THE WEED WORKERS' HANDBOOK

A Guide to Techniques for Removing Bay Area Invasive Plants



The Watershed Project

California Invasive Plant Council

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"It's an amazing feeling of accomplishment when I visit some of our old sites. What had been a monoculture of an invasive species is being transformed by native plants taking the site back over, making it look like we had never been there."

Ken Moore, Wildlands Restoration Team, Santa Cruz



"When environmental restoration is most successful, it also improves our hearts, and cultivates an enduring relationship with Nature. . . . Done properly, environmental restoration restores far more than just the land."

Richard Nilsen, from Helping Nature Heal



"While we bemoan the lack of funding for our restoration work, it has an undeniable positive side: it forces us to rely on volunteers. How many of us have made exciting discoveries, gained insights into the world and into ourselves—learned things we didn't even know existed until they came into our consciousness? We who work in the difficult environment of fragmented, highly impacted natural systems in urban areas develop insights which may prove invaluable as the human societal and environmental crisis deepens. The knowledge gained from our experience may become in demand as awareness of the connection between human welfare and the natural world increases. Such knowledge cannot be found in our traditional repositories and disciplines. And, most surprising of all, we discover that when we understand how the world works we come to understand ourselves."

Jake Sigg, California Native Plant Society, Yerba Buena Chapter

CONTENTS

PREFACE vii

CHAPTER 1 Background: Putting Weed Work in Context 1

CHAPTER 2 Strategy: Planning for Effectiveness 7

CHAPTER 3 Communication: Talking about Wildland Weeds 13

CHAPTER 4 Coordination: Organizing Volunteer Weed Projects 19

CHAPTER 5 Tools and Techniques: Manually Controlling Wildland Weeds 29
- Integrated Pest Management 30
- Key Control Techniques 34
- Tool Safety, Care, and Selection 44
- Weed Workers' Tools Explained 46
- Weed Workers' Tools Illustrated 50

CHAPTER 6: The Plants: How to Remove Bay Area Weeds 53
- Vines
  - Cape ivy *(Delairea odorata)* 56
  - Ivy species *(Hedera helix* and *H. canariensis)* 58
  - Himalayan blackberry *(Rubus discolor)* 60
  - Periwinkle *(Vinca major)* 62
- Shrubs
  - Broom species *(Genista monspessulana, Cytisus scoparius,* and *Spartium junceum)* 64
  - Cotoneaster species *(Cotoneaster franchetii, C. pannosa,* and *C. lactea)* 68
  - Sticky eupatorium *(Ageratina adenophora)* 70
- Perennials and Biennials
  - Artichoke thistle *(Cynara cardunculus)* 72
  - Bull thistle *(Cirsium vulgare)* 74
  - Fennel *(Foeniculum vulgare)* 76
  - Perennial pepperweed *(Lepidium latifolium)* 78
  - Poison hemlock *(Conium maculatum)* 80
- Annuals
  - Italian thistle *(Carduus pycnocephalus)* 82
  - Mustard species *(Brassica nigra* and *B. rapa)* 84
  - Wild radish species *(Raphanus sativus* and *R. raphanistrum)* 85
  - Yellow starthistle *(Centaurea solstitialis)* 87

Perennial Grasses
Ehrharta *(Ehrharta erecta)* 90
Giant reed *(Arundo donax)* 92
Harding grass *(Phalaris aquatica)* 94
Pampas grass and Jubata grass *(Cortaderia selloana* and *C. jubata)* 96
Perennial ryegrass *(Lolium perenne)* 99
Purple velvet grass *(Holcus lanatus)* 100
Annual Grasses
Annual ryegrass *(Lolium multiflorum)* 102
Ripgut brome *(Bromus diandrus)* 104
Trees
Acacia species *(Acacia melanoxylon* and *A. decurrens)* 106
Blue gum eucalyptus *(Eucalyptus globulus)* 108
Tree of heaven *(Ailanthus altissima)* 110

RESOURCES 112
GLOSSARY 115
BIBLIOGRAPHY 119
ACKNOWLEDGMENTS 120

PREFACE

Welcome! The handbook you're holding contains vital information for restoring Bay Area wildlands. We hope it becomes a valuable tool for guiding your efforts in protecting local natural areas from the impacts of invasive plant species.

Most likely, you know from first-hand experience that invasive weeds are a serious ecological problem in the Bay Area. You may have witnessed grasslands overrun by yellow starthistle, or walked through an ivy-choked woodland. And, like many others, you are working to do something about it.

