INTEGRATED PEST MANAGEMENT FOR MUNICIPALITIES

A Guidance Manual to Assist Municipalities with Complying with Provision C.9 Pesticide Toxicity of the Municipal Regional Permit

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

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Glossary

Aerate: to remove small cores of soil from turf to improve the exchange of air between the soil and the atmosphere, to 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

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

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.

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.

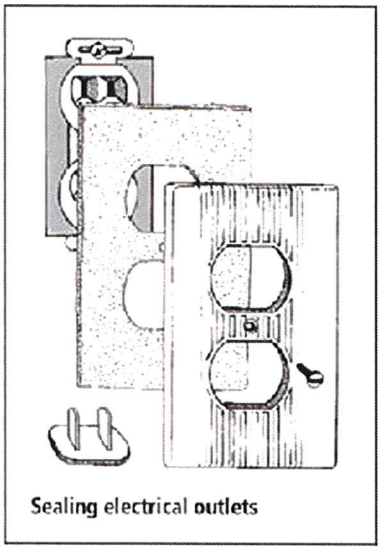
Ecotoxicity: the degree to which a substance can damage an ecosystem, including the organisms living within an ecosystem such as wildlife, plants, and insects

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

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 fences, benches, etc.

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.

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.

Ominivorous: 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

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.

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 acknowledges that the processes of who eats who 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—traditional use: lawn used in landscaping for decorative, aesthetic, or recreational purposes

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.

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

This overview will help you obtain a general understanding of the documents provided and how they may assist your municipality in complying with Provision C.9 Pesticides Toxicity Control of the Municipal Regional Permit (MRP). Provision C.9 requires municipalities to:

> ***C.9.a. Adopt an Integrated Pest Management (IPM) Policy or Ordinance***
> *i. Task Description – In their IPM policies or ordinances, the Permittees shall include provisions to minimize reliance on pesticides that threaten water quality and to require the use of IPM in municipal operations and on municipal properties.*
>
> ***C.9.b. Implement IPM Policy or ordinance***
> *i. Task Description – The Permittees shall establish written standard operating procedures for pesticide use that ensure implementation of the IPM policy or ordinance and require municipal employees and contractors to adhere to the IPM standard operating procedures.*

The MRP identifies certain pesticides of concern in C.9 that threaten water quality. For a list of the specific pesticides, please refer to the MRP currently in effect.

The documents contained in this *Guidebook* may be used as reference material and will provide information to assist a municipality when implementing its IPM Policy and IPM Program. The *Guidebook* was developed by the Contra Costa County Ad Hoc IPM Workgroup: Beth Baldwin, Watershed Management Planning Specialist, Contra Costa County Clean Water Program; Dan Cloak, Consultant to the Contra Costa Clean Water Program; Tanya Drlik, IPM Coordinator, Contra Costa County; Stephen Prée, Environmental Programs Manager/City Arborist, City of El Cerrito; and Karineh Samkian, Environmental Program Analyst, City of San Pablo.

The *Guidebook* is divided into three chapters. **Chapter One** provides a model IPM Policy and Program that municipalities may want to consider adopting and implementing to help meet Provision C.9.a and C.9.b (including the standard operating procedures). **Chapter Two** provides detailed IPM guidance for managing landscape pests, plant health, turf, and weeds. **Chapter Three** provides detailed IPM guidance for managing structural pests.

The *Guidebook* also contains four appendices that complement Chapters Two and Three and provide additional resources. **Appendix A** includes sample landscape and structural IPM contract language. **Appendix B** contains Pest Factsheets for managing both landscape and structural pests. **Appendix C** provides detailed instructions for sheet mulching. **Appendix D** contains a list of sample pest management materials for municipal buildings and LEED Certified buildings.

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

Model Integrated Pest Management (IPM) Policy

The [City or Town] of [name] 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 integrated pest management 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 [City or Town] 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:

- 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-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 combined multiple strategies for pest management are more effective in the end 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 also best achieved by combining a number of strategies.

Model Integrated Pest Management (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 quality[1] 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 County] staff to help identify when Standard Operating Procedures are not applicable or sufficient to 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.

