-native species (Brenton and Klinger 1994). Klinger and Brenton (in prep. and in review) found there was a significant increase in native herbaceous species shortly after removal of fennel, but the areas quickly became dominated by non-native grasses.

HOW DOES IT GROW AND REPRODUCE?

Fennel reproduces from both root crowns and seeds. Flower production generally begins when individuals are eighteen to twenty-four months old. Flowering stems begin to be produced in late winter to early spring, and flowers appear by early May. Seed production is prolific and can begin as early as May and continue through early November. Generally, seed production peaks in August and September. Seeds are dispersed by water, by animals, and by humans by clinging to clothing or mud on vehicles.

Seeds may persist in soil for several years without germinating. Germination can occur almost any time of the year. Vegetative growth begins in mid-winter and peaks in July to August. Initial growth during winter and spring is slow, then becomes rapid in early summer. Flowering stems die during late fall and early winter, although some remain alive and begin to produce new leaves with the onset of rains. Plants have a thick taproot.



There is little quantitative data on the population biology of fennel. Data on germination rates, seed production, survival, and longevity, density, and viability of the seedbank would be useful for developing management programs.

[\(click on photos to view larger image\)](#)



HOW CAN I GET RID OF IT?

Little published information is available on controlling fennel (Brenton and Klinger 1994, Dash and Gliessman 1994). Management plans should include a survey of where fennel occurs, the current land use, land use in adjacent areas, anticipated changes in land use, and primary dispersal mechanisms.

In areas where fennel stands are already well established, management will require a long-term commitment of time and resources. Management efforts should focus on preventing or reducing disturbance favorable to further spread (soil disturbance, moderate to heavy grazing) and reducing fennel density within dense stands. Dash and Gliessman (1994) reported that non-native species dominated all areas following fennel control regardless of the technique used. For these reasons, fennel removal should be considered only a first step in a larger restoration process that will require other actions to favor recolonization by native species (Dash and Gliessman 1994). It is probably impossible to completely eradicate fennel from wildlands, but reducing stand density and disturbance will minimize its impacts.

Physical control:

Manual/mechanical methods: Manual methods are most effective when infestations are light and locally restricted (Dash and Gliessman 1994). Digging out individual plants by hand is preferred to plowing or bulldozing because it minimizes soil disturbance, but it is labor-intensive.

Cutting, mowing, and chopping temporarily reduce the height of fennel plants within a stand, but they are ineffective as methods of removal and minimally impact the spread of fennel stands (Dash and Gliessman 1994, Colvin 1996). These techniques leave the roots intact, alive, and ready to support regrowth of shoots. Repeated cuts may have more impact by helping to exhaust the resources of the taproot over time. However, intervals between cuts must be short, because fennel recovers rapidly from cutting and begins to replenish its root energy supplies (Brenton and Klinger in review, Dash and Gliessman 1994). Cutting while plants are producing seed will promote dispersal.

Prescribed burning: Experiments on Santa Cruz Island indicate that burning is not an effective control method by itself (Klinger and Brenton in prep.). However, fall burns (November-December) followed by herbicide sprays the following two springs can reduce fennel cover 95 to 100 percent (Klinger and Brenton in prep.). For reducing fennel in large areas with dense stands, this method is effective but costly.

Biological control: Insects and fungi: No biological controls agents for fennel are known.

Grazing: Use of livestock to control fennel will probably be ineffective except where stands are small, not very dense, and young. In older and/or dense stands grazing will spread fennel further (Brenton and Klinger 1994). Since fennel can reproduce by roots as well as seed, removal of above-ground shoots will slow, but not prevent, vegetative spreading. If livestock are in pastures when fennel is producing seed, they will spread the seed to new areas. Most heavily infested areas of Santa Cruz Island were formerly used as cattle pastures (Beatty 1991).

Chemical control: Brenton and Klinger (1994 and in review) found that 95 to 100 percent kill was achieved when amine and ester formulations of triclopyr (Garlon 3A® and Garlon4®, respectively) were applied to fennel in early spring at rates of 6 lbs/100 gallons water (1 lb active ingredient/acre) on Santa Cruz Island. Lower concentrations (3.0 and 4.5 lbs/100 gallons) of both the amine and ester formulations were less effective, and all treatments were less effective when administered in late summer rather than early spring. Cutting fennel and treating the cut stems did not increase the effectiveness of the herbicide.

Dash and Gliessman (1994) reported that glyphosate (as Roundup®) sprayed in spring at the manufacturer's recommended rate reduced fennel cover 75 to 80 percent. Cutting prior to spraying did not increase the effectiveness of the treatments.

FIELD BINDWEED

Integrated Pest Management for Home Gardeners and Landscape Professionals

Field bindweed, *Convolvulus arvensis*, (Fig. 1) is a native of Eurasia that first was documented in California in 1884 in San Diego. By the first quarter of the twentieth century, field bindweed was proclaimed the worst weed in California and many other Western states. It most likely arrived in the United States as a contaminant in farm and garden seeds. However, because of its flowers and climbing nature, some seeds were probably planted as ornamentals, as a ground cover, in hanging baskets, or on trellises. Field bindweed has been given many names including perennial morningglory, creeping jenny, bellbine, sheepbine, and cornbind.

IDENTIFICATION

The first two leaves (cotyledons) of a field bindweed seedling are nearly square with a shallow notch at the tip (Fig. 2). Plants that arise from rhizomes (underground stems) lack these seed leaves. The first true leaves are arrowhead shaped and have petioles (leaf stems) that are flattened and grooved on the upper surface (Fig. 3).

Mature field bindweed plants have arrowhead-shaped leaves that can be 1/2 to 2 inches long, depending on environmental conditions. Mature leaves at the base of the stem are larger than the young leaves at the stem terminal. The flowers are trumpet shaped, white to pink, and 1 to 1 1/2 inches wide.

Field bindweed is a prostrate plant unless it climbs on an object for support. It often is found growing on upright plants, such as shrubs or grapevines, with its stems and leaves entwined throughout the plant and the flowers exposed to the light (Fig. 4). Under warm, moist conditions, leaves



Figure 1. Field bindweed.



Figure 2. The first two leaves (cotyledons) of a field bindweed seedling are notched.



Figure 3. Field bindweed seedling.

are larger and vines more robust than under drought conditions.

The root system has both deep vertical roots and shallow horizontal lateral roots (Fig. 5). The vertical roots can reach depths of 20 feet or more. However, 70% of the total mass of the root structure occupies the top 2 feet of soil. Most of the lateral roots are no deeper than 1 foot. Experiments on bindweed have shown that its root and rhizome growth can reach 2 1/2 to 5 tons per acre.



Figure 4. Field bindweed climbing up the stem of a shrub.

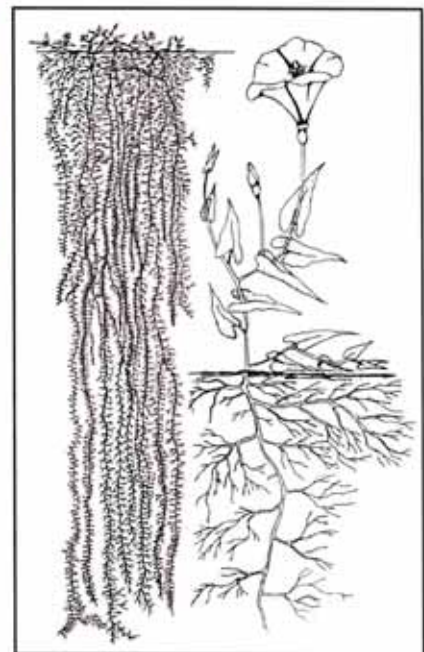


Figure 5. The root system of field bindweed can reach depths of up to 20 feet.

PEST NOTES

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In contrast to field bindweed, the ornamental annual morningglory (in the genus *Ipomen*) has a larger (2-inch wide) and more showy flower that can be white to blue or purple (Fig. 6); it also has a thicker stem, that is sometimes hairy, and heart-shaped leaves that are 1 1/2 inches wide and 2 inches or more long. The two species are easy to distinguish from each other.

LIFE CYCLE

Field bindweed is a hardy perennial found throughout California below the 5,000-foot elevation line. It spreads from an extensive rootstock and from seed. Most parts of the bindweed roots and rhizomes can produce buds that can create new roots and shoots. Roots capable of budding are found to depths of 14 feet. Fragments of vertical roots and rhizomes as short as 2 inches can form new plants (Fig. 7). Lateral roots serve another important function. About 15 to 30 inches from the parent plant, a lateral often turns downward, becoming a secondary vertical root, and sends out both roots and shoots from the turning point. By this means a single field bindweed plant can spread radially more than 10 feet in a growing season. This extensive underground network allows for overwintering without foliage, and it can persist for many years in the soil.

One to four dark brown seeds (Fig. 8) are produced in round, smooth, 1/4-inch capsules. An average plant produces about 550 seeds. Within one month after forming, the seed coat matures and becomes impervious to water. Seed that is 60 years old has been found to be viable. Once the seed coat is weakened, the seed will germinate at temperatures of 41° to 104°F.

Drought tolerance is a characteristic of field bindweed. In California, it seems to prefer heavy clay soils rather than sandy soils. When water is withheld, bindweed competes better than most other plants. If an area is well watered, some ornamentals might compete better than the bindweed; however, in most cases, bindweed will flourish and twine up plants. In the landscape,

field bindweed will survive with sprinkler or drip irrigation. If there is no summer water, the plant reduces its seed production first and then reduces growth and leaf size, but it still will produce some flowers and seed.

IMPACT

Field bindweed is one of the most persistent and difficult-to-control weeds in landscapes and agricultural crops. It has a vigorous root and rhizome system that makes it almost impossible to control with cultivation between desirable plants or broad scale tillage alone; in fact, it often spreads the infestation. Its seed has a long dormancy and can last in soil for up to 60 years. It has a climbing habit that allows the plant to grow up other plants. In addition rhizomes have the ability to penetrate through fabric, plastic, and other barriers. Field bindweed also is very drought tolerant and once established is difficult to control even with herbicides.

If field bindweed is present, land is devalued and the weed precludes planting of many vegetable crops.

MANAGEMENT

Control of field bindweed isn't easy, and it can't be accomplished with a single treatment or in a single season. Effective control requires prevention of seed production, reduction of stored carbohydrates by deep tillage of the root system, competition for light from other plants, and constant vigilance in removing top growth. Application of herbicides, which reduce bindweed growth and kill germinating seedlings, can also be part of an integrated pest management program.

Prevention

Three practices can reduce the possibility of introducing field bindweed—purchase and plant clean seed and ornamental stock, remove any seedlings before they become perennial plants, and prevent any plants from producing seed. If topsoil is introduced to a site, it should be free of roots, rhizomes, seeds, and other



Figure 6. Field bindweed (left) and the larger flowers of western morningglory (right).



Figure 7. Field bindweed plants developing from underground roots or rhizomes don't have seed leaves.



Figure 8. Field bindweed seeds.

bindweed propagules. It is important to control new infestations when they are small, because spot control is the least expensive and the most effective strategy.

Cultural Control

Experiments in some annual and perennial crops have demonstrated the effect of shade on bindweed growth. In these studies, alfalfa, cereal grains, sorghums, and corn partially reduced bindweed growth. Shade from shrubs and trees also should reduce growth, especially if there is another planting under the trees and the bindweed isn't allowed to climb above the foliage of these plants.

Seedlings of field bindweed are easy to control with cultivation, but only for about 3 to 4 weeks after germination. After that, perennial buds are formed, and successful control is much more difficult.

Cultivation or hoeing has been partially effective in reducing established stands of field bindweed. Cultivate about every 2 to 3 weeks and repeat whenever necessary. In conjunction with cultivation, withholding water to dry the site might help to reduce the perennial population in a summer season, assuming the roots have not tapper into deep moisture.

Landscape fabrics such as polypropylene and polyester and other mulches such as black plastic or cardboard have been effective for bindweed control if no light is allowed to reach the soil and the plant. The edges of the fabric must overlap so that the bindweed stems can't grow between the sheets and into the light. If holes are made in the fabric or plastic for plants, however, bindweed can also grow through these holes. A landscape fabric placed over soil then covered with bark or other plant-derived product (e.g., organic matter) or rock will likely keep field bindweed from emerging. It might take more than 3 years of light exclusion before the bindweed dies. Once landscape fabric or other mulch is removed, new bindweed plants might germinate from seed in the soil; be sure

to monitor the site and control any new seedlings. Complete death of the plant under the mulch takes 3 to 5 years.

Chemical Control

Herbicides have been relatively effective for suppression of bindweed but have been only partially effective for eradication (Table 1). If herbicides are used, supplementing them with appropriate preventive and cultural controls has the most success in eradication.

Turfgrass areas. In turfgrass areas field bindweed normally isn't a problem because frequent mowing reduces its vigor, though once established it will persist. Mowing the turfgrass won't get rid of established bindweed. Bindweed often will flower above the turf. For control, products containing 2,4-D and/or dicamba have been effective without injuring the grass turf. More than one application will have to be made during the summer growing season.

Ornamental areas. In ornamental landscape settings, field bindweed grows between and up through the canopy of plants. For control, products containing trifluralin, oryzalin, or pendimethalin applied before emergence will reduce new perennial shoots and control the germinating seedlings, but they won't kill

established bindweed plants. In open areas where there are no desirable plants, glyphosate (e.g., Roundup and other formulations) using a 2 percent solution is effective when bindweed plants are actively growing with no moisture stress. Glyphosate takes 2 to 3 weeks, depending upon the temperature at treatment, to kill the top growth, but it is effective, even though eradication isn't always possible. Glyphosate doesn't have residual activity, so repeated applications are necessary. It won't affect germination of field bindweed seed, so new seedlings will have to be controlled with mulch, preemergent herbicides, or persistent cultivation.

Some people have used a 2 percent solution (volume to volume) of glyphosate to paint the leaves of bindweed in shrub areas, but if you try this be sure not to allow the herbicide to touch mature leaves or green bark of ornamental shrubs or trees, or injury can result. To reduce the chance that glyphosate will contact desirable plants, place the bindweed vines on newspaper before painting the leaves. Once the glyphosate solution has dried on the bindweed leaves, the newspaper can be removed. Any regrowth of the field bindweed must be re-treated. Using a shield such as cardboard or wood is advisable while spraying herbicide treatments near ornamental plants.

Table 1. Summary of Herbicides for Use Against Field Bindweed.

Site	Material	Applied to soil before seeds germinate?	Applied to actively growing plants?	Available for homeowner or professional use?
turfgrass	2,4-D	no	yes	Found only in combinations for homeowner use.
	dicamba	no	yes	Found only in combinations for homeowner use.
ornamentals	glyphosate	no	yes	Readily available for homeowner use.
	oryzalin	yes	no	Some products available for homeowner use; some for professional use only.
	pendimethalin	yes	no	Readily available for homeowner use.
	proflaminate	yes	no	Readily available for homeowner use.
	trifluralin	yes	no	Readily available for homeowner use.
orchard/vineyard	glyphosate	no	yes	Readily available for homeowner use.
	trifluralin	yes	no	Readily available for homeowner use.
noncrop areas	dicamba	no	yes	Found only in combinations for homeowner use.
	2,4-D	no	yes	Found only in combinations for homeowner use.
	glyphosate	no	yes	Readily available for homeowner use.

If an area infested with bindweed is to be planted, irrigate the area to make the bindweed grow well, then treat the field bindweed with glyphosate before planting. After planting, use an appropriate preemergent herbicide or mulch and continue to control any seedlings or regrowth from the previously treated plants.

Orchard and vineyard areas. In orchards or vineyards where bindweed is growing beneath the branches or canes, glyphosate can be applied safely to the bindweed under the woody crop plants without injuring them, as long as tree suckers or low hanging branches aren't sprayed. For best control, apply glyphosate to the bindweed in fall when the bindweed is actively growing; however, spring treatment has the additional benefit of reducing seed production, vigor, and spread of the plant. Generally, additional applications need to be made when the bindweed regrows.

Seedlings must be controlled with mulch, tillage, or preemergent herbicides before they become established plants. Repeated cultivations are required to prevent bindweed from reestablishing. Because the seed lasts such a long time in the soil, control practices must be conducted continuously. See the UC IPM Pest Management Guidelines for grapes or specific tree crops for more information on managing weeds, <http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html>.

Noncrop areas. In areas outside the landscape or orchard, cultivation and herbicide treatment can be used. If herbicides are to be used, treat the bindweed plants before they are drought stressed. Use a translocated herbicide, such as glyphosate, or a combination of glyphosate and dicamba, in areas where its use is allowed, when the plant is actively growing. There is a plant-back interval to crops based on the crop to be planted. Re-treatments will be necessary to control both established plants and seedlings. If

possible, grow a competitive planting of other plants to reduce field bindweed growth and a crop that has herbicides available to use.

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NUTSEDGE

Integrated Pest Management for Home Gardeners and Landscape Professionals

Nutsedges are common weeds in landscapes and gardens in the coastal valleys, Central Valley, and southern areas of California. They thrive in waterlogged soil, and their presence often indicates drainage is poor, irrigation is too frequent, or sprinklers are leaky. Once established, however, they will tolerate normal irrigation conditions or drought.

The two most common species of nutsedge in California are yellow nutsedge, *Cyperus esculentus*, (Fig. 1) and purple nutsedge, *C. rotundus*, (Fig. 2). Yellow nutsedge grows throughout California, while purple nutsedge grows mostly in the southern portions of the state.

IDENTIFICATION

Although nutsedges resemble grasses and often are referred to as “nutgrass,” they aren’t grasses but are true sedges. Their leaves are thicker and stiffer than most grasses and are arranged in sets of three at their base (Fig. 3); grass leaves grow across from each other in sets of two. Nutsedge stems are solid, and in cross section they are triangular; grass stems are hollow and round, and in cross section they are almost flat or oval.

Nutsedge has three long, leaflike bracts at the base of each flower head. Yellow nutsedge has light brown flowers and seeds, while purple nutsedge flowers have a reddish tinge and the seeds are dark brown or black.