This handbook distills the collective knowledge of Bay Area individuals and organizations that have been involved in weed control and wildland restoration projects for over a decade. It provides background on the strategic planning that needs to happen before you actually remove any weeds, and offers detailed information on specific weeds and the techniques and tools best suited to working on them. The information in this handbook is intended to help us all conduct our weed control efforts more effectively.

Countless Bay Area volunteers and park managers have helped us learn about invasive plant control over the last decade. Many of them also contributed their time and expertise to this handbook—thanks to all.

If you have comments or suggestions for future editions, please let us know at www.cal-ipc.org.

We look forward to seeing you in the field!

Sharon Farrell, The Watershed Project
Doug Johnson, California Invasive Plant Council

1

BACKGROUND: PUTTING WEED WORK IN CONTEXT



Invasive species are one of the most serious environmental problems of the twenty-first century. They crowd out native species, disrupt natural processes, and impose tremendous costs on human communities. This is even more true for California than for most other states in the country. A few key facts illustrate the scope of the problem:

- Nearly half of the plants and animals listed as endangered species in the United States have been negatively affected by invasive species.
- Invasive species inflict an estimated $116 billion in economic damages annually in the United States and impose an additional $21 billion in control costs.
- Yellow starthistle has expanded its range in California at an exponential rate since mid-century. It now occupies 14 million acres of rangeland, more than 15 percent of the state's land area.
- Of the nearly 1,400 non-native plant species naturalized in California, at least 72 have significant ecological impact.

Scientists have been watching these problems get worse for several decades, but only in recent years has the matter received serious attention at national and international levels. In 1997, five hundred scientists and land managers wrote an open letter to then-Vice President Gore requesting action on invasive species. They declared, "We are losing the war against invasive exotic species, and their

economic impacts are soaring. We simply cannot allow this unacceptable degradation of our Nation's public and agricultural lands to continue."

In response, President Clinton signed Executive Order 13112 in 1999. This established a National Invasive Species Council to coordinate federal activities and develop a National Invasive Species Management Plan. The council has since released a draft plan. The State of California is also working on its own plan, the California Noxious and Invasive Weed Action Plan.

But leadership is hardly limited to these formal institutions. In fact, such plans exist mainly because of a groundswell of public interest in invasive species and the damage they can cause. During the last decade, tens of thousands of Bay Area residents have dedicated at least part of a Saturday morning to removing weeds by hand. No matter what happens to the national and state plans, it's people like them—weed workers and land stewards, dedicated volunteers and hardworking professionals—who will have the greatest impact on the invasive species problem in our local parks and open space for some time to come.



This handbook arose in response to widespread interest among Bay Area weed workers for a compilation of information on the best tools and techniques for addressing the invasive plant problem in local parks and open space. (Throughout this handbook, we refer to parks and open space in a general sense, meaning any parcel of land, whether public or private, where invasive plants pose a problem to remnant wild ecosystems.) During our months working on this handbook, we spoke with several dozen weed workers, most of whom have more than ten years of experience with Bay Area weeds. We have sought to distill their expertise and experience and deliver it to you in a clear and straightforward way.

The primary audience for this handbook includes volunteers who are just getting into weed work, more seasoned volunteers who aim to start a weed program on their own, and interns and seasonal staff who work for the diverse agencies that manage public open space. But even long-time volunteers and professionals may find something useful in these pages.

This sense of the audience drove some of our decisions about what to include. Because of the heavy emphasis on volunteers and interns, we focused our review of tools and techniques on hand tools and manual removal techniques, although we do provide some information about power tools and herbicide treatments as well.

This chapter provides an overview of the invasive problem in the Bay Area and the various agencies and non-profit organizations that are key actors in the field. The second chapter provides strategic advice about setting priorities. If you

can only remove a small portion of the weeds in a park, which ones do you work on, and where? Chapters 3 and 4 address some of the social dimensions of weed work: educating people about weeds and organizing volunteer work parties. The last two chapters are the heart of this handbook: chapter 5 contains a synopsis of the most useful tools and techniques used by Bay Area weed workers, and chapter 6 contains information on the control of thirty-six invasive plants found in the Bay Area.

WEEDS AND WEED WORK IN THE BAY AREA

Weeds have a long history in the Bay Area. Some may have arrived here as early as the middle of the eighteenth century, dispersing northward from European settlements in Baja California in advance of the arrival of the first Europeans in San Francisco Bay in 1769. The spread of invasive plants since then has been swift and steady. California's grasslands were the first to be transformed as invasive annual grasses from the Mediterranean quickly became dominant, helped by heavy overgrazing and droughts during the nineteenth century.