[1] As defined in the Municipal Regional Permit that is currently in effect.

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.

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

Example of a Format for a Pesticide Use Report for a Municipality

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

Introduction

Maintaining healthy plants and a healthy landscape on multiple properties can be a challenge to 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 require less maintenance time and are significantly more immune to pest and disease problems than plants that are overly pruned, stressed, or otherwise unhealthy.
2. **Proper maintenance of turf grass.** 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. **Weed management**. Appropriate site design, plant selection, and mulching will eliminate many weed problems. Equally important is managing weeds *before* they set seed to prevent weeds from increasing and spreading.

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

Plant Health Care and Integrated Pest Management

Plant Health Care (PHC) is a method of managing landscapes that was developed from the concept of integrated pest management (IPM) as it applies to tree care and landscape maintenance. The difference is that PHC is management of the plant and its environment, not just 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 material 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 that are 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 to show a "perfectly" designed site immediately after planting instead of designing for sustainable maintenance costs and the long-term viability of the landscape. Often these short sighted 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 too close 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 the 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 prevents plants from getting water, or drown 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 together that have similar water requirements.

- *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, Liquidambars, 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.

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" to 6" of mulch to prevent evaporation from the soil. Keep mulch at least 6" 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 check and cause more serious damage.
- *Excess soil moisture and poor drainage favor many root diseases of plants.*
- *Bark damage from such things as improper pruning, storm damage, and lawn mowers creates wo*unds 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 and adapt to the life cycle changes in the plants they care for.

Use the principles of integrated pest management to manage landscape pests.

Integrated pest management (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, as many different tactics as are feasible are integrated into a management program.

Treatments are chosen to be effective, economical, precise, and the least hazardous to humans, pets, wildlife, and the environment.

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

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?*
- *Is the insect or mite 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 Publication #3420), see 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 am to 5 pm. 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. For photos of and information about the most common natural enemies, see http://www.ipm.ucdavis.edu/IPMPROJECT/ADS/poster_naturalenemies.html.

  At http://www.ipm.ucdavis.edu/PMG/NE/#PREDATOR you can find more detailed information about specific predators and parasites.

  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 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 U.C. Statewide IPM Project. Their website 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 chosen 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 and using proper sanitation with regard to the disease; 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 and their flowering periods.

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												
Ceanothus 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												
Bottletree	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 all year around. 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 fact sheet 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 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 with these observational principles in mind 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.

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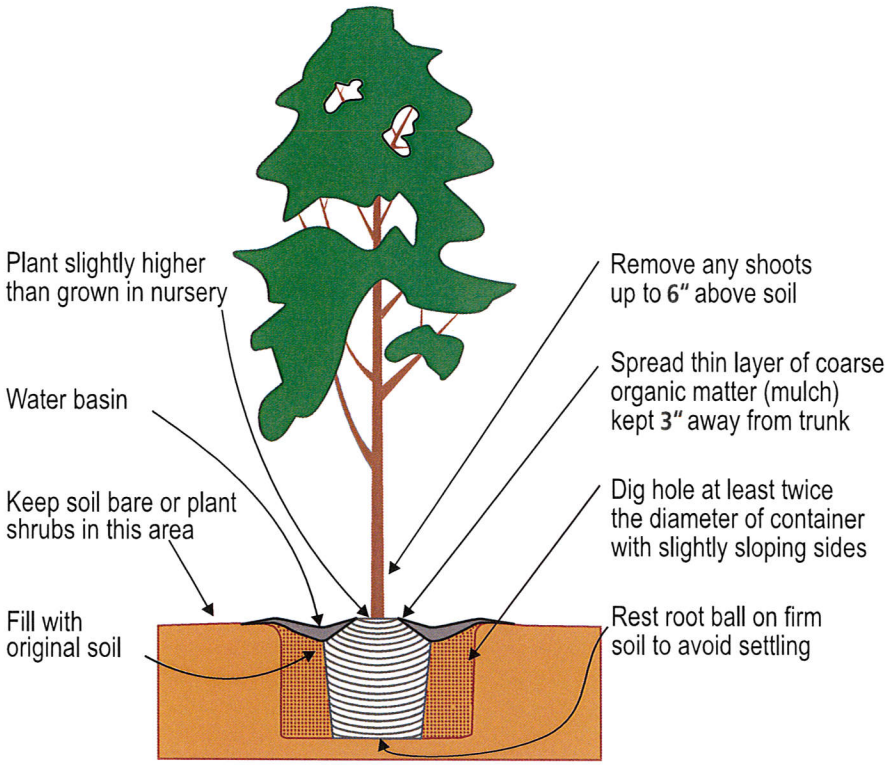