Yellow and purple nutsedges produce tubers, which are incorrectly called “nuts” or “nutlets,” thus the origin of their common name. The plants produce these tubers on rhizomes, or



Figure 1. Mature yellow nutsedge plant.



Figure 2. Mature purple nutsedge flower.

underground stems, that grow as deep as 8 to 14 inches below the soil surface. Buds on the tubers sprout and grow to form new plants and eventually form patches that can range up to 10 feet or more in diameter.

Yellow nutsedge produces round, smooth, brown or black tubers that can be up to 1/2 inch at maturity (Fig. 4). Only a single tuber forms at the end of a rhizome, and the tubers have a pleasant almond taste.

Red or red-brown scales cover purple nutsedge tubers. The tubers grow in chains with several of them on a single rhizome (Fig. 5), and they have a bitter taste. Purple nutsedge tubers can be up to 1 inch at maturity.

One weed often confused with yellow or purple nutsedge is tall umbrella

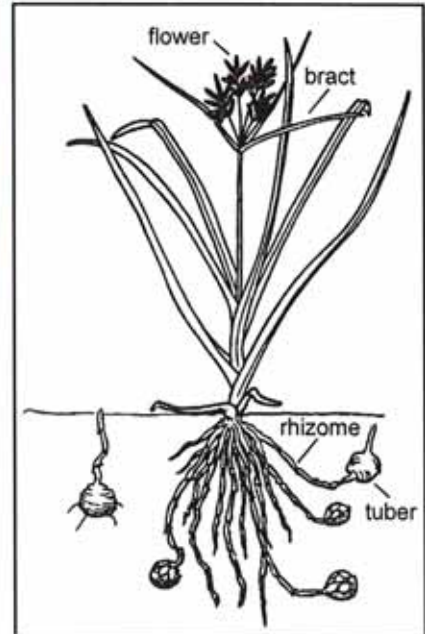


Figure 3. Yellow nutsedge leaves and bracts are arranged in sets of threes.



Figure 4. Yellow nutsedge roots, rhizomes, and tubers.



Figure 5. Purple nutsedge root system showing tubers linked in chains.

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sedge, *C. eragrostis*, (Fig. 6), another perennial sedge that grows in wet, soggy soils. Tall umbrella sedge is a large, light green sedge that doesn't produce tubers. It spreads by seed or by new plants that form on short, thick rhizomes around the base of the mother plant. If left unmowed, it grows taller than nutsedge, but in a mowed turf you can distinguish it from nutsedges by its tendency to grow in tight clumps that are less than 1 foot in diameter, its wider leaves and stems, and its short, thick rhizomes and lack of tubers.

Another weed often confused with nutsedges is green kyllinga, *Kyllinga brevifolia*, (Fig. 7), which also is a major problem in turf and ornamental plantings. (See *Pest Notes: Green Kyllinga* in References.) Green kyllinga flowers are visibly different from those of nutsedges, and the plant produces rhizomes but not tubers.

LIFE CYCLE

Yellow and purple nutsedges are perennial plants. Their leaves and flowering stalks generally die back in fall as temperatures decrease, but tubers and rhizomes survive in the soil and sprout the following spring once soil temperatures remain higher than 43°F for yellow nutsedge and higher than 59°F for purple nutsedge.

The majority of tubers occur in the top 6 inches of soil where they can survive for 1 to 3 years. In field crops, research indicates most nutsedges sprout from tubers, and seeds don't contribute much to the spread of the plant; however, no work has been done to examine the role of seed in the spread of nutsedge in the landscape.

DAMAGE

Nutsedges are a problem in lawns because they grow faster, have a more upright growth habit, and are a lighter green color than most grass species, resulting in a nonuniform turf. In gardens and landscapes, nutsedges will emerge through bark or rock mulches (Fig. 8) in shrub plantings and vegetable and flower beds throughout the growing season.

MANAGEMENT

The best approach for avoiding nutsedge problems is to prevent establishment of the weed in the first place. Once established, nutsedge plants are difficult to control.

Prevent establishment by removing small plants before they develop tubers, eliminating the wet conditions that favor nutsedge growth, using certain fabric mulches in landscape beds, and making sure nutsedge tubers aren't brought in with topsoil or other materials. In addition to consistently removing small plants, you can reduce nutsedge populations by drying, shading, and using properly timed applications of herbicides.

Cultural Control: Removing Plants and Tubers

Tubers are key to nutsedge survival. If you can limit production of tubers, you'll eventually control the nutsedge itself.

To limit tuber production, remove small nutsedge plants before they have 5 to 6 leaves; in summer this is about every 2 to 3 weeks. Up to this stage, the plant hasn't formed new tubers yet. Removing as much of the plant as possible will force the tuber to produce a new plant, drawing its energy reserves from tuber production to the production of new leaves.

Continually removing shoots eventually depletes the energy reserves in the tuber, because the nutsedge will have to use 60% of its reserves to develop the first plant and 20% for the second. However, mature tubers can resprout more than 3 times. Even though these newer sprouts start out weaker than the previous ones, plants can develop from them and produce new tubers unless you remove them.

The best way to remove small plants is to pull them up by hand or to hand hoe. If you hoe, be sure to dig down at least 8 to 14 inches to remove the entire plant. Using a tiller to destroy mature plants only will spread the infestation,



Figure 6. Flowers of tall umbrella sedge (shown here) are dense and headlike in contrast to the looser flowers of nutsedge. Plants also lack tubers and are taller and have wider leaves than the nutsedges.



Figure 7. Green kyllinga doesn't have tubers as do nutsedges but instead spreads by rhizomes.



Figure 8. Yellow nutsedge seedling emerging through bark mulch.

because it will move the tubers around in the soil. However, repeated tillings of small areas before the plants have 6 leaves will reduce populations. If you find nutsedge in small patches in your turf, dig out the patch down to at least 8 inches deep, refill, and then seed or sod the patch.

Drying. During the middle of summer, you can control purple nutsedge by cultivating the infested area and then withholding all moisture to allow the sun to dry the tubers. Repeated tilling and drying are required to give good control. This method is effective only

in areas where other plants don't need irrigation. Drying isn't effective for controlling yellow nutsedge.

Shading. Nutsedges don't grow well in shade, so changing landscape plantings might reduce their growth. For example, a highly infested, annually planted flower bed might be better off if you replant it with a tall, dense ground cover or shrub. Low-growing ground covers won't shade out nutsedge.

Mulching. The commonly used black polyethylene plastic mulches don't control yellow or purple nutsedge, because the sharp points at the ends of their leaves can penetrate them. Landscape fabrics made from polypropylene polymers are available that effectively suppress nutsedge growth and have the added benefit of being water and air permeable, unlike polyethylene. If the planting permits, mulching with a thick, nonwoven landscape fabric covered with a bark or gravel mulch will suppress nutsedge growth. For complete control, however, you still will need to remove any emerging nutsedge plants.

Chemical Control

Few herbicides are effective at controlling nutsedge, either because of a lack of selectivity to other plants or a lack of uptake. For herbicides that are suitable, apply them when they'll be most effective (Table 1). Most herbicides aren't effective against tubers.

Nonselective Postemergent Herbicides. The only nonselective postemergent herbicide currently available to help control nutsedge in the home landscape is glyphosate (e.g. Roundup) or glyphosate with nonaonic acid (Roundup Plus). This herbicide requires repeated applications, and its use will result only in limited suppression of these weeds.

Many people mistakenly use glyphosate on fully grown plants to try to kill the tubers. Unfortunately, when tubers are mature the herbicide usually doesn't move from the leaves to the tubers, leaving them unaffected. Instead, apply glyphosate when the plants are

Table 1.

Controlling Nutsedges with Chemicals.¹

Herbicide	Commercial Name	Apply Before Plants Emerge	Apply to Young Plants	Available to Home Gardeners
dichlobenil	Casoron	yes	no	yes
dimethenamid-P	Freehand	yes	no	no
glyphosate	Roundup	no	yes	yes
halosulfuron	Sedgehammer	no	yes	yes
metolachlor	Pennant	yes	no	no
penoxsulam	Green Light Wipe Out Tough Weed Killer for Lawns	no	yes	yes
sulfosulfuron	Certainty	no	yes	no
trifloxysulfuron-sodium	Monument	no	yes	no

¹ None of these products effectively controls mature plants.

young, actively growing, and haven't recently been mowed or cut.

Be sure to read the label to determine how much time after application must occur before irrigation can resume. Don't apply if rainfall is expected within 24 hours of application. Glyphosate works most quickly when the weather is warm and sunny; cool, cloudy weather following an application can delay activity. Don't spray any herbicide when it is windy to avoid injuring other plants with spray drift.

Selective Postemergent Herbicides. Postemergent herbicides that have some selectivity, particularly in turf, are halosulfuron (Sedgehammer) and MSMA. These herbicides move through the plant rapidly, but to be effective, you must apply them to nutsedges before the fifth-leaf stage, when the plant is still building energy reserves by drawing energy from its leaves to the newly forming tubers. After this stage, this translocation to the tubers slows down or ceases, and the herbicide will kill only the aboveground portion of the plant, leaving the tubers unaffected.

Halosulfuron is used in such minute amounts the manufacturer markets it in premeasured, water-soluble bags. Follow all label directions for optimal control of nutsedge, and be sure to add a nonionic surfactant to the spray solution. MSMA is more effective on

yellow than on purple nutsedge. Other herbicides available to professionals for use on turf include trifloxysulfuron-sodium (Monument) and sulfosulfuron (Certainty). Be sure to read the label carefully, as these products will injure some turf species.

Preemergent Herbicides. Although no preemergents control purple nutsedge, those that reduce yellow nutsedge include dichlobenil (Casoron), metolachlor (Pennant), and dimethenamid-P (a component of Freehand). Metolachlor and dimethenamid-P are safer around many ornamentals than dichlobenil, but they are available only to professional pesticide applicators.

No preemergent herbicides that effectively control nutsedge can be used on turfgrass, but you can use them on selected ornamental plants. Read the label directions to see which ornamentals will tolerate each herbicide, and follow all label instructions regarding how to apply the product. Preemergent herbicides reduce the number of emerging nutsedge plants, but for long-term control, retreatment is necessary.

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Oxalis pes-caprae L.

Buttercup oxalis (Bermuda buttercup)

Family: Oxalidaceae

Range: In the western U.S., it occurs in California and Arizona.

Habitat: Coastal dunes, scrub, grasslands, oak woodlands, gardens, turf, urban areas, orchards, vineyards and agricultural fields. Grows in most environments and can tolerate many soil types. Grows in full sun in cool coastal areas, but inland it grows primarily in semi-shaded sites.

Origin: Native to South Africa and brought to North America as a garden ornamental.

Impacts: Buttercup oxalis is a major problem in field-grown flowers and in the home landscape, especially in groundcovers. In the last 10 years, this plant has spread extensively throughout California invading native coastal dunes and natural areas along the coast. Due to its extensive occurrence in yards and gardens, buttercup oxalis has the potential to rapidly spread via the production of bulbs and the movement of contaminated soils into adjacent natural areas. Plants contain variable quantities of soluble oxalates and can be lethally toxic to livestock when ingested in quantity.

California Invasive Plant Council (Cal-IPC) Inventory: Moderate Invasiveness



Buttercup oxalis is a low-growing perennial with clover-like leaves and yellow flowers. Plants grow from bulbs and produce a loose basal rosette of leaves to 14 inches tall. Stems are mostly below ground. Leaf stalks are 5 inches long with a trifoliate leaf, green to dark purple-tinged, 6 to 10 mm long, and 5 to 24 mm wide. Leaflets are glabrous to sparsely pubescent, broadly heart-shaped, often pubescent below, and typically folding downward at midday and at night. Small, whitish-brown bulblets develop on the stem at the base of the rosette of leaves, and new bulbs form underground along the rhizome. A plant forms about a dozen small bulbs per year, each less than 1 inch long. Slender white rhizomes are about 4 inches long with true roots growing upward from the mature bulb apex. The leaves and flowers develop from the top of the rhizome. A threadlike rhizome grows downward from the mature bulb base and produces a tuberous root with many fibrous roots below. Small bulbils develop in the leaf scale axils along the length of the threadlike rhizome. Bulbs and bulblets readily detach from rhizomes.

The flowers are bright yellow, 0.75 to 1.5 inches wide, and are borne on top of a leafless stalk rising 6 to 12 inches tall. Viable seed never has been documented in the United States, and rarely has it been seen anywhere else in the world. The foliage dies and the bulbs become dormant when temperatures rise in late summer. Plants reproduce vegetatively by bulbs and spread with cultivation, soil movement, intentional planting, and disposal of garden refuse and nursery soil.

NON-CHEMICAL CONTROL

Mechanical (pulling, cutting, disking)

Hand pulling can provide control but care must be taken to remove the entire plant, including underground rhizome and bulbs. Repeated pulling of the tops will deplete the bulb's carbohydrate reserves, but these efforts take years to be successful.

Cultivation can provide control on new infestations. Repeated tillage is required to effectively control the bulbs.

Cultural

Grazing is not considered an effective control option. Plants contain variable quantities of soluble oxalates and can be lethally toxic to livestock when ingested in quantity.

Burning is also not considered to be an effective control option.

Biological

There is currently no biocontrol agent available for the control of *O. pes-caprae* in North America. A potential biocontrol agent is *Klugeana philoxalis*, a larval feeder on shoots of *O. pes-caprae*, but no other information on this species is available.

CHEMICAL CONTROL

The following specific use information is based on published papers and reports by researchers and land managers. Other trade names may be available, and other compounds also are labeled for this weed. Directions for use may vary between brands; see label before use. Herbicides are listed by mode of action and then alphabetically. The order of herbicide listing is not reflective of the order of efficacy or preference.

GROWTH REGULATORS

Fluroxypyr <i>Vista XRT</i>	Rate: 15 to 22 oz product/acre (5.3 to 7.7 oz a.e./acre) to thoroughly wet all leaves Timing: Early postemergence when plants are growing rapidly. Remarks: Fluroxypyr provides selective postemergent control of many annual and perennial broadleaf weeds. It has no soil activity.
Triclopyr <i>Garlon 4 Ultra</i>	Rate: 2 to 4 qt product/acre (2 to 4 lb a.e./acre) plus 0.25 to 0.5% v/v surfactant to thoroughly wet all leaves Timing: Postemergence when plants are growing rapidly. Remarks: Triclopyr is a selective herbicide for broadleaf species. It has no soil activity.

AROMATIC AMINO ACID INHIBITORS

Glyphosate <i>Roundup, Accord XRT II, and others</i>	Rate: Spot treatment: 2% v/v solution <i>Roundup ProMax</i> (or other trade name with similar concentration of glyphosate) and water to thoroughly wet all leaves Timing: Postemergence when plants are growing rapidly. Applications in early spring provide best control. Remarks: Glyphosate is a nonselective systemic herbicide with no soil activity. Repeated applications may be necessary for complete control.
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BRANCHED-CHAIN AMINO ACID INHIBITORS

Imazapyr <i>Arsenal, Habitat, Stalker, Chopper, Polaris</i>	Rate: 3 pt product/acre (12 oz a.e./acre) plus 0.25 to 0.5% v/v surfactant to thoroughly wet all leaves Timing: Postemergence when plants are growing rapidly. Remarks: Imazapyr is a preemergent and postemergence herbicide effective for controlling broadleaf weeds and grasses. It has fairly long soil residual activity.
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PHOTOSYNTHETIC INHIBITORS

Hexazinone <i>Velpar L</i>	Rate: 2.75 to 4.5 pt product/acre (0.7 to 1.1 lb a.i./acre) to thoroughly wet all leaves Timing: Early postemergence when plants are growing rapidly. Remarks: Hexazinone provides both contact and residual control of many broadleaf and grasses. It has a long soil activity, is considered mobile, and should not be used in areas where the water table is shallow. High rates of hexazinone can create bare ground, so only use high rates in spot treatments.
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POISON OAK

Integrated Pest Management for Home Gardeners and Landscape Professionals

Poison oak, also known as Pacific poison oak or western poison oak (*Toxicodendron diversilobum*), is native to western North America with a distribution extending from British Columbia to the Baja California peninsula. In Washington and Oregon, poison oak is found mainly in the western regions of the states. In California it is widespread and grows in a wide range of habitats from sea level to the 5,000-foot elevation and in areas including open woodland, grassy hillsides, coniferous forests, and open chaparral.

IDENTIFICATION

Poison oak is a woody shrub or vine that loses its leaves in winter. In open areas under full sunlight, it forms a dense, leafy shrub usually 1 to 6 feet high (Fig. 1). In shaded areas, such as in coastal redwoods and oak woodlands, it grows as a climbing vine, supporting itself on other vegetation or upright objects using its aerial roots (Fig. 2).

Leaves normally consist of three leaflets with the stalk of the central leaflet being longer than those of the other two (Fig. 3); however, leaves occasionally are comprised of 5, 7, or 9 leaflets. Leaves of true oaks, which are superficially similar, grow singly, not in groups. Poison oak leaves alternate on the stem. Each leaflet is 1 to 4 inches long and smooth with toothed or somewhat lobed edges. The diversity in leaf size and shape accounts for the Latin term *diversilobum* in the species name. The surface of the leaves can be glossy or dull and sometimes even somewhat hairy, especially on the lower surface.

In spring, poison oak produces small, white-green flowers (Fig. 4) at the point where leaves attach to the stem. Whitish-green, round fruit (Fig. 5) form in

late summer. In early spring the young leaves are green or sometimes light red. In late spring and summer the foliage is glossy green and later turns attractive shades of orange and red (Fig. 6).

IMPACT

Poison oak thrives along roadsides and other areas where established vegetation is disturbed, in uncultivated fields, and on abandoned land. It also is a problem in wood lots, Christmas tree plantations, rangeland, and recreation areas. While it can reduce optimal grazing area in rangeland or pastures, the primary concern associated with poison oak is the allergic reaction it causes in many people.

All members of the genus *Toxicodendron*—which includes poison oak, poison ivy, and poison sumac—cause allergic contact dermatitis. About 2 million cases of skin poisoning are reported in the United States each year, primarily from these three species. In California, the number of working hours lost as a result of dermatitis from poison oak makes it the most hazardous plant in the state.