In the last few decades of the nineteenth century, land speculators planted tens of thousands of blue gum eucalyptus trees across California in an attempt to increase the value of their property for resale. Touting the silvicultural value of the trees, these speculators made profits while the unfortunate ones who purchased the land found that the trees were almost useless for lumber. Despite the mounting evidence, several more waves of eucalyptus plantings followed, finally stalling by the first part of the twentieth century.

This fervor for planting trees, stoked by the invention in Arbor Day in 1872 and the popularity of Frederick Law Olmsted's urban beautification movement, led to widespread plantings of many other tree species in the Bay Area, including some, like acacia and tree of heaven, that have since become invasive. Periwinkle and pampas grass were quite popular among gardeners in late nineteenth-century California, which explains their widespread distribution today.

Other invasives were never planted intentionally but spread into Bay Area wildlands once they had arrived in the area. Yellow starthistle, a native of southern Europe and western Eurasia, was first documented in Oakland in 1869. It probably arrived here by way of Chile, as a contaminant in imported bags of alfalfa seed. It spread quickly in the Bay Area and the Sacramento Valley and eventually throughout the state. In 1919 botanist Willis Jepson noted how quickly it had spread near his boyhood home of Vacaville: "It is 1,000 times as common as ten years ago, and perhaps even six years ago." Now that's a good argument for catching the next invasion early and preventing it from getting out of hand!

Public Agencies and Organizations

Open space protection also has a long history in the Bay Area, including such notable events as William Kent's donation of Muir Woods to the nation in 1907; East Bay voters taxing themselves in the middle of the Great Depression to purchase lands that became the heart of the East Bay Regional Park District; the innovative preservation efforts in Marin that led to the founding of Audubon Canyon Ranch and the Point Reyes National Seashore; and the parks-to-the-people movement of the late 1960s and early 1970s that led to the creation of the Golden Gate National Recreation Area (GGNRA) in San Francisco, Marin, and San Mateo counties.

This network of protected open space is governed by an alphabet soup of different public agencies, each with a mandate to protect the natural resources they contain. Since that often means controlling invasive plants, these agencies are often at the forefront of the struggle. These agencies include the National Park Service, the California Department of Parks and Recreation, the East Bay Regional Park District, the Midpeninsula Regional Open Space District, and many other city, county, and regional authorities that manage Bay Area wildlands.

In 2000, the State of California authorized funding to promote local coordination among weed workers in every California county. The legislation encouraged the formation of Weed Management Areas to receive the state funding. Most counties now have WMAs, and these groups provide a forum for public and private landowners and interested non-profit organizations to coordinate their land management efforts and to develop countywide strategies for controlling weeds.

Non-Profit Organizations

In 1965, a group of citizens in the East Bay organized a campaign to save an arboretum in Tilden Park, and the California Native Plant Society evolved out of that effort. CNPS is now the largest such society in the United States. Its members have long been concerned about the growing threat of invasive plants to the state's flora. In 1990, its Yerba Buena chapter began regular weeding work parties in San Francisco under the leadership of Jake Sigg, who also became active in statewide invasive plant issues.

Around the same time, the GGNRA's invasive plant program got off the ground with the formation of the Habitat Restoration Team under the leadership of Maria Alvarez (National Park Service) and Greg Archbald (Golden Gate National Parks Association—now the Golden Gate National Parks Conservancy). That effort gave rise to one of the nation's largest community-based stewardship programs, involving thousands of community members in

weed work every year and training dozens of professional weed workers who now hold leadership positions throughout the Bay Area.

Also in the early 1990s, up in Davis, John Randall was developing what would become the Nature Conservancy's Wildland Invasive Species Program. And down in Santa Cruz, Ken Moore was leading the Wildlands Restoration Team in its efforts to address invasive plants in the Santa Cruz Mountains. As other groups began to join the struggle, it was clear that a critical mass was gathering.

In 1993, weed workers from around the state gathered to found Cal-EPPC, the California Exotic Pest Plant Council (now the California Invasive Plant Council). The organization patterned itself after the Florida EPPC, which was having considerable success bringing people together to strategize about invasive plants and develop better techniques for controlling them. Cal-IPC's annual symposium (held each October), newsletter, brochures, and Web site all aim to make information accessible to weed workers in the state. The group also coordinates efforts to assess which plants are invasive in California.