Figure 1. Proper planting of a container-grown tree.

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.

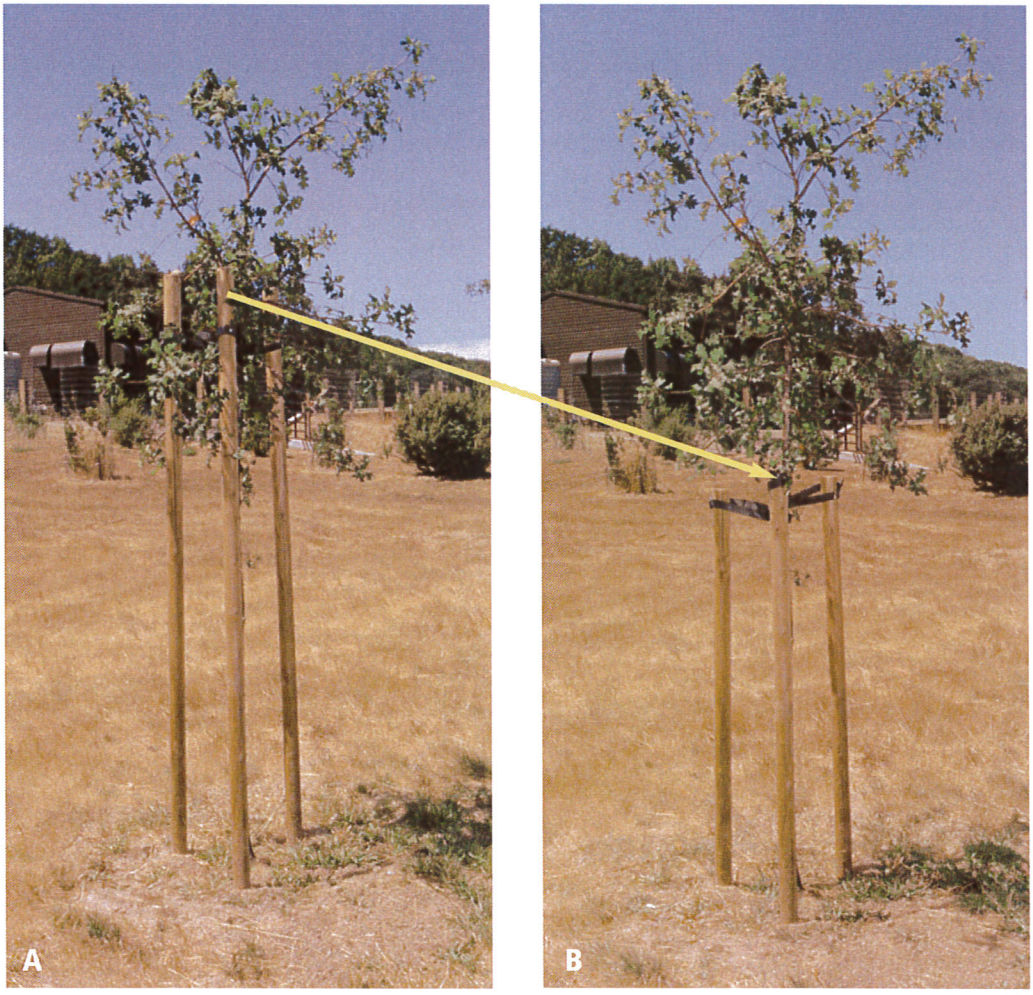

Figure 2. (A) Valley oak tied and staked too high. (B) Stakes and ties properly adjusted.