Contact with poison oak leaves or stems at any time of the year can cause an allergic response. When the allergen contacts the skin surface of sensitive individuals, the surrounding cells rapidly absorb it. Within 1 to 6 days, skin irritation and itching will be followed by water blisters, which can exude serum. Contrary to popular belief, the exuded serum does not contain the allergen and does not transmit the rash to other regions of the body or to other individuals. The dermatitis rarely lasts more than 10 days. Only about 15 to 20% of the population is immune to the allergenic reaction caused by poi-



Figure 1. Poison oak as a shrub.



Figure 2. Poison oak as a vine.

son oak and show no symptoms when exposed to the plant. Once a reaction occurs, repeated exposures further increase sensitivity. Conversely, long periods with no exposure will reduce an individual's susceptibility. Animals with fur usually don't suffer skin irritation, although a dog can develop symptoms on its nose or underbelly.

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Livestock can graze on the tender foliage with no adverse effects.

In addition to direct contact with the plant, transmission of the allergen can occur by touching contaminated clothing, gloves, tools, or animals, particularly pets. When poison oak is burned, the oils can disperse via the smoke particles. Breathing this smoke can cause severe respiratory irritation.

After coming in contact with the allergen, the best way to prevent skin irritation is to pour a mild solvent such as isopropyl (rubbing) alcohol over the exposed area then wash with plenty of cold water; avoid using warm water, since it enhances the penetration of the oil. If isopropyl alcohol is not available, use cold water by itself to help dilute the oil, so it no longer is as harmful.

Perform these steps within five minutes of exposure. Even if it's too late to prevent the rash, washing the skin to remove excess plant oil will keep the rash from spreading. Be sure to thoroughly wash your hands, since they serve as the major route for transferring the allergen to other parts of the body, especially the face.

Using only a small amount of water or disposable hand wipes is more likely to spread the toxin than remove it. You can use soap but only if you also use copious amounts of water.

If you wash with isopropyl alcohol or soap, be sure you are done working outside for the day, since these products also will remove your skin's protective oils, which help repel the plant toxin; your body will not regenerate these protective oils for 3 to 6 hours. If re-exposure could occur within 6 hours, you will have better results washing with lots of water.

The product Tecnu, which most drug stores sell, will remove the poison oak oil from your skin. You should wash the contacted areas within 2 to 8 hours after exposure. You also can use Tecnu to decontaminate laundry, pets, and tools.

BIOLOGY

A variety of birds will eat poison oak fruit, and establishment of this plant in new locations generally is from seeds these birds have transported. The passage of the hard-seeded fruit through the bird's digestive tract facilitates germination by reducing the period of dormancy. Once established, the plant spreads slowly using its underground horizontal rootstalks, which actually are stem tissue. A single root system can cover a very large area, several feet in diameter.

Poison oak can survive under a wide range of temperatures, elevations, soil types, moisture conditions, and light intensities. However, it is most commonly found on hillsides with shallow soils.

MANAGEMENT

The primary ways of managing poison oak are mechanical removal by hand pulling, which is not recommended for individuals who are sensitive to this plant, and treatment with herbicides. Maintaining a healthy cover of desirable vegetation will reduce potential invasion. This is easiest where you have available irrigation and regularly cultivated soil.

Poison oak is a native species in the western United States. As such, a number of indigenous insects and pathogens already are present. Typically, biocontrol isn't an option with a native species. Furthermore, in most areas, poison oak is not a pest, but rather a natural component of the plant community.

Don't burn poison oak, since it creates a serious health hazard and doesn't effectively reduce infestations. Grazing by sheep and goats can be effective in small areas. Deer or horses also will graze poison oak when the foliage is young, before the plant flowers.

Mechanical

You can physically remove plants located in a yard or near houses through hand pulling or mechanical grubbing



Figure 3. Poison oak leaves and flower.



Figure 4. Poison oak flowers.



Figure 5. Poison oak fruit.



Figure 6. Poison oak fall foliage.

using a shovel or pick. It is essential to remove the entire plant including its roots. Remove plants in early spring or late fall when the soil is moist and it is easier to dislodge rootstalks. Grubbing when the soil is dry and hard usually will break off the stems, leaving the rootstalks to vigorously resprout. Detached and dried brush still can cause dermatitis, so bury or stack the plant material in an out-of-the-way location, or take it to a disposal site. Again, never burn poison oak.

Ideally, anyone engaged in hand pulling poison oak should have a high degree of immunity to the allergen. Whether you are sensitive or believe you are immune, wear appropriate protective clothing, including washable cotton gloves over plastic gloves. Wash all clothing thoroughly, including shoes, after exposure.

Other forms of mechanical control have not proven to be successful. Brushrakes and bulldozers often leave pieces of rootstalks that readily can resprout. In some cases, brush removal late in summer, when plants are experiencing moisture stress, can slow their ability to recover. Mowing has little effect in poison oak control, unless you perform it at least four times during the growing season. Within 2 months of germination, young plants usually have produced underground rootstalks large enough to recover from mowing damage. A single plowing is of no value and often serves to propagate the shrub. However, good seedbed preparation and planting cultivated crops for a year or more will control poison oak infestations.

Chemical Control

Herbicides used to control poison oak in California include glyphosate (Roundup, etc.) and the auxinic herbicides triclopyr (Garlon, Ortho Brush-B-Gon, etc.), 2,4-D (Brush Buster Woody Plant Herbicide, etc.), a combination of 2,4-D and dicamba (Spectracide Brush Killer Spray Concentrate, Spectracide Poison Ivy & Poison Oak Brush Killer, and Ortho Weed B Gon Max), or a combination of glyphosate and imazapyr

(Ortho Groundclear Vegetation Killer). You can apply some of these herbicides as stump or basal applications, but all are applied as a foliar spray.

Glyphosate is one of the most effective herbicides for controlling poison oak. However, effective control depends upon proper timing of the application. Apply glyphosate late in the growth cycle, after the fruit has formed but before leaves have lost their green color. If you are using hand-held equipment, you can apply glyphosate as a 2% solution in water. Products or spray mixtures containing less than 2% glyphosate may not effectively control poison oak. It is important to note that glyphosate is a nonselective compound and will damage or kill other vegetation it contacts.

Auxinic herbicides such as triclopyr, 2,4-D, dicamba, and combinations of these herbicides also control poison oak. You can apply these herbicides earlier than glyphosate, when plants are growing rapidly from spring to midsummer.

Triclopyr is the most effective auxinic herbicide for poison oak control. It has a wider treatment window than glyphosate, and it often gives more consistent control. Two formulations of triclopyr are available. Triclopyr amine is the least effective of the formulations and requires relatively high rates. Triclopyr ester or triclopyr ester plus 2,4-D ester gives better herbicide absorption into the foliage and is more effective.

When 2,4-D is combined with dicamba, it provides much better control than if it is used alone in a 1% solution. Premixed combinations of these herbicides are available. Dicamba applied at 0.5% gives better long-term control of poison oak than 2,4-D.

A new herbicide in California, imazapyr, also is very effective for controlling poison oak, but it is available for application only by licensed pesticide applicators. In forestry, two formulations are available. The water-soluble formulation (Arsenal) is effective as a foliar treatment at 1% plus a 0.25% surfactant.

A similar treatment with an emulsifiable concentrate formulation (Chopper, Stalker) will control poison oak at a 2% solution in water or a 1% solution plus 5% of a methylated or ethylated seed oil. The best timing is in either spring after full leaf expansion or in mid-August through September.

Stump Application. Stump treatments are most effective during periods of active growth. Cut poison oak stems 1 to 2 inches above the soil surface, and immediately after cutting, treat the stump. A delay in treatment will result in poor control. Apply an herbicide such as glyphosate, triclopyr, or combinations of triclopyr with 2,4-D (or 2,4-D and 2,4-DP) with a paint brush that is 1 to 2 inches wide or with a plastic squeeze bottle that has a spout cap. Treatment solutions should contain either undiluted glyphosate (use a product that contains at least 20% glyphosate), triclopyr amine, or a 20 to 30% triclopyr ester solution mixed with 70 to 80% methylated or ethylated seed oil.

Be sure to completely cover all surfaces of the stumps with the herbicide until it runs down the base of the stubs. Spray any regrowth from cut stumps with a foliar spray when the leaves fully expand.

Basal Application. Basal bark applications can be made almost any time of the year, even after leaves have discolored or dropped. Apply triclopyr to basal regions of poison oak using a backpack sprayer with a solid cone, flat fan, or a straight-stream spray nozzle. Thoroughly cover a 6- to 12-inch basal section of the stem, but not to the point of runoff.

Foliar Sprays. The effectiveness of herbicides applied to poison oak foliage depends upon the plant's growth stage and whether spray-to-wet coverage and proper concentration occurred. Foliar application is most effective after leaves are fully developed and when the plant is actively growing. This period is normally from April into June or July, when soil moisture is still adequate. The flowering stage is the optimum

time to spray. Do not apply herbicides before plants begin their spring growth or after the leaves have begun to turn yellow or red in late summer or fall.

To achieve spray-to-wet coverage, all leaves and stems should be glistening following herbicide application. However, coverage should not be to the point of runoff. One application of an herbicide usually doesn't completely control poison oak. Treat again when new, sprouting leaves are fully expanded,

generally when the plants are about 2 feet tall. Watch treated areas closely for at least a year, and re-treat as necessary.

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SPOTTED SPURGE AND OTHER SPURGES

Integrated Pest Management for Home Gardeners and Landscape Professionals

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

IDENTIFICATION

Spotted spurge grows close to the ground, often forming a dense mat (Fig. 1). Its dark green leaves, which grow in pairs called "opposites," are $\frac{1}{8}$ to $\frac{1}{2}$ inch long and about $\frac{1}{8}$ inch wide. Frequently a red spot will mark the leaf halfway down its center vein (Fig. 2).

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

Spotted spurge produces tiny, pinkish flowers (Fig. 3) that consist only of stamens and pistils grouped in small, flowerlike cups, called cyathia, in the leaf axils, the area where the leaf joins the stem. The fruit is a three-celled seed capsule that is $\frac{1}{16}$ inch or less. Each cell contains one seed that is about $\frac{1}{25}$ inch long. The plant's central taproot system is capable of extending more than 24 inches into the soil.

Although spotted spurge is the major spurge weed in California, six other

species of spurges appear regularly as weeds in the state—ground spurge (*E. prostrata*), creeping spurge, petty spurge, garden spurge (*E. hirta*), nodding spurge (*E. nutans*), and thyme-leaved spurge (*E. serpyllifolia*). Ground and creeping spurges are troublesome weeds throughout California, while petty spurge is a problem only in Southern and coastal California landscapes.

All spurges have milky sap, which can be toxic to some animals. Ground spurge (Fig. 4) and creeping spurge (Fig. 5) grow prostrate like spotted spurge but have no markings on their leaves. All spurges reproduce by seed, and creeping spurge also can produce roots along the stem, creating new plants vegetatively. Petty spurge (Fig. 6) is a cool season annual found in shady, moist areas, particularly in flower beds. Native to Europe, it grows upright and is much less invasive than spotted and creeping spurge species. Garden, nodding, and thyme-leaved spurges cause fewer problems.

There are 18 native species of spurge occurring in various parts of California. Some of these native species can appear at the edges of cultivated areas adjacent to wildlands, but they are poorly adapted to cultivated conditions and rarely occur as weeds.

The plant key in Table 1 provides information to help with identifying spurges commonly encountered as weeds in California. Any weedy spurge collected in California that doesn't appear to fit these characteristics can be keyed using *The Jepson Manual* listed in References, or you can take the weed to your local cooperative extension office. The Weed Identification Tool available online through UC Davis' Weed Research



Figure 1. Mature spotted spurge is a low-growing plant.



Figure 2. Spotted spurge with red leaf spots and a broken stem exuding milky sap.



Figure 3. Spotted spurge flowers and leaf spots.



Figure 4. Ground spurge plant.

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and Information Center (<http://weedid.wisc.edu/ca/weedid.php>) is an easy-to-use program useful for homeowners and professionals.

BIOLOGY

Most weedy spurges are summer annuals that don't like competition and depend on their prolific seed production for survival. A single plant can produce several thousand seeds, which are small and can remain dormant in the soil until conditions are suitable for germination (sprouting). Seeds produced in summer germinate immediately while those produced in late fall mostly will lie dormant and won't germinate until spring.

Spotted spurge germinates best when temperatures are 75° to 85°F, but germination can occur at temperatures as low as 60°F and as high as 100°F. When moisture is available, germination can occur from February through September in most areas of California. Light also is a requirement for maximum germination; seeds buried deeper than 1/2 inch won't germinate well. Plants that germinate early in spring in cool conditions can remain as small seedlings until temperatures are more

desirable for growth. Once the seed germinates, a small rosette of leaves develops. As growth continues, the leaves form a dense mat that can grow up to 3 feet in diameter. Reproductive growth is rapid, and the plant can produce seeds as soon as 5 weeks after germination.

IMPACT

Spotted spurge can establish itself in horticultural, agricultural, and non-crop sites. It overgrows sparse turf areas and low-growing ground covers, invades open areas in gardens and landscapes, and can grow in sidewalk cracks. In addition to reducing the growth of desirable plants, spotted spurge reduces uniformity and quality of turf, provides a habitat for undesirable insects in citrus groves, serves as an intermediate host for fungal diseases of cultivated crops, and attracts ants with its seed.

Spotted spurge is poisonous and can kill sheep grazing in pastures where it is the predominant weed. Sheep that consumed as little as 0.62% of their body weight of this plant have died within a few hours.



Figure 5. Creeping spurge infesting a field-grown, container plant.



Figure 6. Mature petty spurge.

MANAGEMENT

The primary method of managing spurges is prevention, since controlling these weeds is very difficult once plants have established themselves. Avoid bringing seeds into uninfested areas by using weed-free planting seed

Table 1.

A Key to the Weedy Spurges of California.

Flowers (cyathia) in dense axillary or terminal clusters (generally greater than 10 cyathia per cluster)	Stems erect , to 3 feet tall, sparsely hairy Nodding Spurge (<i>Euphorbia nutans</i> Lagasca)		
	Stems prostrate with numerous, spreading hairs Garden Spurge (<i>E. hirta</i> L.)		
Flowers (cyathia) solitary or paired in leaf axils (Note: Since leaves are opposite, 2 to 4 cyathia will be in close proximity.)	Cyathia, fruit, stem, and leaves hairy	Fruit very sparsely hairy , 1.5–2 mm long; seeds 1–1.25 mm long and wrinkled with low rounded ridges; leaves lacking reddish central spot (rare form) Thyme-leaved Spurge (<i>E. serpyllifolia</i> Persoon)	
		Fruit distinctly hairy ; less than 1.5 mm long; seed generally less than 1 mm, cross-ridge with narrow sharp ridges, or wrinkled; if wrinkled, leaves usually with reddish central spot (very common species)	Seeds cross-wrinkled ; fruit with appressed hairs over entire surface; leaves generally (greater than 95% of plants) with a reddish central spot Spotted Spurge (<i>E. maculata</i> L.)
	Cyathia, fruit, stem and leaves hairless	Stipules (appendages at leaf base) united into a whitish scale between the leaves; stems almost always rooting at the nodes; leaf margins smooth-edged or faintly toothed Creeping Spurge (<i>E. serpens</i> Kunth)	Seeds cross-ridged ; fruit spreading hairy, mostly on edges only; leaves never with reddish central spot Ground Spurge (<i>E. prostrata</i> Aiton)
		Stipules separate and hairlike; stems rarely or never rooting at the nodes; leaf margins distinctly toothed, at least near the tip Thyme-leaved Spurge (<i>E. serpyllifolia</i> P.)	

and uncontaminated planting stock. Clean work clothing and machinery such as lawn mowers to remove any seeds that might be present, and remove spurge plants as soon as you discover them.

Cultural Control

Weeding or cultivating. Constantly monitor infested areas, so you can mechanically till or hand pull new plants before they produce seed. Take care as you weed, since plants that you hand pull often break at the stem, leaving the root and several buds or a single stem from which regrowth is possible. Wear gloves when you hand pull, since the sap can be a skin irritant. Mowing is an ineffective method of control, since most species grow closely to the ground.

When planting new, container-grown ornamentals and ornamental beds, be sure to use sterilized or weed-free planting mix. When purchasing plants for ornamental beds, avoid those with spotted spurge infestations. Mulches can effectively limit spotted spurge if they prevent light from reaching the seed.

Solarization. Before planting an area with turf or ornamentals, you might want to follow the management method known as soil solarization. Covering the soil with sheets of clear plastic for 4 to 6 weeks during the summer can effectively reduce the number of seeds in areas where summer daytime temperatures are very hot. In areas where summer temperatures are lower than 90°F, soil solarization can partially control this weed. For more information, see *References, Soil Solarization for Gardens & Landscapes*.

Mulch. Probably the most common strategy for controlling weeds in ornamental plantings is to use organic or synthetic mulches, which prevent light from reaching weed seeds and seedlings, starving them before they can start making food through photosynthesis. Bark, compost, or straw laid at least 2 inches thick can effectively control many weed seeds including

many spurge species. A large, coarse bark will require a 3- to 4-inch layer to be effective; however, larger, coarser mulches last longer than finely shredded ones. Thick mulch eventually can accumulate soil, decaying organic matter, and weed seeds that can germinate. All organic mulch needs periodic replacement.

Black, synthetic polypropylene weed barriers (fabrics or geotextiles), which are available at nurseries, also block sunlight and starve weed seedlings. The fabrics are porous to allow water to drain through them. Often a synthetic barrier with bark or rock on top makes the area more aesthetically pleasing. Organic mulches such as bark and straw don't need to be as thick if you also are using the fabric. Since mulches and weed barriers reduce evaporation from the soil surface, adjust the irrigation cycle to prevent overwatering.