In a parallel development, public awareness and concern was beginning to grow about the state of San Francisco Bay and its natural resources. The Watershed Project (formerly the Aquatic Outreach Institute) formed to bring an educational message to the community—that our actions, whether through using pesticides in the garden, pouring oil down the storm drain, or allowing invasive plants to take over creeks and open space, affect the water quality of the Bay. The Watershed Project has helped support the steady growth of citizen involvement in creek groups, especially in the East Bay, where these groups are especially active in removing invasive plants. Through its workshops, newsletters, teacher training initiatives, and other outreach activities, Watershed Project staff members have taught thousands of students, teachers, and concerned citizens how to prevent pollution and protect and restore natural resources.

Today, these groups have partnered to produce this handbook. Drawing on the technical expertise of Cal-IPC members and the educational expertise of the Watershed Project, the handbook is aimed at increasing the effectiveness of Bay Area weed workers. The next episode of this story is yours to write!

2

STRATEGY: PLANNING FOR EFFECTIVENESS



Someone once described the spread of invasive plants as a "raging biological wildfire—out of control and spreading rapidly." It's an apt analogy. Invasive plants and wildfires can both inflict heavy economic and ecological damage. Much like wildfires, weed infestations can start small and then expand rapidly if not quickly controlled. And like wildfire management, effective weed management depends on four key strategies: prevention, early detection, control, and restoration.

We'll cover these four strategies a bit later, but first a question: Do those who fight wildfires try to get as much information about a fire before deciding how best to fight it? Of course they do, and they use maps to help organize that information. The same is true for weed workers. Knowing what's at stake—which invasive plants are threats and what they are threatening—is an essential step in developing an effective weed management strategy. Are there particular natural resources that are especially important to protect? Are there particular weeds that you know from reputation or personal experience could cause serious damage if they become established in your park? Which of the weeds in your park have the potential for rapid expansion and which have been there for decades without much change in the size of their populations? These are all geographical questions in the end, so it's only natural to use a map to organize the information.

MAPPING

Weed maps are great tools for prioritizing your work, monitoring your success, and creating a documentary record for those who will take your place in the future. A well-made map can also be an engaging outreach tool; like photographs, a single map can be worth a thousand words.

Mapping by hand is the simplest way to track weed infestations, rare plant populations, or other conservation targets. Select a base map—a USGS quad, a park trail map, or even an aerial photo—and then mark where particular weeds are found. Some weed workers make maps of particular invasive plant species on separate copies of the base map, one species per copy; others mark up a single copy. A map with just the right level of detail is what you're after, and that depends on your goals and aptitude. Map the type and size of the infestation using a standard set of symbols and indicate areas you have found to be weed-free. Also, of course, mark your conservation targets—the things you want to conserve.

It is also possible to map your weeds using a Geographic Information System (GIS) in combination with data collected in the field using a Global Positioning System (GPS) unit. This computer-intensive method is becoming the norm among professional weed managers, but many continue to rely on hand-drawn maps. For more information on both methods, refer to the California Department of Food and Agriculture's weed mapping handbook at cain.nbii.gov/weedhandbook.

PRIORITIZATION

Once you have identified your conservation targets and the weed infestations that threaten them, you can begin establishing some priorities. You may find that your first priority is to protect endangered species populations and other valuable areas, just like someone fighting a wildfire might seek to protect people and buildings. But that's not your only priority. You also want to contain the fire (stop the big infestations from expanding) while extinguishing spot fires that have jumped outside the perimeter (eliminating pioneer weed populations). You're looking for a balanced mix of the four main strategies mentioned earlier: prevention, early detection, control, and restoration.

PREVENTION

Preventing a new weed from becoming established in a park or open space is one of the best things you can do for the land. Weeds are so numerous in the Bay Area that it may be hard to imagine having to deal with new ones, but the distribution of weeds is always changing, due, in large part, to the activities of humans. You and your fellow outdoor enthusiasts may even be contributing to the spread of

weed seeds from one local park to another. They can be dispersed by mountain bike tires, for example, or hiking boot treads.

If you want to prevent new invasions, think about how they might get there. If there are equestrian users in your park or open space, work with them to use certified weed-free hay for their animals. If there are neighboring properties that have an invasive weed that has not yet arrived on yours, then work with them to eliminate it on theirs, or at least prevent it from reproducing. If there is construction work, landscaping, or other management that might entail seeding or planting, make sure that they don't include invasive plants in their seed mix or planting palette. You'd be surprised how often this happens! Construction equipment itself is also a vector for moving weed seeds, so it's a good idea to keep an eye on the area over time.