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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Integrated Pest Management for Turf Grass

Summary

Maintaining the vigor and health of a lawn is the best way to prevent damage from turf grass 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 turf grass/sports field maintenance and pest management. Specific information can be found on the World Wide Web links listed in the body of this document. 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 University of California also has 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 turf grass 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, kikuyugrass, etc.

   For more about turf grass species see
   http://www.ipm.ucdavis.edu/TOOLS/TURF/TURFSPECIES/index.html

   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 and the 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 micro organisms 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

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. Other sources of ETO information are the California Irrigation Management Information System (CIMIS) at http://wwwcimis.water.ca.gov/ and [www.dpla.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 website (http://www.ebmud.com/) for water conservation information including free audits and rebate programs. EBMUD will perform a free audit about every 5 years and will explain to staff what to look for, how to set timers, what equipment to use, and what rebates are available. Currently rebates up to $20,000 are available for commercial entities, including government.
- The Contra Costa Water District (http://www.ccwater.com/) also has water conservation programs for large 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:
California Turfgrass Culture Volume 47, Nos. 3 &4, 1997. Using ETO (Reference Evapotranspiration) for Turfgrass Irrigation Efficiency by W. Richie, R. Green and V.Gibeault
See: 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
See: http://ucanr.edu/sites/EH_RIC/newsletters/Vol2_No2_Spring_199837628.pdf

Managing Turfgrass During Drought from U.C. Division of Agriculture and Natural Resources byM Ali Harivandi, et al.
See: 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 are the three numbers (in that order) 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 own specific soil test results.

Nitrogen
Cool season grasses need no more than four (4) pounds actual nitrogen per 1000 square feet per year. More is not better. A good application schedule in the San Francisco Bay Area is 1 lb. actual nitrogen/1000sq.ft. on March 1, April 15, September 1, and October 15.

Warm season grasses need six (6) lb. actual nitrogen per year and are recommended to receive monthly applications at ¾ 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 1lb./1000sq.ft. For established turf, applications should be made at 1-2 lb./1000sq.ft. in spring or fall when it is needed most, or 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. /1000sq.ft./year applied equally in late spring and early fall or when applied when using a complete fertilizer.

Managing Lawns on Heavy Soils- M. Ali Harivandi, Environmental Horticulture Advisor, San Francisco Bay Area; and Victor A. Gibeault, Environmental Horticulturist, Cooperative Extension, University of California Riverside
See: 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, M. Ali Harivandi; University of California Agriculture and Natural Resources Publication 8080
See: 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 turf grass 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 blades.
- Maintain sharp mower blades for clean cuts.
- Clean the mower between lawns to minimize weed seed transport from the mower.
- Mowing when it is hot or when the soil is dry can injure the turf.

Proper mowing practices facilitate the beneficial practice 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

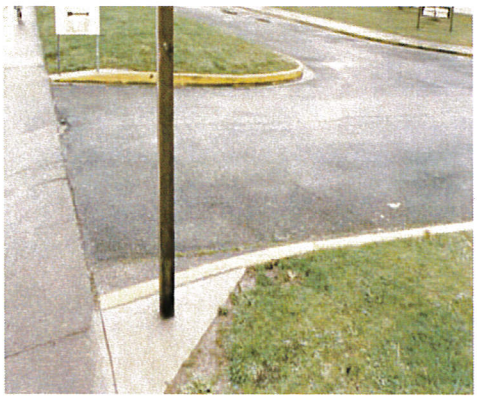
Maintaining healthy plants and eliminating weeds in the environment can be a challenge for municipal staff. Weeds are hearty and opportunistic, but there are a number of approaches that staff can use to prevent weeds from germinating, reduce the likelihood of their spreading, and reduce their presence 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.