Turf management. One of the best control measures for spotted spurge in turf is to maintain a competitive stand of grass. When open areas develop in turf due to stress, disease, lack of fertility, insects, or abuse, light penetrates to the soil surface, allowing spotted spurge to germinate. Once spotted spurge establishes itself, altering cultural practices such as fertilization or irrigation won't control it. However, raising the mowing height to 2 inches or more in tall fescue or perennial ryegrass can reduce initial invasions. Check turf for excessive thatch, which should be less than 1/2 inch high.

Food Crops. In home vegetable gardens, you can control spurge seedlings by using soil solarization, mulches, and early cultivation.

Chemical Control

Preemergent herbicides can help prevent spotted spurge outbreaks if you apply them in late winter before weed seeds germinate. Time the application, so it occurs before the soil temperature exceeds 55° to 60°F at a depth of 1 inch.

Preemergent herbicides for turf and ornamentals include benefin (Balan),

pendimethalin (Pendulum), isoxaben (Gallery), oryzalin (Surflan), trifluralin (Treflan, Preen), and dithiopyr (Dimension). Of these, only pendimethalin, trifluralin, dithiopyr, and oryzalin are available for use by home gardeners. Combination products such as oryzalin plus benefin are available to both home gardeners and landscape professionals.

Preemergent chemicals are almost never used in home vegetable gardens, because chemical residues last for months after application, and product labels routinely regulate against such use. Herbicide recommendations for commercial orchard and vegetable crops are available online; see the UC IPM Pest Management Guidelines at <http://www.ipm.ucdavis.edu/PMG/>.

Postemergent herbicides available to home gardeners include 2,4-D/MCPP/dicamba combination products, triclopyr (Turflon), and glyphosate (available for both commercial and home landscape use). In general, 2,4-D and its combinations don't control the larger, more mature spotted spurge plants.

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Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original, labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down the sink or toilet. Either use the pesticide according to the label, or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

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YELLOW STARHISTLE

Integrated Pest Management for Home Gardeners and Landscape Professionals

Yellow starthistle, *Centaurea solstitialis*, is native to Eurasia and was introduced to California around 1850 via South America. It is now common in open areas on roadsides, rangeland, wildlands, hay fields, pastures, and waste areas. Recent reports indicate that yellow starthistle infests between 10 and 15 million acres in California. Disturbances created by cultivation, poorly timed mowing, road building and maintenance, or overgrazing favor this rapid colonizer. It forms dense infestations and rapidly depletes soil moisture, thus preventing the establishment of other species. It is also poisonous to horses, causing a nervous disorder called "chewing disease" (nigropallidal encephalomalacia), which is fatal once symptoms develop. Horses are the only animal known to be affected in this manner and should not be allowed to graze on yellow starthistle.

IDENTIFICATION

Yellow starthistle is a gray-green to blue-green plant with a deep, vigorous taproot. It produces bright, thistlelike yellow flowers with sharp spines surrounding the base. Yellow starthistle grows to heights varying from 6 inches to 5 feet. The stems of mature plants are rigid, spreading, and typically branching from the base in open areas (Fig. 1). Stems and leaves are covered with a loose, cottony wool that gives them a whitish appearance. Stems appear winged due to leaf bases that extend beyond the nodes. Basal leaves are 2 to 3 inches long and deeply lobed. Upper leaves are short (0.5 to 1 inch long) and narrow with few lobes.

BIOLOGY

Yellow starthistle is a long-lived winter annual that is usually found below 7,000 feet elevation in dry, light-intensive areas where average annual

rainfall is between 10 and 60 inches. Seed output can be as high as 30,000 seeds per square meter, with about 95% of the seed being viable soon after dispersal. Most seeds germinate within a year of dispersal, but some can remain viable in the soil for more than 3 years.

Yellow starthistle seeds germinate from fall through spring, which corresponds to the normal rainy season in California. After germinating, the plant initially allocates most of its resources to root growth. By late spring, roots can extend over 3 feet into the soil profile, although the portion above ground is a relatively small basal rosette. This allows yellow starthistle to out-compete shallow-rooted annual species during the drier summer months when moisture availability is limited near the soil surface. It also helps explain why yellow starthistle survives well into the summer, long after other annual species have dried up, and why it can regrow after top removal from mowing or grazing.

The competitive ability of yellow starthistle also depends on light intensity at the soil surface during the seedling and rosette stages of development. Yellow starthistle proliferates at high light intensity and does poorly in low light. High light conditions often occur along roadsides, in disturbed sites, grasslands, and on south-facing slopes at higher elevations.

MANAGEMENT

Control of yellow starthistle cannot be accomplished with a single treatment or in a single year. Effective management requires control of the current population and suppression of seed production, combined with establishment of competitive, desirable vegetation.



Figure 1. Yellow starthistle.

Prevention

Yellow starthistle proliferates along roadsides. Invasion by this weed may be increased with disturbances created by road building and maintenance. Seeds are often spread by vehicles or with the transportation of livestock or contaminated soil. Survey roadsides for the presence of this weed and immediately control new infestations to prevent seed production and its subsequent spread.

Yellow starthistle also can be spread as a contaminant in grass seed. Only certified seed should be used for range or pasture seeding. Seed may also come as a contaminant in all classes of hay, particularly grass hay. Carefully check hay shipments for evidence of yellow starthistle. Hay used as mulch along

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roadsides or disturbed areas can be a source of yellow starthistle introduction. When feeding hay is suspected of containing yellow starthistle, place bales in one area and periodically check around feeding areas for signs of starthistle seedlings. Livestock that have fed in yellow starthistle-infested areas should not be pastured or shipped to uninfested areas. Control newly emerged seedlings to prevent establishment. It is important to control new infestations when they are small because spot eradication is least expensive and most effective at this time.

Biological Control

Four natural enemies of yellow starthistle have been imported from Europe and by 2003 were well established in California. These biological control agents include two weevils (*Bangasternus orientalis* and *Eustenopus villosus*) and two flies (*Urophora sirunaseva* and *Chaetorellia succinea*). They all attack the flower/seed head and directly or indirectly reduce seed production, the only means of reproduction and spread of the weed. The insects lay their eggs in, on, or near flower/seed heads and complete their development within them. *Eustenopus villosus* adults also directly reduce seed production by feeding on immature flower heads. All of these insects are highly host-specific to yellow starthistle and do not attack commercially valuable crops or native plants.

These insects already occur in most areas of California that are infested with yellow starthistle. If additional releases of these natural enemies are made, protect the release area from practices that may damage the insects. Such practices include insecticide applications, soil cultivation, summer-prescribed burning, or mowing when the plants are in the flowering stage. After establishment, the insects are capable of building up to high numbers and spreading on their own. These insects do best in areas with warm, dry summer climates.

The most recent releases, *Eustenopus villosus* and *Chaetorellia succinea*, have

proven to be the most effective agents for yellow starthistle seed suppression. These insects are becoming more widespread throughout the state. However, they only suppress yellow starthistle seed production by about 50%, so they should not be considered as the sole method of control. It is possible that a combination of herbicides and biological control will provide more sustainable control than either technique used alone. Landowners and managers with yellow starthistle problems may contact their county agricultural commissioner's office about obtaining these biological control insects.

Most recently a rust, *Puccinea jaceae* var. *solstitialis*, was approved for release in California. Trials are under way to determine the potential effectiveness of this organism on yellow starthistle.

Cultural Control

Yellow starthistle begins emergence with fall rains and continues to germinate throughout the rainy season. A single cultivation after the rainy season when soils are dry effectively controls yellow starthistle seedlings and rosettes. This treatment must be made after the last rains but before seeds are produced. If cultivation is carried out too early (e.g., before the last rains) seed will continue to germinate and another cultivation will be needed to control each new flush of seedlings that results from a spring rain.

Mowing can be used to manage yellow starthistle, provided it is well timed and used on plants with a high branching pattern. Mowing early growth stages results in increased light penetration and rapid regrowth of the weed. If plants branch from near the base, regrowth will occur from recovering branches. Repeated mowing of plants too early in their life cycles (rosette or bolting stages) or when branches are below the mowing height will not prevent seed production, as flowers will develop below the mower cutting height. Plants with a high branching pattern are easier to control, as recovery will be greatly

reduced. Even plants with this growth pattern must be mowed in the late spiny or early flowering stage to be successful. An additional mowing may be necessary in some cases.

To encourage growth of desirable vegetation, let these species set seed before mowing, but be sure to mow well before starthistle is in full flower. In general, mowing is most effective when soil moisture is low and no irrigation or rainfall follows mowing.

Grazing is effective in reducing yellow starthistle seed production. Sheep, goats, or cattle eat yellow starthistle before spines form on the plant. Goats will eat starthistle even in the spiny stage. The plant's crude protein concentration is variable, but ranges from 28% at the rosette stage down to 11% at the bud stage and should be sufficient to meet the general maintenance requirements for most ruminants. When it is abundant, yellow starthistle appears to have the ability to sustain animals several weeks beyond annual grass "dry down." Intensive grazing in late May and June using large numbers of animals for short duration can reduce plant height, canopy size, and seed production. Avoid overgrazing, however; do not allow more than half the grass forage to be removed. Grazing more than this will reduce the grasses' recovery rate and ability to shade out yellow starthistle.

Burning is best performed at the end of the rainy season when flowers first appear. Yellow starthistle should be green at this time and will require desiccated vegetation to burn. Most annual vegetation other than yellow starthistle, particularly grasses, should have dried and shed their seeds by this time. The foliage of these plants serves as a fuel source to allow a more complete burn. Burning for 2 or more consecutive years helps suppress yellow starthistle and deplete the soil seedbank. Burning can also increase the recovery and density of perennial grasses. Burning can damage biological control agents, but insects from adjacent areas will readily move back into the site the fol-

lowing year.

Revegetation

Control practices are capable of reducing yellow starthistle populations, but in the absence of competition, starthistle will often reestablish. Effective management requires that desirable plant species be encouraged or planted and managed to prevent yellow starthistle germination or growth. Species choice for revegetation will depend on the intended use of that site. Resident vegetation such as perennial bunchgrasses or wildflowers may be desirable along roadsides, abandoned pastures, or in rangelands and wildlands. In these situations, cultural, biological, or chemical methods can be used to reduce yellow starthistle while encouraging other plant species, if possible, with practices such as fertilization. Research efforts to reestablish native perennial grasses are in progress. Perennial grasses are slow to establish and may require herbicide treatments to assist yellow starthistle or annual grass control during establishment, but once well established, alternative controls such as properly timed grazing, mowing, or burning can be used effectively.

In pastures, eliminate dense stands of yellow starthistle and reseed the area with a fast-growing, competitive forage species. Although annual legumes work well for this purpose, the lack of selective herbicides makes follow-up treatments difficult. Therefore, grasses are best because selective herbicides can then be used to control yellow starthistle plants not eliminated by grass competition. In areas with scattered yellow starthistle infestations, eliminate scattered plants and overseed with a desirable species to provide enough competition to prevent yellow starthistle from reestablishing.

In all instances, choose desirable species that are well adapted to the site and not likely to become invasive themselves. Species that grow well are the best competitors.

Chemical Control

Both postemergent and preemergent herbicides are available to control yellow starthistle along roadsides, rights-of-way, and noncrop areas. Most herbicides registered for use in rangeland and pastures are only active postemergence. Clopyralid, however, has both preemergence and postemergence activity on yellow starthistle.

Postemergent Herbicides. Postemergent herbicide treatments generally work best on seedlings. The long germination period of yellow starthistle makes control with a single application almost impossible. A treatment following the first flush of seedlings opens a site up for later flushes. Waiting until later in the rainy season to apply a postemergent herbicide allows a greater number of seedlings to be treated, but larger plants will require higher herbicide rates and may not be controlled.

Aminopyralid and *clopyralid* are growth regulator herbicides for use in non-crop areas, including rangeland and pastures. Unlike other growth regulator herbicides, these are effective on yellow starthistle both postemergence and preemergence. The most effective timing for aminopyralid application is from December to March, when yellow starthistle is in the seedling to midrosette stage; its soil residual should last until the end of the rainy season. Clopyralid has a shorter soil residual and should be applied January to March. For both chemicals, earlier applications (i.e., in fall) may not provide full-season control, and later applications (bolting to early spiny stage) will require higher rates. A single application at the recommended time will provide season-long control. Aminopyralid is used at 0.75 to 1.75 oz acid equivalent/acre, and clopyralid is used at 2 to 3.96 oz acid equivalent/acre. Both chemicals are selective on many members of the sunflower family, particularly thistles, but can also injure legumes, including clovers. Most other broadleaf species and all grasses are not injured. There are no grazing restrictions after aminopyralid or clopyralid use in

rangelands. While not registered for use around the home, aminopyralid and clopyralid do have registration for use in pastures, rangelands, rights-of-way, roadsides, and other noncrop areas. Clippings from treated areas should not be used as compost; these herbicides degrade slowly in compost and can be a problem when used as a mulch or fertilizer source in sensitive crops or landscapes.

2,4-D can provide acceptable control of yellow starthistle if it is applied at the proper rate and time. Treatment in the rosette growth stage provides better control than later applications. Amine formulations are as effective as ester formulations at the small rosette growth stage, and amine formulations reduce the chance of off-target movement.

Application rates of 0.5 to 0.75 lb active ingredient/acre will control small rosettes. Applications made later in the season, when rosettes are larger or after bolting has been initiated, require a higher application rate (1 to 2 lb active ingredient/acre) to achieve equivalent control. 2,4-D is a growth regulator and a selective herbicide that controls many other broadleaf plants, but has minimal effect on clovers and generally does not harm grasses. It has little, if any, soil activity. Drift from 2,4-D applications is common, particularly from ester formulations. Use caution when applying near sensitive vegetation or during windy or high temperature conditions. Certain formulations of 2,4-D require a restricted materials permit; generally formulations that are sold in small quantities (i.e., liquid formulations that do not exceed 1 quart and dry formulations that do not exceed 1 pound) do not require a permit.

Dicamba is very effective at controlling yellow starthistle at rates as low as 0.25 lb active ingredient/acre. When yellow starthistle rosettes are small, about 1 to 1.5 inches across, the 0.25 lb active ingredient/acre rate works well, but higher rates (0.5 to 0.75 lb active ingredient/acre) are needed if plants are larger. Applications made in late

rosette to early bolting stages have provided excellent control, although earlier treatments are better.

Dicamba is also a growth regulator and selective herbicide that controls many broadleaf plants, including clovers, but does not harm grasses. Its soil activity is very short. Like 2,4-D, it is available as both an amine and as an ester formulation. Drift from dicamba applications is common, especially from the ester formulation. Some formulations have lower drift potential than others. Use caution when applying near sensitive vegetation. Certain formulations of dicamba require a restricted materials permit; generally formulations that are sold in small quantities (i.e., liquid formulations that do not exceed 1 quart and dry formulations that do not exceed 1 pound) do not require a permit.

Triclopyr at 0.5 lb active ingredient/acre provides complete control of yellow starthistle seedlings but is not as effective on larger plants. More mature plants require rates up to 1.5 lb active ingredient/acre. Like 2,4-D and dicamba, triclopyr is a growth regulator herbicide with little or no residual activity. It is foliar-absorbed and active on broadleaf species, including clovers, but typically does not harm grasses. Triclopyr is formulated as both an amine and ester. The ester formulation is more sensitive to drift than the amine form. Caution should be observed when using the ester formulation. This material is registered for use around the home as well as for pastures, rangelands, rights-of-way, roadsides, and other noncrop areas.

Glyphosate controls yellow starthistle at 1 lb active ingredient/acre. Good coverage, clean water, and actively growing yellow starthistle plants are all essential for adequate control. Unlike growth regulator herbicides, glyphosate is nonselective and controls most plants, including grasses. It has no soil activity. A 1% solution of glyphosate also provides effective control and is used at this concentration for spot treatment of small patches. An application of glyphosate

is a very effective method of controlling starthistle plants in the bolting, spiny, and early flowering stages at 1 to 2 lb active ingredient/acre. However, glyphosate will severely damage desirable perennial grasses if they are sprayed as well. Glyphosate is registered for use around the home as well as for pastures, rangelands, rights-of-way, roadsides, and other noncrop areas.

Preemergent Herbicides. Preemergent herbicides must be applied before seeds germinate to be effective. The long germination period of yellow starthistle requires that a preemergent material have a lengthy residual activity. Make applications before a rain, which will move the material into the soil. Because these materials adhere to soil particles, off-site movement and possible injury of susceptible plants could occur if the soil is dry and wind occurs before rain. When yellow starthistle plants have already emerged, it is possible to combine a postemergent herbicide (to control emerged plants) with a preemergent herbicide (to provide residual control of any subsequent germination) for an effective control strategy.

Chlorsulfuron and sulfometuron are preemergent herbicides registered for roadsides and other noncrop uses. Chlorsulfuron was recently registered for use in rangelands. Both are very effective at controlling yellow starthistle when applied at 1 to 2 oz active ingredient/acre. Little postemergence activity occurs on yellow starthistle with these two compounds. Best control is achieved when applications are made before weeds emerge. They may not be used around the home.

Integrated Approaches

Combinations of prescribed burning and clopyralid can be very effective for yellow starthistle control. However, when using this integrated approach it is important that a prescribed burn be conducted the first year (or possibly for 2 years) and that clopyralid be applied in the last year of the program. Treating in the first year and burning in the second year

may increase the starthistle problem because burning has been shown to increase seed germination during the following rainy season. Continued control of yellow starthistle after the last year of treatment can be accomplished by either mowing, spot spraying, or hand-pulling. ♦

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

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APPENDIX C: Structural Pest Factsheets

Argentine Ant (*Linepithema humile*)



Photo by Joyce Gross

The goal of ant management is to prevent the ants from becoming a nuisance to people working in a building. It is impossible to eliminate ants outdoors.

Biology and Life Cycle

Argentine Ant Colonies

- Colonies are linked by tunnels, allowing workers and queens to move freely from nest to nest. Each colony has many queens and all queens and workers live in harmony. Perhaps it is more accurate to think of Argentine ants as living in huge colonies over large areas of land with perhaps millions of entrances.
- Because of these huge “supercolonies,” the concept of finding and killing “the” nest is not always valid.
- The energy that most other ant species use in defending the colony is used by Argentine ants for reproduction.