EARLY DETECTION AND ERADICATION

Detecting new weeds and responding to them quickly is as important as prevention. It's almost certain that new weeds will arrive in your park. But the inevitability of arrival doesn't mean that they will persist. That's where you come in.

Containing a new weed, like containing an epidemic, depends on identifying it as soon as possible and initiating a rapid, coordinated response. Sounds challenging, but at a local scale it can be relatively straightforward. The main thing is to be attentive. If you see a plant that you've never seen before, try to find out what it is by asking an expert or keying it out (using the *Jepson Manual*, for instance). If it turns out to be an invasive plant and still occurs in relatively low numbers, try to eradicate the entire population.

Eradication means eliminating every single individual from the population, not just most of them. If you're diligent enough, and visit the site year after year to ensure that plants germinating from the seedbank are never able to set seed, you can be successful in eradicating the population. (Imagine if someone had done that with yellow starthistle back in the nineteenth century when it was first becoming established in California!)

The keys to eradication are detecting a new infestation early, responding quickly, and monitoring it carefully. An underlying assumption is that the invasive plant, once eradicated, is unlikely to reinvade. If it's likely to do so—for instance, if it occurs in great numbers on an adjacent property—then by all means try to keep it out of your park or open space, but it doesn't make sense to mount an all-out effort to eradicate every last individual. The probability of reinvasion is too high.

It's hard to overemphasize the importance of detection. New weed populations can't be eradicated if they're not detected! The good news is that it gives you an excuse to spend time hiking around your favorite place. Many weed workers

make a habit of walking every trail in the park at least once or twice a year to increase their likelihood of detecting any new weed populations. Some agencies have even instituted invasive plant patrols made up of volunteers who systematically search trails and other likely places for weed populations.

All this work is really worth it. As two veteran weed workers put it, "preventing or stopping just one new invasive weed would be of greater conservation benefit in the long run than far more costly and difficult efforts to control an already widespread pest."

CONTROL

When a particular weed has become widespread—like wild oats in a park with extensive annual grasslands—eradication is often no longer a sensible strategy. Instead, the most effective action may be to control its spread or lessen its impacts. Your park or open space may have, in addition to grasslands dominated by annual grasses, serpentine prairies where wild oats are just getting established. Though it may be well beyond your ability to eradicate wild oats from the entire park, you might more easily limit its spread into the serpentine prairies.

This example illustrates why focusing on outlier populations—small patches of a weed in an area that is otherwise relatively free of it—is often much more important than focusing on large, dense patches of that weed. It's easy to feel compelled to throw all your effort into working on a major infestation. But that's like sending fire fighters into the middle of a huge wildfire while ignoring its perimeter. It keeps on spreading, as if you hadn't done a thing.

A strategy of containment may be your best option for invasive plants like Cape ivy or blue gum eucalyptus, which would require huge amounts of labor to fully eradicate and whose spread is mostly limited to areas in the immediate vicinity. For such plants, it's better to focus on containing the large infestations and eliminating all the outlier populations than to spend countless hours trying to eradicate the main populations. Containment works well with infestations of these two plants because their pattern is to expand outward from the edge of the infestation, Cape ivy with advancing vines, and blue gum eucalyptus with new seedlings. (Eucalyptus seeds don't tend to disperse very far.) Cleared areas around a patch of Cape ivy—containment paths—allow weed workers to easily patrol for new vines. Plants that disperse their seeds more widely, such as jubata grass, are not as effectively controlled using containment.

Once you've tackled an outlier population and removed all the plants you can find, keep track of its location—preferably on a map—and take notes on your effort. You are working against not only the plants you see in front of you, but also the weed seeds in the soil. They can last a long time in the seedbank, for many decades in the case of French broom, or just a few years in the case of small-

seeded plants like pampas grass. Once you've decided to eliminate that outlier population, it's important to return every winter or spring until no more seeds are germinating. Maps and good record-keeping will help you be persistent.

Except in really small parks, it is nearly impossible to keep track of all the sites where you have removed weeds unless you keep written records. Since every site where you have removed weeds needs to be revisited, you will come to rely on your records to make sure that you do. Develop a simple form for tracking the what, where, when, why, and who of work performed.

Conservation targets, maps, outliers, containment, and persistence—these basic ideas will stand you in good stead as you decide how to focus your weed efforts. The aim of control is not to eradicate weeds, but to reduce weed density and abundance below an acceptable threshold. The methods for both eradcation and control are similar and include a wide variety of techniques that are treated at much greater length in chapter 5.