I. Designing and Re-designing Landscapes to Avoid Weeds

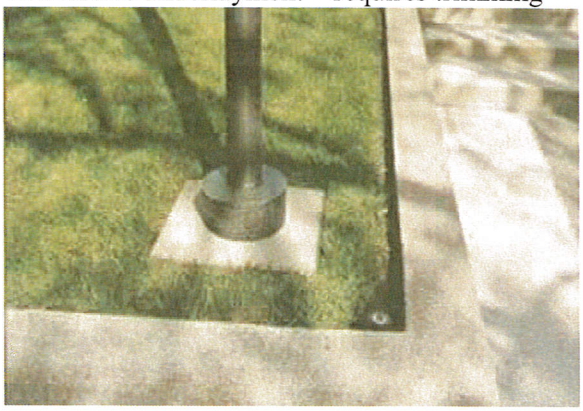
Design the entire site—don't leave awkward spaces that are prone to weedy growth.

Use underlayments (paving under fences, trash cans, benches, and other site furnishings) and mow strips (paving under fences, poles, and posts) to prevent weeds and make maintenance easier.

Effective underlayment for a sign



Ineffective underlayment—requires trimming



Mow strips can be an integral part of the design.

Mow strips and underlayments can be retrofitted to the landscape.

Header board (bender board) can be used to define the landscape and help contain plantings and grass intrusion

Underlayments can eliminate difficult weed problems.

Let pedestrian circulation dictate paving

Place structural elements in paving, not in turf

Minimize joints in low traffic/low maintenance areas.

Monolithic (or stamped) paving—attractive and 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.

II. Site Preparation Designed to Reduce Weed Intrusion

Before planting, prepare the site carefully.

Planning, potentially some additional labor, and the judicious use of a low toxicity herbicide can prevent later headaches with weeds.

A. Minimize soil disturbance during construction activities.

B. Don't allow equipment to be driven through weedy areas and into the new site.

C. Eliminate existing weeds on site before they go to seed.

D. 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.

E. Sheet mulching can be used to cover and kill all kinds of weeds, even weeds like Bermuda grass.

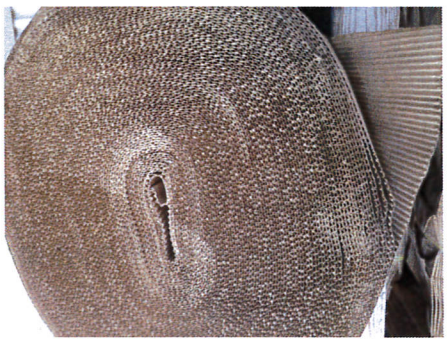
Sheet mulching consists of laying down at least two layers of cardboard directly on top of the weeds or turf that you want to get rid of, lightly wetting the cardboard, and then covering the cardboard with at least 3" of wood chip mulch. This method can also be used as a preventive weed treatment on new construction projects.

Tips for sheet mulching (see also Appendix C - 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' 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" holds up well during installation and has a 40% recycled content. There may be other suppliers that carry cardboard with a higher recycle content.

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

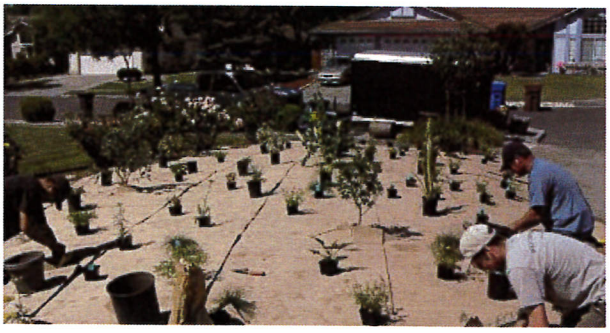


Single face "b" flute roll

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.



7. 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.

III. Alternatives to Herbicides for Weed Management

Prevention Methods

A. **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.

B. **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.

C. **Think about how you can redesign the area to prevent weed problems (see Section I)**

D. **Don't use plants that are known to be invasive.** Understand the plant materials 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.
See: http://www.cal-ipc.org/landscaping/index.php

E. **Maintain healthy soil**. Weeds like healthy soil too, but to keep desirable plants growing vigorously and outcompeting weeds, you need healthy soil.
   a. Except for turf, fertilizer is not needed for plants growing in healthy soil.
   b. In general, native plants do not need fertilizer.
   c. 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.
   d. Add as much organic matter, such as mulch or compost, to your soil as practical taking care not to cover the base of the plant stems. These materials reduce compaction, improve the quality of the soil, and act as fertilizer.