Feeding Behavior

- Worker ants, which are all females, feed and care for the young (larvae) but also feed each other and the queens. This is the way toxic baits are spread throughout a colony.
- On average, at any one time, a very small proportion of a colony is out foraging, so killing these ants with a pesticide spray will not eliminate the colony.

- Adult ants can swallow only liquids, but they collect solid food to feed to their young, which digest the solid food and regurgitate liquids for the adults to feed on.
- Argentine ants feed on just about anything, from dead animals (including insects) to all kinds of human and pet food, to vomit, feces, and even human sputum.
- A favorite food is the honeydew produced by insects like aphids, mealybugs, scales, and whiteflies. Argentine ants protect these insects from their natural enemies.

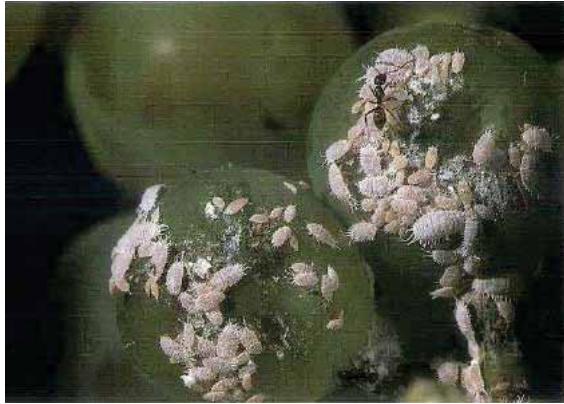


Photo by Jack Kelly Clark

Argentine ants collecting honeydew from mealybugs

- Plants that harbor these pests and are growing near a structure will attract ants to the building.
- If ants are excluded from plants with honeydew-producing insects, natural enemies will often eliminate the plant pests.
- Removing these plants will greatly help with ant management.
- Liquid baits that use sugar as an attractant are a very effective method for managing ants in the landscape because adult Argentine ants will feed on liquid sugary baits year-round.



Photo by Whitney Cranshaw, CO State Univ., Bugwood.org

Argentine ants feeding on sugar water/boric acid bait

- Baits with a protein attractant may only be useful when the colony is expanding and adult ants are feeding a large number of young (i.e., late winter/early spring).
- For details on baiting, see Baiting Tips for Ants, below.

Nesting sites

- Within hours, an Argentine ant colony can move its nest to take advantage of a food source or to escape inhospitable conditions. In winter, the ants look for places that are warmer and drier, and in summer, they seek cooler and moister sites.
- Their shallow nests are primarily in the ground, and they are not marked by significant soil mounds. They prefer moist, well-drained soil.

Outdoors, some places to find nests are

- near irrigated turf and other landscaping,
- in planters and potted plants,
- in the ground under trees, especially trees with honeydew producing insects,
- near faucets and irrigation valves,
- under sidewalks, stones, and patios, and
- in soil or decomposing leaves accumulated in the corners of a roof.

Inside, nests can be found

- in potted plants,
- inside cupboards and drawers,
- under tiles on kitchen counters,
- behind wall tile and brick veneer,
- in the insulation in dishwashers, washing machines, and refrigerators,
- in wall voids,
- in vehicles, and
- in unusual places, including inside metal curtain rods and inside bathroom sinks in the void that allows overflowing water to escape down the drain.

Seasonal Colony Development and Feeding Behavior

Winter (November thru January): many adults die, the colony essentially stops breeding, and the ant population is small.

Liquid sugar baits are accepted better than other baits, and less is needed because of the low population.

Late winter/early spring: breeding increases, and adult workers seek honeydew for themselves and protein to feed developing larvae.

Both solid protein and liquid sugar baits are accepted.

Summer: honeydew producers decline (beginning in July/August), and ants start to look elsewhere for food, often in nearby buildings.

In early summer, solid protein baits are still accepted.

Liquid sugar baits are readily accepted all summer.

Fall: the ant population has reached its maximum, honeydew food sources have declined, and foraging pressure results in more nearby building invasions.

Liquid sugar baits are readily accepted.

Ant Management

To limit availability of food and water

- Discuss the importance of not feeding wildlife, including feral cats, with those who may want to do so, or implement *and* enforce a policy prohibiting the feeding of feral animals. Pet food, both wet and dry, is very attractive to ants.
- Discuss with the appropriate people the importance of sanitation in relation to ant invasions.
- Thoroughly rinse recyclables that will be stored. It is preferable to store them outdoors if at all possible. If they must be stored indoors, special care must be taken during times of ant invasions to make sure the recyclables are clean and dry.
- Remove garbage containing food wastes from the building before nightfall, or, if this is not possible and rats are not a problem, tie a knot in the plastic liner.
- Store garbage, especially garbage containing food wastes, in garbage cans or dumpsters outside the building. These receptacles must have tight-fitting lids that are kept closed.
- Thoroughly clean food preparation and eating areas daily.

- Regularly steam clean large appliances in commercial kitchens.
- Store food in the refrigerator, freezer, or cooler, or in ant-proof containers such as plastic containers with tight-fitting lids or screw-top jars. Screw-top jars are not ant-proof unless the lid has a rubber gasket.
- Discourage people from storing food in desks or lockers. Insist that food in personal spaces is stored in ant-proof containers.
- Use plastic liners in wastebaskets and garbage cans.
- If ants coming to food waste create a continual problem, you can set small garbage cans on ant-proof stands such as the Antser® (soapy water under a platform prevents ants from accessing anything placed on the device).
- Treat honeydew-producing insects on vegetation near the structure by washing with plain water or with insecticidal soap and water. Aphids, scales, mealybugs, whiteflies, and psyllids are examples of honeydew-producing insects.
- An alternative is to remove and/or replace plants that regularly have large populations of honeydew-producing insects.

Some plants that are highly attractive to honeydew-producing insects are:

- Citrus
- Bottlebrush bush
- Chinese elm
- Conifers (pines, redwoods)
- *Eugenia*
- Figs
- London planetree (sycamore)
- *Pittosporum*
- Roses
- Tulip magnolia



Ant-proof stand with platform cover removed

To limit availability of shelter/habitat

- Reduce excessive moisture and irrigation leaks near structures.
- Reduce areas covered with black plastic and decorative rock, especially next to the foundation.
- Reduce or eliminate bark mulch within at least 6" of a building.
- Cut back or eliminate ground covers next to the structure. This will also allow better access to the foundation to observe ant and other pest activity.
- Manage potted plants with ant infestations:
 - Move to the outdoors any potted plant with an ant nest, water the plant, and then set the pot in a container of water. Provide a bridge (a pencil or stick) from the potted plant to the edge of the water container, and wait for the ants to leave the pot.
 - After the ants have left the potted plant, place the pot on an ant-proof stand, such as the Antser® (see photo above).
 - Potted plants can also be placed in a moat of soapy water: place the pot on a small overturned saucer inside a larger saucer and add water to the larger saucer along with several drops of liquid detergent. The water should come to just below the overturned saucer so the plant is not sitting in soapy water.

To limit access to the structure

- Trim branches that touch the building to prevent ants from using them as highways into the building.
- Whenever you find an ant trail inside a structure, try to find the spot where they are getting into the room. If you routinely caulk these little entrance points, you will eventually close up most of the easy entrances into the building without having to caulk every square inch. It is most efficient to let the ants show you where to caulk. Over time, you can also close up holes around wires and pipes that go into the building.
- Insert foam insulator sheets behind electrical face plates to seal off ant access and reduce infiltration of hot or cold air.
- Blow low-toxic insecticidal dusts, such as silica gel or diatomaceous earth, into cracks and wall voids.

Ways to remove ants from an area

- Vacuum up ant trails.
- Pick up ants with a sticky lint roller
- Clean up ant trails with soap and water



Various sizes of sticky lint rollers (washable)

Chemical Controls (Insecticides)

Baiting is the preferred chemical control method for Argentine ants.

Why use baits?

- Baiting may take longer to kill ants but will have a much greater impact on the colony as a whole because ants take bait back to feed their nest mates. Sprays kill only a small fraction of the ants that are out foraging, and the foragers only represent a very small fraction of the total colony.
- Spraying pesticides around the outside of a structure can lead to run-off that contaminates creeks, rivers, and the Bay. This is especially true if pesticides are sprayed on impervious surfaces. Rain or irrigation can move the pesticide residues into storm drains that drain to creeks and the Bay.

Note: Do not spray pesticide on or near ant bait stations because the pesticide can repel the ants.

Baiting Tips for Ants

- Outdoors, baiting can be used to draw ants out of a structure or to prevent them from going in.
- Inside, baits should be left only long enough to stop the trail of ants entering the building. At that point, the bait stations should be removed in order not to attract more ants into the building.
- Liquid baits that use sugar as an attractant are a very effective method for managing ants in the landscape because adult foraging ants will feed on liquid sugary baits year-round. Use liquid baits that contain boric acid (orthoboric acid) or borax (sodium tetraborate decahydrate) as the poison. It is preferable to use baits that contain only 1% to 2% of either boric acid or borax because the lower percentage allows more foraging ants to take bait back to the nest to feed to nest mates, instead of succumbing to the poison on the way home. Place bait stations along ant trails, at the base of the affected plant, or near the nest, if you can locate it. (Note that there may be a number of nests.)



Bait station for liquid bait,
cut away to reveal interior



Argentine ants entering a
bait station using solid bait

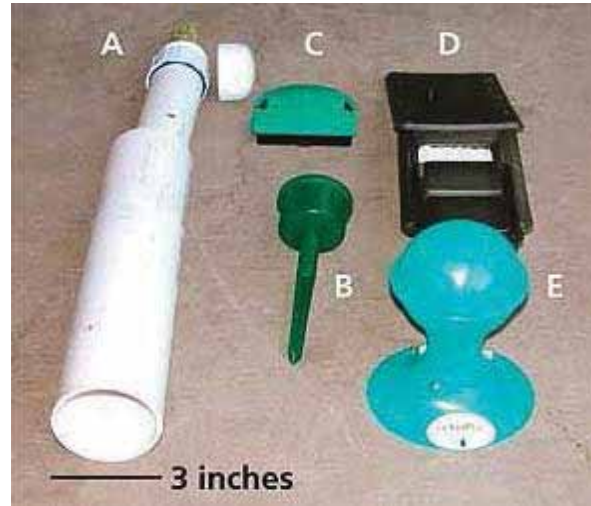


Photo from U.C. Riverside

Liquid and granular bait stations

(A) liquid bait station constructed from PVC pipe—Univ. of CA design used in trials to control Argentine ant on citrus

(B) granular bait station (Kness Manufacturing Co., Albia, IA)

(C) granular bait station, B&G Perimeter Patrol System (B&G Equipment Co., Plumsteadville, PA);

(D) liquid bait station (Whitmire Micro-Gen, St. Louis, MO)

(E) liquid bait station, (Km AntPro, Nokomis, FL)

All except (A) are commercially available.

- You can also experiment with commercially available bait stations with active ingredients such as indoxacarb or hydramethylnon in a solid matrix. Ants can change their food preferences frequently, so having several different kinds of bait stations on hand can be useful.
- If ant populations are high, or invasions persist and placing bait stations around the exterior perimeter of the building is not feasible, use bait stations inside and apply an insecticidal dust, such as diatomaceous earth or silica gel, to cracks, crevices, wall voids, electrical boxes, conduits, etc. If necessary, insecticidal dusts can be used to spot-treat under the edge of carpets and behind baseboards. Step up sanitation measures and seal all cracks and holes where ants are entering.

The UC Statewide IPM Program Web site provides additional information on managing ants at <http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7411.html>

Bed Bugs



Bed bug nymph (left) and adult

Bed bugs should be handled by a professional, but municipal staff should be aware of their existence.

Municipalities need to have a plan in place for handling a bed bug infestation in municipal buildings, as well as plan for handling bed bug complaints from citizens.

Worldwide, bed bug populations are on the rise, and the reasons for this resurgence are unclear. Many areas of the U.S. are severely affected, and as bed bugs become more numerous, the threat to public facilities becomes greater. Bed bugs are small and are easily moved from one place to another on furniture, luggage, backpacks, purses, and other human belongings. Bed bugs have infested buses, taxis, trains, police cars, fire stations, theaters, hospitals, libraries, and public waiting rooms, not to mention homes, apartment buildings, and five star hotels.

Bed bugs have not been found to transmit diseases to humans, but their presence, their bites, and the stigma attached to having bed bugs can take a serious psychological toll. Bed bugs can be very expensive to treat, and lawsuits about who is responsible for that treatment are raging across the country.

Bed bugs are not caused by being poor, “being dirty,” or by keeping a “dirty” home; however, the more clutter in a dwelling, the harder it can be to find and treat bed bugs. Bed bugs are a “pest of exposure,” which means that if you are exposed to bed bugs, you run the risk of taking them home (or to the office).

It is the responsibility of municipal and County staff to help dispel the stigma attached to bed bugs and promote awareness by educating the general public, since scientists agree that the problem is only going to get worse. Municipalities will most likely be called on to help citizens whose homes are infested but whose landlords refuse to provide treatment.

Contra Costa County's IPM Web site provides information on bed bug identification, biology, and treatment, see www.cchealth.org/ipm

Cockroaches

Biology and Life Cycle

- There are a number of different cockroach species that are considered pests. In Contra Costa County, the species that are most likely to be found in buildings are the German cockroach (*Blattella germanica*) and the Oriental cockroach (*Blatta orientalis*).



Photo by J. Kalisch, U.of NB-Lincoln Extension

Comparison of cockroach species

- The German cockroach is the most common indoor species and is typically found in warm, humid environments near food and water, most often in kitchens and bathrooms.



Photo by J. Kalisch, U.of NB-Lincoln Extension

German cockroach life stages—adult male, adult female (carrying an egg case), nymphs and egg case

- The oriental cockroach primarily lives outdoors in dark, damp environments, such as water meter boxes and decaying organic matter, and it invades the ground floors of buildings only periodically.



Photo by J. Kalisch, U.of NB-Lincoln Extension

Oriental cockroach life stages—adult male, adult female (note $\frac{3}{4}$ wings), nymphs, and egg case

- The American cockroach (*Periplaneta americana*) prefers warm, humid environments and lives in places like sewers, steam tunnels, and masonry storm drains. It may occasionally invade the ground floor of a building because of a break in a sewer pipe or for other reasons.



Photo by J. Kalisch, U. of NB-Lincoln Extension

American cockroach life stages—adult male (note that wings extend beyond abdomen), adult female, nymphs, and egg case

Food preferences

Cockroaches feed on a wide variety of substances found in inhabited buildings:

- Starch, sweets, grease, meat products, cheese, and beer;
- Leather and glue;
- Hair and flakes of dried skin; and
- Dead animals and plant material.

Behavior that impacts management

- Cockroaches are mainly active at night, but they may be seen in the day, especially if there is a large infestation.
- During the day, cockroaches primarily hide in cracks and crevices.
- Most pest cockroach species originated in tropical or sub-tropical environments and therefore prefer warm, moist habitats.
- Although immature German cockroaches may not feed directly on toxic baits, they are susceptible to secondary poisoning from any baits used to control cockroaches in the vicinity. This is because immature German cockroaches will feed on cockroach droppings, and those droppings can contain minute amounts of the pesticide active ingredient in the cockroach bait.

Life cycle

- Cockroaches mature through three life stages: egg to nymph to adult. The nymphs resemble the adults but are smaller, sexually immature, and without wings or wing pads.

- Mated adult females produce an egg case that is called an ootheca, which contains two rows of eggs. The German cockroach female carries the egg case with her until just before it is ready to hatch, and then she deposits it into a crevice or other sheltered location. Oriental cockroach females carry their egg cases around for about 30 hours before depositing them, and American cockroach females carry theirs for about a day.
- The amount of time it takes for a cockroach to go from egg to adult varies among species and within species. The speed of development depends on the temperature, humidity, quality of the nymph's diet, and other environmental factors.

The UC Statewide IPM Program Web site provides additional photographs and more detailed descriptions of each pest cockroach species, see <http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7467.html>

Cockroach Management

To limit availability of food and water

- Discuss with the appropriate people the vital importance of sanitation in relation to cockroaches.
- Food preparation and eating areas should be thoroughly cleaned daily. Drain sinks and remove all food debris. Do not leave food prep and eating areas wet or dirty overnight.
- Store food in the refrigerator, freezer, or cooler, or in roach-proof containers such as Tupperware or screw-top jars. Screw-top jars are not roach-proof unless the lid has a rubber gasket.
- Discourage people from storing food in desks or lockers. Insist that food in personal spaces is stored in roach-proof containers.
- Limit areas where food can be eaten, and make sure to clean those areas after holiday, birthday, or other kinds of parties. Regularly steam clean large appliances in commercial kitchens.
- Periodically give all food preparation areas a deep cleaning, focusing on drains, vents, deep fat fryers, ovens, and stoves. Steam clean drains and infested appliances. Use a vacuum cleaner to capture cockroaches driven out by the steam.
- Use plastic liners in waste receptacles.
- Thoroughly rinse recyclables that will be stored. It is preferable to store them outdoors, if at all possible. If they must be stored indoors, special care must be taken to make sure the recyclables are clean and dry.

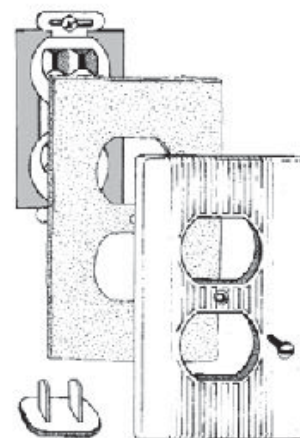
- Remove garbage containing food wastes from the building before nightfall, or, if this is not possible and rats are not a problem, tie a knot in the plastic liner.
- Store garbage, especially garbage containing food wastes, in garbage cans or dumpsters outside the building. These receptacles must have tight-fitting lids that are kept closed.
- Keep waste receptacles and dumpsters clean.
- Fix all leaking faucets and pipes.
- Drain and/or ventilate moist areas.
- Keep food preparation areas dry when not in use, especially overnight.