> "It's invaluable to have intimate on-the-ground experience with the land. Where you're working with the same piece of land, where you see the changes, season by season, year after year, you're making acute observations about the dynamics going on, and that is what is in such short supply. If you don't know the actual on-the-ground situation, then anything you do as a manager is going to be somewhat off."
>
> *Jake Sigg, California Native Plant Society, San Francisco*

RESTORATION

Weed removal is ultimately about returning the native plant community to the area. Once we have removed the weeds, there are often native seeds in the soil that helps restore native vegetation. But in other cases, if the native seedbank has been exhausted, revegetation—that is, replanting with natives—might be necessary after weed removal. This handbook does not cover revegetation, but here are a few tips to keep in mind. In heavily impacted areas, it may be necessary to partner with a native plant nursery that can propagate seedlings from locally gathered seed. When describing your project to others, make sure to communicate the role of weed removal in the greater picture of restoration. This is especially important when you are working on large areas that are in the public eye.

WEED WORK IN PRACTICE: ADAPTIVE MANAGEMENT

Translating these key strategies into action will keep you busy. Learning from your initial actions, so that your next set of actions is more effective, will keep

you smart. It's common sense really—start with a plan, carry it out, check to see if it worked, adjust accordingly, and carry on.

Conservation practitioners have formalized this common sense approach into what they call *adaptive management*. We always have the potential to learn something from our management actions—but only if we monitor and assess the impact of those actions. For weed workers, this can mean something as simple as visiting an outlier population a year after removing all the above-ground individuals. If there are seedlings coming up, then we need to do something we didn't have to do last year: treat seedlings, not big plants. This might call for a different control technique, one more suitable for seedlings.

Monitoring is the key. Without some kind of monitoring, there is essentially no way that you can succeed. The seedbank will always work against you. But monitoring doesn't have to be painful and involve lots of data collection and analysis. The simple steps of keeping good records and visiting all your sites repeatedly go a long way.

3

COMMUNICATION: TALKING ABOUT WILDLAND WEEDS



Reaching out to all kinds of people is one of the best things you can do for the long-term health of your favorite park. Talking to passers-by while you're working can be even more important than getting the work done. Doing so can lead to a big donation to your cause or even turn angry adversaries into awesome advocates.

Such outreach can have ripple effects that extend far beyond the park's borders. When enough people understand the impacts that invasive plants can have on the landscape, they will avoid planting them in their gardens and become more likely to support stewardship efforts at the ballot box by voting for local parks and open space measures.

Some people are blessed with the ability to communicate complicated ideas quickly and effectively. These natural communicators make it look effortless in a way that can be intimidating for the rest of us. But we're not doomed to being tongue-tied. This chapter provides some simple techniques that will help you convey important messages about wildland weeds to diverse audiences.

THE ABCs OF INTERPRETATION

You are engaged in the art of interpretation whenever you are talking with park visitors along a trail or to a group of volunteers at a work party. This word came into widespread use among park rangers during the last half-century to distinguish between mere instruction and information on one side and provocation

and revelation on the other. The National Association for Interpretation defines interpretation as "a communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource."

Interpretation is an art rather than a science because it requires you to re-create all the information that you have learned—the number of weeds in the park, their names, what plants they're crowding out, all the stories you've heard about invasive plants worldwide—in a way that's accessible, meaningful, and compelling to your audience. Since it took you months and years to learn all those things, it doesn't make sense to expect your audience to do so in just a few minutes. But that doesn't mean you can't convey complicated ideas. Follow these ABCs of interpretation, which come from a talented interpreter who has also led hundreds of work parties.

> "When we encounter people on the trail, they'll ask, 'What are you doing?' They can even be a little bit confrontational. They just see green plants lying dead on the ground. We sit down and explain why we're doing this, and more often than not—probably 80 percent of the time—they turn around completely and say, 'You know, I've never thought of that. I've never thought that a plant could be a problem.' And sometimes people walking along the trail have said, 'You know, I'd like to write you a check right now, on the spot.' Even as much as $500!"
>
> *Ken Moore, Wildlands Restoration Team, Santa Cruz*

Know your Audience. If you can connect what you have to say to something in your audience's experience, your message is much more likely to be remembered. Don't assume that they know how pervasive the problem of invasive plants is, or how it affects the beauty of this special place. Build connections with them by using photographs (before-and-after photos of your site) and visual cues (point out a plant in flower that you're trying to protect). Engage as many senses as possible. Crush a yerba buena leaf, for example, and invite them to smell the delicious scent and then tell them how it's threatened by ivy. Have fun with those common names. Why is it "sticky" monkeyflower? What about skunkweed? Should you make a coffeeberry brew?