F. **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" to 6" away from the base of the plant and 12" away from tree trunks.

G. **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.

H. **Require weed-free seed in specs and demand weed-free nursery plants.**

I. **Reduce weed seed germination**.
   a. Increase the mowing height for turf in order to shade the soil surface.
   b. In landscapes, use desirable plants to shade out weeds.
   c. Minimize soil disturbance during planting and maintenance to reduce the numbers of weed seeds brought to the surface where they can germinate.
   d. Use mulch to cover bare soil to prevent weeds from coming up.

J. **Avoid driving equipment through weedy areas. Clean equipment that has been in weedy areas before using it elsewhere.**

K. **Clean clothing and tools after working in weedy areas so you don't spread weeds.**

Horticultural Methods

Cover the soil. Weed seeds can tell 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 will help prevent 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 to deliver water only to desired areas/plants and not to provide water 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

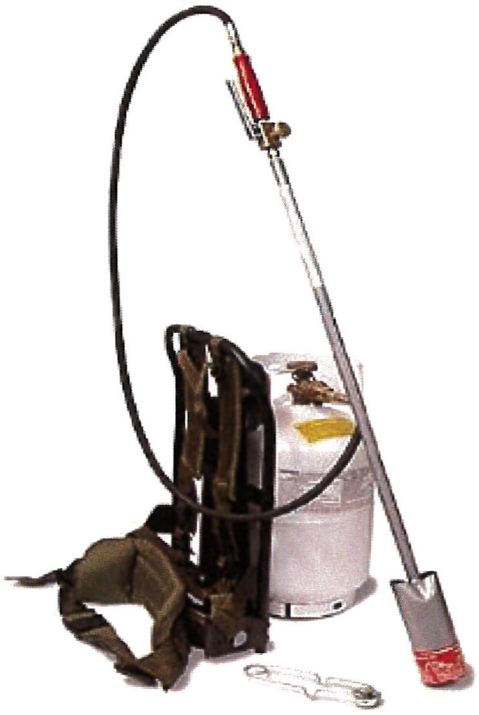
Flame weeding

Flame weeding uses an open flame, usually fueled by propane, to vaporize the water in the 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, to be effective against broadleaf weeds, they 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 latter.

As with other weed management techniques, certain equipment is required when employing this method:

a. Torch—many types are available at garden suppliers or on the internet
b. Propane canister to fit torch
c. Personal fire extinguisher on your belt or live water hose nearby. You may want a 5 gal. 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, about the size of the head of a pin, 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 along 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

- 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 a 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 weed seeds set 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 remove them from the site.
- 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
- Goats can be useful where it is dangerous for humans to work (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 goats for vegetation management and would be happy to provide help to cities interested in using grazing. Call Tanya Drlik, Contra Costa County IPM Coordinator, at 925-335-3214 to get in touch with the most experienced County staff.

IV. Managing Specific Weeds

The University of California Statewide IPM Program (http://www.ipm.ucdavis.edu/) has a wealth of information on managing many different pests, including specific information on many common landscape weeds (http://www.ipm.ucdavis.edu/PMG/menu.homegarden.html). 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 U.C. Weed Research and Information Center (WRIC). You can find the book under "Publications" on the WRIC website (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 U.C. IPM Pest Notes for some of the weeds commonly found in Contra Costa County landscapes. The sources for weed fact sheets not from U.C. IPM are identified in parentheses.

1. Annual bluegrass
2. Arundo or giant reed (from *Weed Control in Natural Areas*)
3. Blackberries
4. Bristly Oxtongue (from *Weed Control in Natural Areas*)
5. Brooms
6. Cape ivy (from *Weed Control in Natural Areas*)
7. Clover
8. Crabgrass
9. Dallis grass
10. Dandelions
11. Fennel (from *Weed Control in Natural Areas*)
12. Field bindweed
13. Invasive plants
14. Nutsedge
15. Oxalis (from *Weed Control in Natural Areas*)
16. Poison oak
17. Spurges
18. Yellow Starthistle