To limit availability of shelter/harborage

- As much as possible, eliminate clutter.
- Break down corrugated cardboard boxes and store them away from vending machines and food storage and preparation areas, preferably in a cool or cold spot. The corrugations provide perfect habitat for cockroaches. Cockroaches routinely hitchhike into buildings in cardboard boxes.
- Keep storage closets and other storage areas well-organized and clean.
- Cockroaches hide in cracks and crevices. Caulk or otherwise seal cracks and crevices, first in areas where cockroach populations are highest. As time and money allow, work on other areas that provide good cockroach harborage.
- If gaps cannot be sealed, they can sometimes be widened to make them unattractive to cockroaches. For instance, the space between free-standing shelves and adjacent walls can be widened by moving the shelves one inch away from the walls.

To limit access to the structure

- Sealing gaps in walls around plumbing and electrical conduit is very important for keeping cockroaches from moving along these “roach highways” from one room to another.
- Foam gaskets inserted behind electrical face plates will seal off cockroach access and reduce infiltration of hot or cold air.



Sealing electrical outlets

- Screening and weather-stripping windows and doors can prevent Oriental cockroaches from entering the building and prevent German cockroaches from infesting different locations in the same building.
- Filling deep cracks and crevices around the foundation of the structure will reduce Oriental cockroach harborage areas and their access into the building.

Removing and trapping cockroaches

- Vacuuming has an immediate impact on the cockroach population and reduces the level of allergens produced by cockroaches.
- Sticky insect monitors and “roach motels” are very effective in capturing cockroaches, but they usually cannot solve a cockroach problem by themselves. They are excellent tools for monitoring for cockroach problems.

Chemical Controls

- **Silica gel and diatomaceous earth** work by adsorbing the outer waxy coating on an insect’s body, which allows water to leak out of the insect and causes death by dehydration. These dusts can be used in wall voids, cracks and crevices, and under appliances.
- **Insect growth regulators (IGRs)** are biorational insecticides that mimic hormones occurring naturally in cockroaches and other insects. They help to manage cockroaches by inhibiting reproduction and preventing young cockroaches from maturing into adults. They also work synergistically with insecticidal baits because they increase the cockroaches’ appetite and bait consumption. Examples are Gentrol® Point Source and Gentrol® IGR Concentrate.
- **Cockroach baits** work best where sanitation is good so that the bait is not competing with freely available cockroach food. Using baits reduces the amount of pesticide in the environment because small amounts of bait, containing minute amounts of pesticide, are placed only in areas where cockroaches are likely to feed.



German cockroaches feeding on gel bait

Filth-Breeding Flies

Resources for Biology and Management

There are a number of fly species that breed in animal manure, animal carcasses, food waste, and other decaying organic matter. These include house flies, little house flies, flesh flies, and blow flies. More detail about fly biology is available on the UC Statewide IPM Program Web site: <http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7457.html>).

Vinegar flies (fruit flies) are most common in decaying fruits and vegetables but can breed in drains and in wet mops. More information is available on the Penn State Entomology Web site: <http://ento.psu.edu/extension/factsheets/vinegar-flies>

Phorid flies also breed in decaying organic matter, both animal and vegetable. Broken drains and broken garbage disposals can produce huge numbers of phorid flies. For more information see the Clemson University Web site: http://www.clemson.edu/cafls/departments/esps/factsheets/household_structural/humpedback_flies_hs24.html

See also the Pest Control Technology Web site: <http://www.pctonline.com/pct0613-phorids-control-inspection.aspx>.

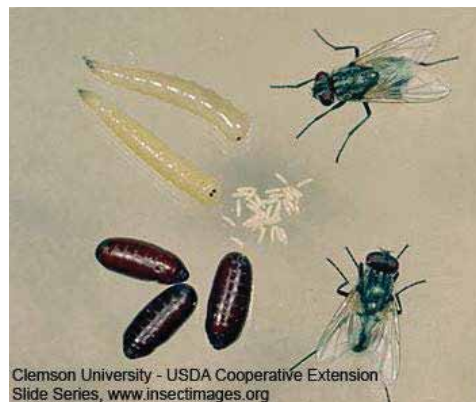
Drain (moth) flies breed in decaying organic matter, especially in and around drains and sewers. More detail about drain fly biology is available on the UC Statewide IPM Program Web site: <http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74167.html>).

Flies mature from egg to larva (maggot) to pupa (cocoon) to adult. Although adult flies may seem to be the most bothersome stage, it is important to concentrate on where the maggots are living to eliminate a problem. Sanitation and exclusion are the most important aspects of fly management.

House Fly Management

To limit availability of food

- Discuss the importance of not feeding wildlife, including feral cats, with those who may want to do so. Wet pet food and dry pet food moistened by irrigation, rain, or spilled water that is intended for feral animals may also provide food for adult flies and for maggots.
- Pet droppings and animal manure will also breed flies.



House fly life stages—eggs, larvae (maggots), pupae, adults

- Flies can breed in piles of grass clippings when the moisture content and temperature are favorable.
- Discuss with the appropriate people the importance of sanitation in relation to flies.
- Drain food wastes before placing in a plastic bag for disposal in a waste receptacle or dumpster.
- Use plastic liners in all waste receptacles that might collect food garbage; seal the plastic liners before placing in outside dumpsters or garbage cans.
- Remove garbage containing food wastes from the building before nightfall, or, if rats are not a problem, tie a knot in the plastic liner.
- Store garbage in closed, rodent-proof dumpsters or garbage cans outside the building and away from doors.
- Keep waste receptacles and dumpsters clean; use a high-pressure stream of water or a brush and soapy water. Rinsing with a mild solution of borax or baking soda and water will eliminate odors. Do not allow wash water to enter the storm drain, and consult with your local sanitary district for proper disposal.
- Flies can breed in soil soaked with water used to clean garbage cans and dumpsters. Check these areas regularly and scrape up any maggots along with the soil, and dispose of the material in a sealed plastic bag.
- Promptly fix drains that allow food waste to accumulate under sinks or floors and repair garbage disposal units that leak. This food waste will attract many different kinds of flies, and once they start breeding in the food waste, you will have a difficult time figuring out where they are coming from.
- If drains or garbage disposal units do leak food waste, remove all the food waste and clean the area *thoroughly*.
- Store food in the refrigerator, freezer, or cooler, or in insect-proof containers such as Tupperware or screw-top jars. Screw-top jars are not insect-proof unless the lid has a rubber gasket.
- Limit areas where food can be eaten, and make sure to clean those areas after holiday, birthday, or other kinds of parties.
- Outdoors, pick up and remove fallen fruit as soon as possible.
- Remove pet feces as soon as possible and place them in a sealed plastic bag, then into a waste receptacle or dumpster.
- Maintain compost piles properly; otherwise, they can produce large numbers of flies.

To limit attractive odors:

Flies are strongly attracted to odors that come from materials that might provide them with food or a place to lay eggs, and they can detect these odors over long distances.

- Place dumpsters, garbage cans, and recycling containers away from outside doors to the building.
- Keep dumpsters and garbage cans clean to eliminate odors (see above).
- Empty dumpsters and garbage frequently, at least once a week; consider twice-weekly garbage pickup during warm weather if the fly problem is severe.
- Store food waste in sealed plastic bags.
- Remove pet feces as soon as possible and place them in a sealed plastic bag, then into a waste receptacle or dumpster.
- Decomposing food left for feral cats can provide many attractive smells.
- The brown- to cream-colored fly specks found on walls and other surfaces where house flies have been resting have a strong fly-attracting odor. They should be frequently cleaned off of surfaces with an odor eliminating cleaner (a mild solution of borax or baking soda and water is effective).

To limit access to the structure

- Tightly screen all windows and doors.
- Weather-strip all windows and doors.
- Seal gaps around windows and doors.
- Screen air intake and exhaust vents.
- Equip doors with self-closing devices to prevent them from being left open inadvertently.
- Install air curtains on doors that must remain open and cannot be screened. The air stream must have a velocity of 1,600 feet per second to be effective.

Trapping flies

- **Indoors**
 - Sticky fly tape and/or fly swatters can eliminate a small number of flies indoors; however, fly paper may be considered unsightly.



Sticky fly tape that can be hung from the ceiling

- Ultraviolet light traps can be effective indoors as a supplement to other measures. They must be used in areas where they are not competing with natural light. Follow the manufacturer's instructions carefully.



Ultraviolet light trap for flies

- **Outside**, cone-type fly traps with strong-smelling bait can be extremely effective in helping to control serious fly populations.



<http://www.biconet.com/flies/RidMaxFlyTrap.html>

Screen cone fly trap—flies enter under the trap, walk up the cone, through a hole, and into the screened cylinder. Flies are attracted to light and because it's always brighter above them, they don't walk back down through the hole.

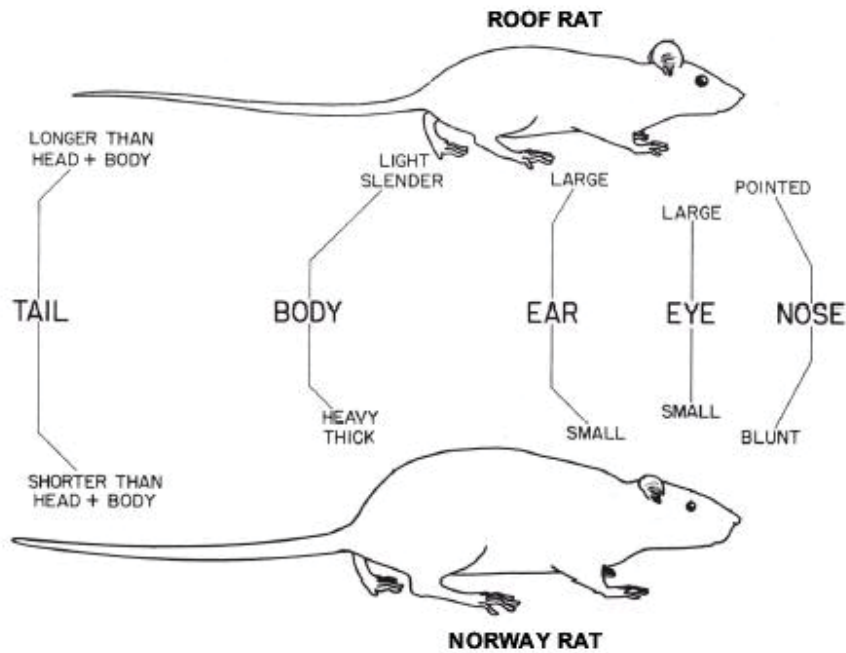
Note that *Fannia* spp. ("little house flies") are not attracted to the same baits or traps as the house fly. *Fannia* is very difficult to distinguish from the house fly. In the Bay Area, these flies are often associated with dog droppings early in the year, and male *Fannia* can be seen circling in a room, outside in the shade, or under the protection of a porch. They circle for long periods of time and seldom rest. This phenomenon is generally a short-lived nuisance in early spring. Females rarely enter buildings. To prevent the circling, direct a fan at the area. Strong air currents disperse them.

Chemical Controls

Chemical controls are not effective and are not recommended for fly control.

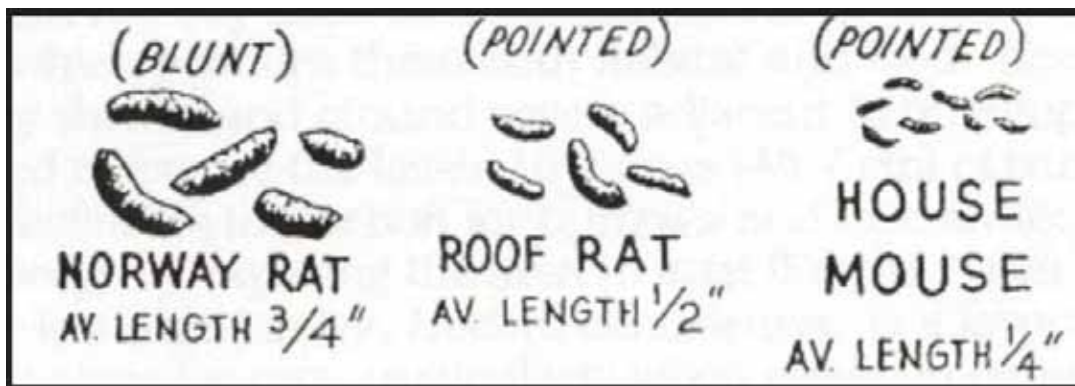
Mice, Roof Rats, and Norway Rats

Identification

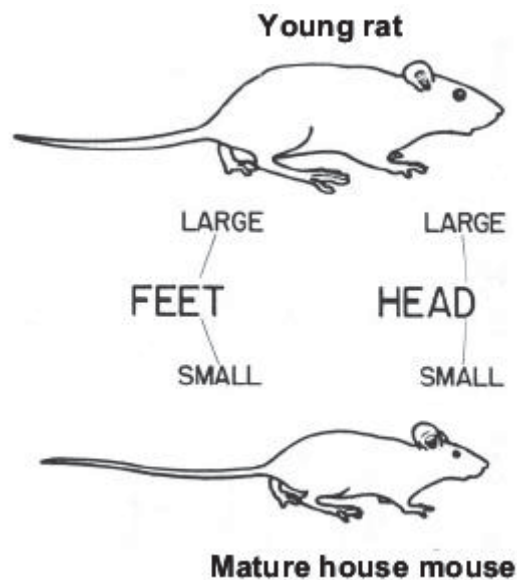


From Bjornson, B. F., and C. V. Wright. 1960 (revised). *Control of Domestic Rats and Mice*. Center for Disease Control, USDHEW, Public Health Service Pub. 56

Key characteristics of the roof rat (*Rattus rattus*) Norway rat (*Rattus norvegicus*)



Comparison of rat and mouse droppings



From Bjornson, B. F., and C. V. Wright. 1960 (revised). Control of Domestic Rats and Mice. Center for Disease Control, USDHEW, Public Health Service Pub. 563.

Key differences between a young rat and the house mouse (*Mus musculus*)

Biology and Life Cycle

Food Preferences

- Mice are omnivorous and will eat almost any food that is readily available. If cereal grains are available, they will be taken regularly.
- Norway rats eat a wide variety of foods, but they are more likely to eat garbage than roof rats. They prefer foods that are high in protein and carbohydrates such as meat, fish, cereal grains, nuts, and pet food.
- Roof rats also eat a wide variety of foods, but prefer fresh plant material such as nuts, fruit (especially avocados and citrus), vegetables, and tree bark. They are fond of snails and slugs.
- A house mouse can obtain all its water from the food it eats, but rats need free water to drink.

Nesting Habits

- Outdoors, Norway rats nest in the ground and in sewers and storm drains.

- Indoors, Norway rats usually prefer to nest on the lower floors of buildings in wall voids, storage areas, and any cluttered area that is little used, but if their population is large or preferred sites are scarce, they will nest on upper floors or in ceilings.
- Outdoors, roof rats usually nest above ground, and their nests can be in trees, especially untrimmed palm trees; in dense, overgrown vegetation, especially Algerian ivy (*Hedera canariensis*); in vines clinging to fences or the sides of buildings; in piles of wood and/or debris; and in the ground if there are no other suitable sites.
- Indoors, roof rats usually nest in the upper parts of the building in the attic and in attic and ceiling voids. They can also nest on the lower floors of the structure.
- Outdoors, mice can nest in fields, in weeds and shrubbery around a building, in storage sheds, and in crawl spaces.
- Indoors, mice nest near their food supply in wall, ceiling, and cabinet voids; within large appliances; in wall voids; in storage boxes, drawers, and desks; and in upholstered furniture.

Behavior that impacts management

- Mice can enter a structure through holes as small as ¼" in diameter. Rats can enter a structure through a ½" diameter hole, but they can gnaw on a small hole until it is large enough for them to squeeze through.
- Rats tend to be extremely wary (though temporarily) of new objects in their environment.
- Mice explore and re-explore their home territory daily, investigating changes and new objects.
- Rats and mice are active at night, but will adjust their habits to the availability of food; rodents seen in the day can also indicate a very large population.
- Rats and mice have a keen sense of hearing, smell, taste, and touch.
- Both rats and mice are prolific breeders.
- Rats can swim through sewers and enter a building through a toilet or a broken drain.
- Construction and weed management in empty lots can disrupt living space for mice and Norway rats and drive them into nearby buildings.
- Mice and rats prefer to travel along edges, such as next to a wall or a foundation. They will also travel along rafters, pipes, and wires.

Life Cycle

- Rats are capable of breeding throughout the year.
- The rat population normally peaks in spring and autumn.
- The number of pups per litter and the number of litters per year is dependent on the food supply and the availability of habitat.
- Rats live less than one year in the wild.
- Mice live less than one year in the wild; perhaps two years under excellent conditions.

Rodent Management

Prevention is the key to managing rats and mice. This must be done in-house.

To limit availability of food and water

- Discuss the importance of not feeding wildlife, including feral cats, with those who may want to do so, or implement *and* enforce a policy prohibiting the feeding of feral animals. Pet food, both wet and dry, is very attractive to rats (and raccoons, possums, other creatures).
- Discuss with the appropriate people the importance of sanitation.
- Limit areas for eating and storing food, and enforce these rules. The fewer designated areas, the easier it will be to limit pests.
- Store food properly: in the refrigerator or in metal, glass, or heavy plastic containers with tight fitting lids.
- Store bags of pet food, bird seed, and grass seed in rodent-proof containers, or, at the very least, inspect them often for any signs of gnawing.
- Do not leave food or food waste out overnight.
- Remove all garbage from the building at the end of the day. If this is not possible and rats or mice are a problem, then it is imperative to remove at least the food waste from the building at the end of every day.
- Store garbage containing food wastes outside in dumpsters that have tight fitting lids.
- Use plastic liners in garbage cans and clean any food wastes off the container with soap and water regularly.
- Require your refuse company to clean or replace the dumpster frequently.
- Never store extra garbage outside the dumpster or garbage cans.

- Pick up fallen fruit and nuts from trees daily.
- Pick up cat and dog droppings daily.
- Fix leaky plumbing and eliminate any unnecessary standing water.
- Avoid planting date palms and Algerian ivy (*Hedera canariensis*) because rats can both feed on and nest in these plants.