Keep it Basic. Don't overwhelm your audience with information, even if it's a captive audience that has joined you for a work party. They came to work, not listen to you ramble on, and a person is only going to retain so much. Stick to the most important ideas. Don't worry, though, that your knowledge about the nat-

ural world will not be useful. It will serve you when the occasion presents itself—when you notice a rare migrant bird singing in a nearby thicket, or when you encounter an uncommon plant that has seeded itself into your worksite following weed removal, or when you respond to innocent questions about the name of that hawk with a red tail. Seize the teachable moment—but keep it only for that moment and then let it go!

Remember the Context. If a couple out on a walk stops to ask a simple question, respond with a simple answer, in a manner that encourages dialogue. Be respectful of the context and make it your goal simply to forge connections with others. Don't launch into a ten-minute lament about how invasive species are turning the planet into a single homogeneous biosphere. Develop an elevator version of your spiel: it should last no longer than an elevator ride and convey enough interesting information and inspiration that your listeners want to spend more time with you.

These principles apply not only to speaking but also to the printed word. Take advantage of opportunities to spread the word about your project. For instance, posting signs at your worksite with before-and-after photographs can serve as excellent advertising for your work.

TERMS

Part of the genius of the English language is its versatility and its remarkable abundance. Take *weeds,* for example, and the other words we use to describe them: invasive plants, alien plants, exotic plants, exotic pest plants, non-indigenous plants, non-native plants. The meanings overlap, but none are exact synonyms.

First, it is important to be accurate. Not all non-native plants are invasive, so these terms should not be used interchangeably. In fact, only a small percentage of non-native plants are widely naturalized in California's wildlands, and of these, only a few cause significant ecological damage—these are the invasive plants.

Second, it is important to use such terms with an appreciation for their cultural meanings. In a place with as much cultural diversity as the Bay Area, consider how your terms might be heard. You may use "non-native" in an innocent and descriptive manner, but it may carry other meanings for an audience of schoolchildren from immigrant families. This makes it doubly important to stress that it is not the non-native nature of the plants that present problems—there are many non-native plants that we love! But there are a few that can be quite destructive.

Familiar metaphors can help illustrate the point. A common one is that invasive plants act like bullies, taking over entire habitats. Another is that invasive

plants act like a business monopoly that uses its market power to force other firms out of business and drive up prices. Like the anti-trust regulators who rein in monopolies, weed workers are helping to level the playing field for everyone.

Metaphors can be incredibly useful, but they can also oversimplify your message. Writers in the popular press often latch onto war metaphors to express a sense of drama. Weed workers are described as "weed warriors" battling an invading army of invasive plants marching through native plant territory. Such metaphors paint an antagonistic image of weed workers and do not capture the positive spirit or complexity of ecological restoration.

FREQUENTLY ASKED QUESTIONS ABOUT INVASIVE PLANTS

Here are some questions that you should be prepared to encounter when you work on invasive weeds, along with some general answers.

Does the park staff know you're doing this? Yes, they are quite supportive of this project. They are especially concerned about these weeds because they threaten some sensitive areas that they're trying to protect.

That plant is pretty, why are you removing it? Pretty, yes, but it can have harmful effects on our natural environment. Many other plants—and the animals that need them—are being crowded out by this plant species. Some invasive plants are easy to hate because they're ugly or prickly, but many are quite beautiful. In fact, many of these plants were brought here originally for use as ornamentals, without knowing that later they would become such problems.

Why are you cutting down trees? It's true that trees are beautiful and we tend to think of trees as good for the environment. We're definitely not removing all the trees. But these particular trees are taking over this area, destroying the vegetation that was here before and replacing it with a much less diverse plant community.

Are all weeds bad? Not all plants that we call ***weeds*** are a problem ecologically. Not all of the "weeds" that grow in your yard are a problem here in the park, although some are. But it's true that wildland weeds have a negative ecological effect. Plants are not inherently good or bad—remember, each of these weeds is native somewhere. Back there, it might even be threatened by invasive plants from somewhere else—perhaps even California! Some plants simply have the ability to do more damage than good in the natural environment in a particular place.