To limit availability of shelter/harborage

- Reduce clutter and debris by using proper storage techniques. Items such as cloth, paper, cardboard, and insulation make good nesting material for rodents, so store these carefully as well.
- Remove rock and wood piles and construction debris.
- In warehouses and commercial storage areas, store items on pallets 12 inches off the floor in rows 6 feet wide or less, at least 18 inches from any wall, and with space to walk between the rows. This creates aisles for inspection and cleaning.
- Trim trees, vines, bushes, grass, and weeds at least 2 feet from all buildings to decrease cover for rodent runways along the edges of buildings, to prevent hidden access to buildings, and to make inspections easier.
- Eliminate dense plantings or break them up with pathways or low groundcover.
- Avoid large expanses of low groundcover that could allow rats to run for long distances without being seen.

To limit access to structures

- Make general building repairs and seal large and small holes and gaps in structures both inside and out. If a pencil can fit in the hole, it should be sealed. Use appropriate, permanent materials. Foam sealant is not rodent-proof. Copper wool or caulk can fill small holes, and copper wool will not rust.
- Cover vents with ¼ inch hardware cloth.
- Seal gaps where pipes and wiring enter the structure.
- Weather-strip doors and windows.
- Use doorsweeps, metal kick plates, or raised metal doorsills to prevent rodent entry.
- Equip doors with self-closing devices to prevent their being left open inadvertently. Mice often gain entry to a building through an open door.
- Make sure air conditioning units are well sealed, especially those on the roof.
- Repair broken sewer pipes.
- Install threaded caps on drains.

Kind of Pest Proofing Material	Quality
Sheet metal	26 gauge thickness, galvanized
Expanded metal	28 gauge or heavier, not larger than ¼ inch (6 mm) mesh, rust resistant coating, or preferably galvanized, unless made of non-rusting metal
Perforated metal	24 gauge thickness or greater, perforations not to exceed ¼ inch (6 mm) in width
Iron grills	Sufficiently heavy to be equivalent to above materials; slots in grill not to exceed ¼ inch (6 mm)
Hardware cloth	19 gauge or heavier, galvanized or other rust-protective coating, with no opening larger than ¼ inch (4 x 4 meshes per square inch or 6 mm)
Cement mortar	Cement mortar should be 1:3 mixture or richer; concrete should be a 1:2:4 mixture or richer

From Handbook of Pest Control, Sixth Edition, by Arnold Mallis

Tolerance levels for rats and mice

- Inside of occupied buildings, the tolerance for rats and mice is zero.
- Outdoors, the tolerance level should be zero for Norway rat burrows within 500 ft of an occupied structure on municipal property. There should be a zero tolerance for the sighting of a roof rat during the day on municipal property. The tolerance level for mice outdoors is undetermined.

Predators

- Barn owls are excellent rat, mouse, and gopher predators, but they alone cannot control an infestation. Erecting barn owl boxes in the appropriate places will attract more owls to the area so that a municipality can benefit from their services. Barn owl boxes or plans may be purchased online. See <http://www.wildwingco.com/boxes.html> or <http://www.hungryowl.org/nesting-boxes.html>.

To purchase barn owl box plans, see http://www.hungryowl.org/nesting_boxes/boxplans.html.

Detailed plans for a barn owl box are also available at www.scvas.org/pdf/cbrp/BuildingBarnOwlBoxes.pdf.

- Cats and dogs will kill rodents, but they will not control an infestation.



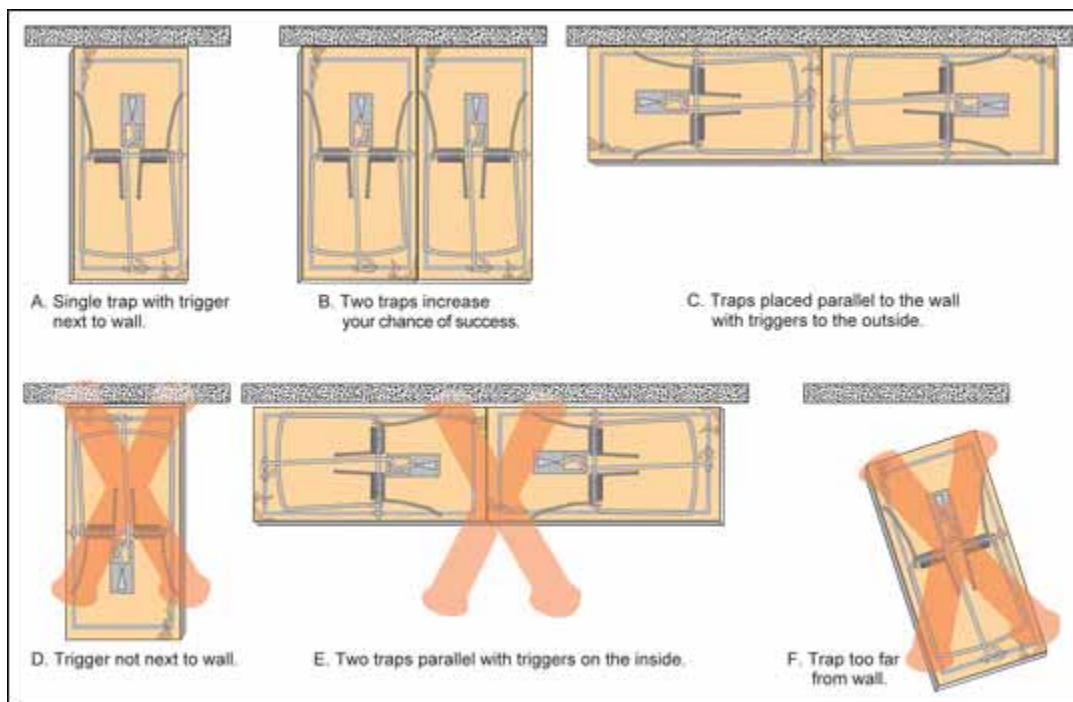
Photo by David Goodman

Barn owl outside a nest box

Trapping

Trapping is the best and safest way to get rid of mice or rats.

- Use snap traps to catch rodents, and record the trap location on your site plan. You don't want to leave dead rodents in a forgotten trap.
- Snap traps with "expanded triggers" are best.
- Always use plenty of traps. It's easy to underestimate the rodent population.
- Indoors, traps should be set along the edges of walls with the traps touching the wall (see the diagram below). For mice, there are multiple catch traps, such as Tin Cat®, that conceal the mice inside a metal box.



- Outdoors, large tamper-resistant bait stations can conceal rat snap traps and prevent children or pets from accidentally encountering the traps. This is the best rat control method for outside of buildings.

Initial Set-up for Using Traps inside of Bait Stations

1. Use T-Rex® rat traps or a similar trap. T-Rex® rat traps work very well inside a bait station; knock-offs and some other traps do not. The trap must be able to spring closed easily within the bait station.

2. Use bait stations such as Protecta Sidewinder® Bait Stations, or any other station that will easily accommodate the trap with its jaws open.
3. Set up and leave the trapping stations around the building. Place the edge of the station touching the building and place the side with the openings closest to the building.
4. Place a non-toxic feeding block, such as Detex Blox®, on the post inside the station.
5. Place a snap trap inside each station, but don't set the trap yet. (Rats are very wary of new things so this process lets them get used to the station as a safe place to get food.)



Protecta Sidewinder bait station

Note: a non-toxic Detex Blox, or similar feeding block, is substituted for the poison bait blocks.

Monitoring

6. Return in one week to check for rodent feeding activity on the feeding blocks.
7. If you see no feeding, continue to monitor the stations weekly.

Trapping

8. If you find evidence of rodent feeding, set the traps and place them so that the rat will encounter the open jaw as it tries to get to the feeding block.
9. You can use one of the baits mentioned below on the traps as an added enticement for the rats.
10. Come back one week later to check for activity or dead rats. Remove rats, re-set the traps, refresh the bait.
11. Repeat steps 8 through 10.
12. Replace the feeding blocks as necessary. Rats do not like old or rancid bait.



A T-Rex rat trap is placed inside the rat bait station.

If you cannot inspect the trapping stations every week:

- Deactivate the traps (but leave them in the stations), and leave the feeding blocks.
- Return in one month and set the traps again if you see feeding activity.

If you have a large infestation:

- Use more bait stations with traps.
- Be sure to inspect your trapping stations every week.
- Step up your sanitation measures.
- Make sure you have made the necessary repairs to the structure to prevent rats from getting in.
- Consider hiring a professional to help with the problem.

Trapping Tips

- Use as bait the food rats or mice are already eating. For roof rats, use nuts, dried fruit, apples, bananas, candy, marshmallows, raisins, or peanut butter. For Norway rats, use pieces of hot dog, cooked hamburger pieces, bacon, liver, peanut butter, or nut meats. For mice, use peanut butter or candy.
- Indoors, you can move objects around to funnel rodents into traps.
- Monitor traps regularly and frequently, and keep bait fresh. Rodents avoid old or rancid bait.

Chemical Controls (Rodenticides)

In general, chemical controls should be used *only* in emergency situations when public health is threatened. Rodenticides can pose hazards to non target animals, including children and dogs. Poisoned rodents often do not die immediately and can be eaten by birds of prey or other predators that can then suffer secondary poisoning. Poisoned rodents may also die in inaccessible places and cause odor and fly problems.

Exclusion methods and trapping should be favored over any chemical controls.

If a rodenticide becomes necessary, **use a first-generation anticoagulant** (see the chart below) for the following reasons:

1. They are less toxic than second-generation anticoagulants.
2. They are less likely to cause secondary poisoning to predators.
3. Vitamin K is a readily available antidote for anticoagulant poisoning.

4. Second generation anticoagulant rodenticides are considered so hazardous that they are now classified by the State of California as “restricted materials”, which means they can only be purchased and used by a certified private applicator with a restricted use permit from the County Department of Agriculture.

First-generation anticoagulants	
Common name	Example products (trade names)*
chlorophacinone	J.T. Eaton AC, Rozol
diphacinone	Ramik, Sierra
warfarin	Kaput, Rodex

* Always check the label for the active ingredient. The same or similar trade names may be used for products with different active ingredients.

Pigeons

Pigeons can transmit a number of diseases to people and can harbor a variety of insects, ticks, and mites that can bite humans. Their droppings deface and accelerate the deterioration of buildings and foul areas where people walk, work, or play. Their droppings and nests can clog drain pipes and air intakes.

The University of Nebraska's Digital Commons has more information on pigeons and many other vertebrate pests: <http://digitalcommons.unl.edu/icwdmhandbook/>



Pigeon (rock dove)

Biology and Life Cycle

- In urban areas, pigeons tend to move in flocks of sometimes hundreds of birds, and may fly up to five miles from feeding to nesting sites.
- They are very dependent on humans to provide them with food, water, and nesting and roosting sites. Pigeons can survive without food for several days but must have water daily.
- Pigeons are primarily grain and seed eaters, but they will also eat garbage, insects, and food provided intentionally or unintentionally by humans.
- For nesting and roosting, pigeons use roofs, ledges, drainpipes, attics, and architectural decorations.
- Nests are sticks, twigs, and grasses that are clumped together to form a crude platform. Pigeons often rely on parts of the structure to provide additional protection for a nest.
- Pigeons have one mate at a time. The male protects the female and the nest. Eight to 12 days after mating, the female lays one or two eggs, and about 18 days later the eggs hatch. The young, called squabs, leave the nest in about four to six weeks.
- Breeding can occur year-round, but it peaks in spring and again in fall.



Pigeon sitting in her nest

To limit food and water availability

- Discuss the importance of not feeding pigeons with those who may want to do so.
- Reduce the number of temporary water sources such as puddles, leaks, or any open container of water.
- Properly discard garbage and food items in and around the infested area; place in a container which inhibits bird access.

To limit shelter/harborage availability

Structural modifications to reduce nesting, roosting, and loafing sites:

- Seal gaps that allow pigeons access to roosting and nesting sites.
- Change ledge angles to at least 45° so pigeons cannot loaf, roost, or nest on them.
- Install plastic bird netting to prevent access to nesting or roosting sites.
- Use repellants such as plastic or metal spines, monofilament or steel lines, or gels or pastes.



Metal spines installed on a ledge to prevent pigeons from landing or roosting.

Trapping

- Trapping and releasing pigeons elsewhere is not an option because of their homing abilities. Pigeons will usually return to the same place where they were trapped and continue to cause problems.

Chemical controls

Lethal controls are usually unsuccessful because the dead birds are rapidly replaced by juvenile birds, and the flock may become larger than it was initially.

The best management tactics are eliminating food and water and limiting habitat through use of structural modifications.

Spiders

Spiders provide superior insect control and should therefore be left alone as much as possible.

A note on spider bites

Throughout the United States, spiders are blamed by both the public and physicians for bites to the skin and for many other dermatological wounds. Note that it is impossible for a physician, or anyone else, to distinguish one kind of bite from another by just looking at the bite because people's reactions to bites are so varied. The vast majority of the time, a spider would have no reason to bite a human. True spider bites (which are rare events) occur when a spider is trapped inside clothing or when someone puts a hand or other body part in a spider habitat without looking or slaps at a spider that is crawling on them.

Black widow spider

Black widows are very shy and will bite only when seriously provoked. Sticky traps can be placed where they will be effective in catching black widows as they migrate into a sensitive area. Black widows can also be removed with a vacuum. If black widows are common in your area, train staff and building occupants to refrain from sticking ungloved hands into dark holes or crevices, and remove clutter and debris both inside and outside.



Photo by Whitney Cranshaw

Black widow spider

Brown recluse spider

There are no populations of brown recluse spiders living in California. Necrotic lesions, similar to those caused by the bites of a brown recluse, can be the result of a bacterial, viral, or fungal infection or any number of other medical conditions.

Other spiders

Spiders and their webs should be removed with a vacuum or Webber (web removing tool that consists of a brush with a long handle). Sticky traps can be placed under furniture and in areas prone to crawling spiders. Changing outdoor lighting, either by moving the lights or changing the bulbs to yellow "bug lights" so that insects are not attracted near doorways, can reduce the number of spiders and webs in places where they are not wanted.

The University of California, Riverside, Department of Entomology Web site has more information on spiders: <http://spiders.ucr.edu/>

Wasps and Bees

Yellowjackets and Paper Wasps

Yellowjackets, if they pose a threat to people, should be handled by a professional. Yellowjackets can be aggressive in defense of their nests, and they carry a powerful sting. However, they are excellent insect predators, and should be left alone if they are not a threat to anyone.

Some yellowjackets are also scavengers. Especially in late summer and in fall, they can be found disrupting barbecues and picnics looking for meat and sodas. They also feed on fallen fruit and food waste in garbage cans.

CCC Mosquito and Vector Control Will Remove Ground Nests

In Contra Costa County, the Contra Costa Mosquito and Vector Control District will remove yellowjacket ground nests for you. You must find and mark the location of the wasp nest before you call them.

Contra Costa Mosquito and Vector Control District 155
Mason Circle
Concord, CA 94520
(925) 685-9301

To submit an online service request:

http://contracostamosquito.com/service_request.htm

The Differences between Yellowjackets and Paper Wasps

Paper wasps are less defensive and rarely sting people. You may be able to remove their (usually) small nests yourself if they are near pedestrian traffic.

Yellowjackets can be confused with paper wasps. Yellowjackets are fierce defenders of their nests, and will sometimes attack a person who is simply walking near their nest. Paper wasps are far less aggressive in defending their nest. Paper wasp nests may not have to be removed unless they are in the line of traffic into a building. Like yellowjackets, paper wasps are also valuable insect predators, and should be left alone as much as possible.



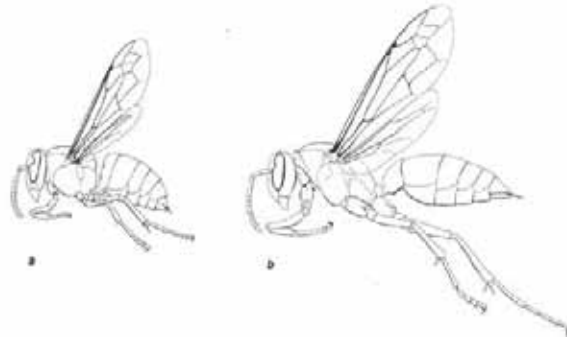
Western yellowjacket
(*Vespula pensylvanica*)



Photo by Eric Matthews © 2009

European paper wasp (*Polistes dominula*)

Yellowjackets are stocky and have relatively short legs compared to the long, dangling legs of the slender, thread-waisted paper wasp (see the illustration below).

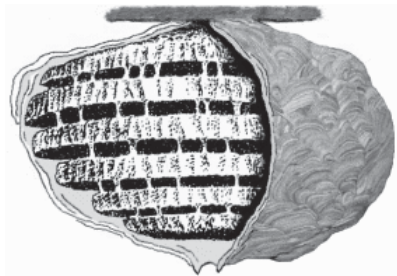


Yellowjacket worker

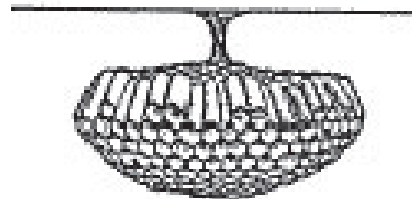
Female paper wasp (*Polistes* sp.)

from: Agriculture Handbook 552, The Yellowjackets of America North of Mexico

Yellowjacket nests are enclosed in a papery substance made from chewed vegetation and have a single opening at the bottom (below left). They can be constructed underground in a hole or animal burrow, or they can be found hanging from eaves or lodged in bushes. Paper wasp nests (below right) are small, rarely more than 6 to 8 inches in diameter, and open, without the papery enclosure of a yellowjacket nest. They are hung from horizontal surfaces such as eaves, window sills, and branches.



Yellowjacket nest with cutaway section to show interior comb structure.



Paper Wasp Nest

Control options vary depending on the proximity to the public and perceived hazard. Ideally treatment should be carried out either at dawn or dusk. Caution tape can be installed around a nest to temporarily warn passersby. The pest control technician must be equipped with an appropriate bee suit to remove a nest.

Yellowjacket nests (and paper wasp nests) can be removed with little or no pesticide use, so discuss this option with the pest control company you hire.

Yellowjacket Prevention and Management Chart

Prevention		
Time of Year	Action	
Early Spring	Set out yellowjacket traps to capture queens that are ready to begin new colonies. Use the pheromone included with the trap as a lure. Set traps away from human activity.	
Ideally year-round, but winter is not as critical	<ul style="list-style-type: none"> If you have a history of yellowjacket problems, keep recyclables tightly covered. Yellowjackets can feast on leftover soda and juice in empty cans and bottles. Keep garbage receptacles tightly covered. Do not allow the feeding of feral cats or other wildlife. Pet food can be very attractive to yellowjackets. 	
Management		
Locations/ Situations	Nonchemical Strategies	Preferred Chemical Treatment(s)
Foraging wasps around outdoor eating areas.	<ul style="list-style-type: none"> Use yellowjacket traps placed at least 20 feet from areas of high human activity to reduce the chance of human/wasp contact. The lure provided with some traps attracts primarily the western yellowjacket. Adding meat or canned mackerel to the chemical lure may increase the catch of other species of yellowjackets. Change meat or fish frequently because yellowjackets are not attracted to dry or putrefying bait. 	None
Foraging wasps near dumpsters and garbage receptacles.	<ul style="list-style-type: none"> Ensure lids and doors of receptacles are present and close easily. Keep doors and lids clean and free of food debris, especially when yellowjackets are in the area. If yellowjackets are a serious problem, consider increasing the frequency of waste pickup, installing receptacles with automatically closing lids or doors, and installing informational warning signs to alert the public. 	None
Nest in the ground.	Professionals can excavate a ground nest and remove the wasps by vacuum.	If you can find and mark the nest, the Contra Costa Mosquito and Vector Control will exterminate the nest. Call 925-685-9301 or make an online request at http://www.contracostamosquito.com/service_request.htm
Nest in a structural void, in a tree, bush, etc.	Professionals can remove nests using vacuums and/or steam.	A trained technician can also use insecticidal soap or pesticides derived from plant oils. Nest elimination should be done during the evening or very early morning hours to prevent risks to the applicator.

Adapted from a chart created by Mike Merchant and Dale Pollet, Texas A&M University

Yellowjacket Trapping

Trapping works by killing foraging wasps and drawing foragers away from areas of high human activity.

- In early spring, traps can be useful for reducing the number of queens that are ready to found new colonies.
- Traps designed especially for yellowjackets are available on the internet and in hardware stores or nurseries.
- While traps may have some benefit in reducing numbers of foraging wasps, they are not generally effective in eliminating entire yellowjacket colonies.



Yellowjacket cone trap



Disposable yellowjacket trap



Yellowjacket jar trap

Wasp and Bee Stings

- Yellowjackets and paper wasps can sting multiple times, while honey bees can sting only once.
- A honey bee stinger has a tiny barb, which locks the stinger in the skin after the bee pulls away.
 - Immediately after the sting, the stinger needs to be removed.
 - Attached to the stinger is a poison sac that continues to pump venom into the sting site for several minutes.
 - This stinger should not be pulled out; rather, it should be scraped off. A stiff sheet of paper or a credit card works well for this.
- A wasp sting does not require scraping.

- After you have identified the stinging insect and, if necessary, removed the stinger, be sure to observe the person for any signs of allergic reaction.
- Treatment for stings
 - If the person has a history of allergic reactions, shows signs of severe swelling, or has trouble breathing, call 911.
 - If the person shows no signs of distress, the sting area can be soothed by applying an over-the-counter insect bite and sting product. An oral antihistamine can relieve the itching caused by the sting.

Sting Prevention

- Keep sweet items covered, especially sodas and juices. This is especially important in parks where yellowjackets are currently foraging. A person could easily take a sip of soda without noticing a yellowjacket that is also taking a drink. This could result in serious stings to the mouth, tongue, or throat.
- Keep recycling bins and outdoor garbage cans clean and sealed, especially when they contain soda cans or cups, and food scraps. Ideally, all outside garbage cans should have self-closing lids.
- Don't walk barefoot on playing fields or on lawns with blooming weeds or flowers. Bees and wasps are nectar collectors, so they are often close to the ground.
- When in close proximity to bees or wasps, move slowly and fluidly. Quick, jerky motions will increase the likelihood of provoking the insects.
- If a bee or wasp lands on your body, don't panic. Gently brush it away, or wait for it to leave by itself.

Bee Swarms and Nests

- If the location of a bee swarm or nest poses a danger to the public, rope off the area and post warning signs. Bees in swarms are docile and are unlikely to sting. Swarms normally move out of the area after 8 to 12 hours.
- The municipality should contract with a bee handler such as the Mt. Diablo Beekeepers Association at (925) 458-3900 (<http://www.diablobees.org/swarmlist/>) for removal and relocation.

- If bees have made a nest in the wall of a structure, the entire honeycomb should be removed to prevent damage to the structure.



Bees on honeycomb

APPENDIX D: Guide to Sheet Mulching

Lose Your Lawn: The Bay-Friendly Way D-1



Lose Your Lawn: the Bay-Friendly Way

Sheet mulching is an easy way to replace your lawn

www.LoseYourLawn.org

Now is a great time to transform your conventional lawn into a Bay-Friendly garden. Sheet mulching is a technique of laying cardboard or newspaper over an existing lawn and then topping it off with layers of compost and wood mulch. The layers suppress weed growth and break down naturally – creating a vibrant ecosystem that gives you healthier soil and plants.

Sheet mulching can be done all at once or a little bit at a time. It doesn't require the use of heavy equipment or pesticides. Sheet mulching can be completed in one day, depending on the size of the area you are covering. The best time to sheet mulch is in the fall to take advantage of the rains, but it can be done any time of year. There are many different ways to sheet mulch. The following is a simple method recommended by the Bay-Friendly program:

1 PREPARE THE SITE

- **Mow or knock down tall weeds** so they lie flat.
- **Remove woody, bulky and invasive plants** such as blackberries, oxalis, horsetail, kikuyu and Bermuda grass.
- **Flag your sprinkler heads** if you plan to retrofit your sprinkler heads for drip irrigation.



Knock down weeds.

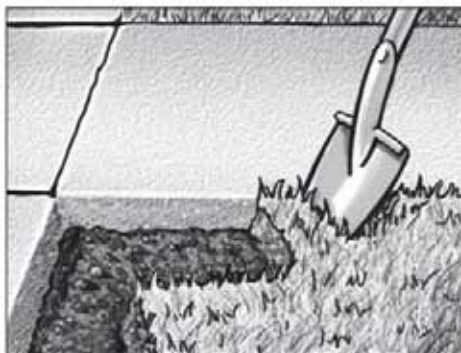


Soak the area.

Soak the area with water to start the natural process of decomposition

2 EDGING & MOUNDING FOR EROSION CONTROL

- **Edge the lawn** to avoid run-off and keep mulch from spilling onto paving. Use a flat-edged shovel to cut the lawn 8-12 inches away from the edge of the concrete. The soil should be at least 3 inches below the top of the concrete.



- **Create mounds** using the leftover soil and sod from edging, or simply sheet mulch in place. Just flip the edges over so the roots and soil face up. Don't worry if you encounter the plastic netting that came with your sod, just throw away the pieces that you see. Mounds can create visual interest in the garden by adding height and depth. Many native plants like well drained soil and thrive on mounds.



3 PLANT LARGE PLANTS

- **Install 5-gallon or larger plants** once the area has been prepared.



4 ADD A WEED BARRIER

- **Add a weed barrier** that is permeable to water and air, such as cardboard, newspaper or burlap. Recycled cardboard boxes can be found at appliance stores or bike shops. You can also buy recycled cardboard rolls. Do not use plastic or types of weed cloth which will not degrade.

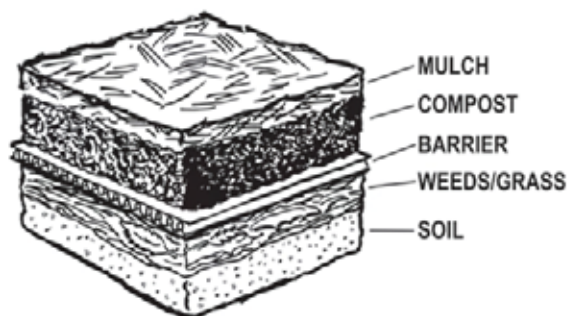


- **Overlap the pieces by 6-8 inches** so the sun won't get through. Any lawn showing at the end of the project will come right back.
- **Wet down the cardboard as you go** to keep it in place and to shape it around obstacles.
- **Work around existing plants** by ripping and folding the cardboard. It's easier to rip once wet.
- **Completely cover the ground** with the cardboard except where there are plants that you plan to keep.



5 LAYER WITH COMPOST AND MULCH

- **Add compost and mulch on top of the cardboard.** Spread compost directly over the cardboard and then cover it with bulky materials like wood chips to optimize water conservation and weed control. Adding 1-2 inches of compost will help build soil and provide a planting medium for 4-inch or smaller plants. However, if your main goal is weed suppression just add the mulch.



- **The compost/mulch layer should be a total of 3 to 5 inches deep.** The top layer of mulch mimics the newly fallen organic matter of a forest. Good materials for the top layer include chipped plant debris, tree prunings, leaves or even straw. You will need a lot of mulch. To determine the amount of mulch and/or compost needed, please see the calculators on LoseYourLawn.org.



6 PLANT

- **Punch or cut holes in the cardboard** and place your larger plants in the soil under the mulch. In cooler climates, smaller plants (4-inch pots) can be planted right into the mulch/compost layer on top of the cardboard. Add compost around the root ball if compost was not included in the previous layer.



7 PROBLEM PREVENTION

- **Your new plants will require water** and attention when they are young, even if they are drought-tolerant.
- **Do not pile materials** up against tree trunks or stems of plants.
- **Small seedlings may need protection** from snails and slugs that like to hide under the mulch, especially in the dry season.
- **Protect young trees from rodents** with physical guards like metal bands that wrap around the base.



For a detailed description and case study of lawn removal with sheet mulch, be sure to check out the *Bay-Friendly Gardening Guide*, download or order online at www.bayfriendlycoalition.org.

For information on lawn conversion rebates, where to find local materials, instructional videos and other resources, visit LoseYourLawn.org.

APPENDIX E: Pest Management Materials

LEED Certified Buildings.....	E-1
Other Municipal Buildings.....	E-2

APPENDIX E: Pest Management Materials

LEED Certified Buildings

The following materials conform to San Francisco’s Tier III (low hazard) pesticide criteria. The list of pesticides that might be used inside a LEED Certified building must be permanently posted in a prominent location in each LEED Certified building. The City of San Francisco has an approved pesticide list that may be used to customize the list below. See <http://www.sfapproved.org/pest-control-for-city#list>.

Brand Name	Active Ingredient	EPA Reg #	Signal Word	To be used for (e.g., ant bait, cockroach control, etc.)	Method of use (e.g., as a bait station, in cracks & crevices, etc.)	Area/building for use (e.g., in food service areas, around the outside perimeter of the building, etc.)
Advance Dual Choice Ant bait stations	Sulfluramid	499-459-AA-499	Caution	Ant bait	Bait station	Inside where needed or outside of buildings at perimeter
Advion Ant Bait Arena	Indoxacarb 0.1%	352-664	Caution	Ant bait	Bait station	Inside where needed or outside of buildings at perimeter
Advion Ant Gel	Indoxacarb 0.05%	352-746	Caution	Ant bait	Spot treatment in cracks and crevices	Inside where needed or outside of buildings at perimeter
Advion Cockroach Gel	Indoxacarb 0.06%	352-668	Caution	Cockroach bait	Spot treatment in cracks and crevices	Food service/ break areas inside buildings
EcoPCO AC Contact Insecticide	Eugenol, 2-phenethyl propionate	67425-4	Caution	Various insects	Spot treatment	Inside
Gentrol Point Source and Gentrol Concentrate	Hydroprene 90.6% and 9% respectively	2724-469 and 2724-351	Caution	Cockroach, moth flies, and pantry pest control (insect growth regulator)	Spot treatment in cracks and crevices, or slow release treatment station	Food service/storage areas inside buildings
Orange Guard	d-limonene	61887-1-AA	Caution	Various	Can be used to clean up an ant trail	Inside where needed
PiGNX	Capsaicin 0.0357%	84418-1	Caution	Pigeon repellent	Spot treatment as caulking	Window ledges, structural fixtures
Safer Brand Ant and Crawling Insect Killer, Powder	Diatomaceous Earth	59913-1	Caution	Ant control (exclusion)	Blown into cracks and crevices, voids	Wall voids
Victor Poison Free Wasp/ Hornet Killer	Mint oil	Exempt		Killing yellow jackets	Spot treatment for nest removal	Outside where needed, wall voids

MSDS and Labels are available in digital format. Hardcopies should be stored at the IPM Coordinator’s office, and must be easily available for any staff that apply pesticides.

Your pest control service provider must alert municipal staff to the placement of bait stations and gel baits and to the location of any other pesticide application. Gel baits and bait stations must be placed so that regular cleaning will not dislodge them.

The UC Statewide IPM Program provides factsheets regarding structural pests, among other topics. See <http://www.ipm.ucdavis.edu/PMG/menu.homegarden.html>

Other Municipal Buildings

The following table is an example of a list of pesticides that might be used in a structural IPM program. For assistance with choosing less hazardous pesticides appropriate for use in structural pest control, or to customize the list below, use the following resources:

- EcoWise Certified Pesticide Criteria with Examples. See http://ecowisecertified.org/ecowise_about_who.html (Select “Materials Criteria/Examples”)
- City of San Francisco Reduced Risk Pesticide List. See <http://www.sfapproved.org/pest-control-for-city#list>

Brand Name	Active Ingredient and %	EPA Reg #	Signal Word	To be used for (e.g., ant bait, cockroach control, etc.)	Method of use (e.g., as a bait station, in cracks & crevices, etc.)	Area/building for use (e.g., in food service areas, around the outside perimeter of the building, etc.)
Advion Ant Bait Arena	Indoxacarb 0.1%	352-664	Caution	Ant bait	Bait station	Inside where needed or outside of buildings at perimeter
Advion Ant Gel	Indoxacarb 0.05%	352-746	Caution	Ant bait	Spot treatment in cracks and crevices	Inside where needed or outside of buildings at perimeter
Advion Cockroach Gel	Indoxacarb 0.06%	352-668	Caution	Cockroach bait	Spot treatment in cracks and crevices	Food service/ break areas inside buildings
Dri Die	Amorphous silica 95%	4816-240	Caution	To prevent bed bugs and other crawling insects	Spot treatment dusted into voids, cracks and crevices	Interior

Brand Name	Active Ingredient and %	EPA Reg #	Signal Word	To be used for (e.g., ant bait, cockroach control, etc.)	Method of use (e.g., as a bait station, in cracks & crevices, etc.)	Area/building for use (e.g., in food service areas, around the outside perimeter of the building, etc.)
Gentrol Point Source and Gentrol Concentrate	Hydroprene 90.6% and 9% respectively	2724-469 and 2724-351	Caution	Cockroach, and pantry pest control (insect growth regulator)	Spot treatment in cracks and crevices, or slow release treatment station	Food service/storage areas inside buildings
Mother Earth Granules	Boric Acid 5.0%	499-509	Caution	Ant and cockroach bait, Oriental cockroach	Spot treatment in cracks and crevices	Inside or outside of buildings at perimeter or voids and cracks cockroaches are hiding
Niban Granular Bait	Boric Acid 5.0%	64405-2	Caution	Ant and cockroach bait, Oriental cockroach	Spot treatment in cracks and crevices	Inside or outside of buildings at perimeter or voids and cracks cockroaches are hiding
OhYeah!	Sodium lauryl sulfate 7% and water 93%	Exempt	Caution	Insects such as bed bugs, roaches, ant, yellow jackets, spiders	Spot spray (contact insecticide)	Anywhere detergent and water can be used
Pyganic	Pyrethrins 1%	1021-1871	Caution	Bed bug control, bird or rat mites	Spot treatment in cracks and crevices, voids	In cracks and crevices at perimeter of rooms or attics and crawlspaces
PiGNX	Capsaicin 0.0357%	84418-1	Caution	Pigeon repellent	Spot treatment as caulking	Window ledges, structural fixtures
Advance Liquid Ant Bait	Sodium Tetraborate Decahydrate (Borax) 1.3%	499-491	Caution	Ant bait	Inside a bait station	Outside of buildings at perimeter
Avert cockroach Bait Station	Abamectin 0.05%	499-467	Caution	Cockroach bait	Bait station	Inside buildings near food service, storage and break areas
Avert Cockroach Gel	Abamectin 0.05%	499-406	Caution	Cockroach bait	Spot treatment in cracks and crevices	Inside buildings near food service, storage and break areas
Safer Brand Ant and Crawling Insect Killer, Powder	Diatomaceous Earth	59913-1	Caution	Ants, cockroaches and other crawling insects, mites (prevention/exclusion/control)	Dusted/blown into cracks and crevices, voids	Wall voids, cracks and crevices in walls, floors, ceilings

Brand Name	Active Ingredient and %	EPA Reg #	Signal Word	To be used for (e.g., ant bait, cockroach control, etc.)	Method of use (e.g., as a bait station, in cracks & crevices, etc.)	Area/building for use (e.g., in food service areas, around the outside perimeter of the building, etc.)
Cimexa	Amorphous Silica Gel, 100%	73079-12	Caution	Bed bugs, ants, cockroaches and other crawling insects, mites (prevention/exclusion/control)	Dusted/blown into cracks and crevices, voids	Wall voids, cracks and crevices in walls, floors, ceilings
Terro PCO Ant Bait	Borax 5.40%	149-8-64405	Caution	Ant bait	Liquid bait used in a bait station	Outside of buildings at perimeter
Terro PCO Ant Bait Station	Borax 5.40%	149-8-64405	Caution	Ant bait	Bait station	Inside and outside of building at perimeter, outside in voids, cracks or under objects