Since most of us humans are from somewhere else, does this mean we should be removed? Definitely not. We're working on plants, and in fact many non-native plants do just fine here. It is a very small percentage that actually take off in the

landscape at the expense of many other organisms. This is typically because the climate suits it, and because native animals or insects don't eat the plant, giving it a competitive advantage over other plants. Weed work is about supporting natural diversity—removing these few problem species allows hundreds of others to flourish.

What will happen if we do nothing? Some of these invasive plant infestations have the potential to become a virtual monoculture, forming patches where almost no other plants grow. The diverse mix of plants and animals that were here before is then lost.

What will happen to the animals that are using those invasive plants? Usually, the animals are using invasive plants for food or shelter because the native plants that historically served that purpose are gone or greatly reduced. If we restore those plants as the invasives are removed, the animals can begin using the native plants again.

What will it look like when you're finished? At the very end, it will look beautiful, more like that area over there that hasn't been invaded. In the medium term, it might look rather bad, since we have to remove a bunch of plants.

Why is this area fenced off? Will it always be fenced? It's important that we protect the newly planted seedlings so they can get established. Once they are strong enough to stand up to deer browsing, foot traffic, and new weed seeds, the fences can come down.

How can I get involved? Glad you asked. We have materials right here with contact information to make it easy for you to get involved.

When confronted with questions like these, keep in mind that you often have only a minute or two to answer the question. Using the ABCs of interpretation—know your Audience, keep it Basic, remember the Context—will help you have a creative, constructive conversation. It's some of the most important work you'll do!

4

COORDINATION: ORGANIZING VOLUNTEER WEED PROJECTS



An increasing number of land managers throughout the Bay Area sponsor regular opportunities for volunteers to participate in weed control efforts. There are dozens of work parties happening every month in public parks and open space, along urban creeks, and even on private land. But there are also tens of thousands of acres that have not yet been adopted by a dedicated band of volunteer weed workers.

Before you go out and start ripping out Cape ivy, however, there are a few important things to think about. Do you have permission to work in the area of concern? Can you confidently recognize your target weed and not confuse it with a native plant? Are you versed in the potential risks of poison oak and wasps? Do you know how to run a work party for volunteers? You need to be able to answer these and other key questions before initiating an invasive weed program. In this chapter, we offer tips for those readers who want to organize their own weed projects.

WORK CLOSELY WITH THE LAND MANAGER

In this era of reduced budgets, our parks and open space can sometimes look and feel as if they have been forgotten by the agencies responsible for them. It's easy to feel indignant towards the land manager—how dare they let such a gem of open space go to ruin! Usually, though, park staff members are just as concerned as you are, but they don't have adequate resources to take care of everything. That's where you and your volunteers can have a huge impact. Your

demonstrated commitment and helpful attitude—not to mention your on-the-ground success—can encourage upper-level managers to devote more attention (and maybe funding) to natural resource management.

Building a good relationship with park staff at the field level will help you in many ways. If they understand and support your work, they can give invaluable logistical assistance, from providing tools and garbage bags to helping publicize your workdays and hauling away your debris. Even if they are too pressed with other business to provide much assistance on the ground, their partnership is still essential, because removing weeds can sometimes be controversial. So make sure that the land manager knows exactly what you are doing and has given you permission to engage in particular land management activities. Public agencies hold parks in trust for the community at large, and they are responsible for the long-term stewardship of the land.

Here are a few tips for building a strong relationship with land managers.

Understand and appreciate the agency predicament. It doesn't help your cause to accuse an agency of being a poor manager that isn't doing its job. Acknowledge that times are tough, and that agency personnel don't have nearly enough resources to do all the work that needs doing. Understand that agencies are usually juggling complex issues like recreational use, grazing, fire control, and the like.

Ask the agency to assign a particular staff member as your liaison. This helps the continuity and clarity of communications. Your liaison can become your best advocate and ally if they know what you are doing. Communicate with your liaison regularly.

Ask for help from the agency when you need it. Park staff will have some resources that can help your work, and soliciting their active involvement helps build a partnership with the landowner. That's a much stronger position than being a lone operator.

Garner support for your work from all levels of management. Your relationship with an agency will be strongest if upper-level managers—particularly those who are elected or serve in supervisory positions—also understand and support your stewardship efforts. Let them know that you are a team player who truly wants to work with them.

Know and adhere to the agency's liability policies and permit requirements. Before you start volunteering—and especially before you start leading other volunteers—make sure that you understand the ins and outs of a particular agency's

liability policies and permit requirements. These are not uniform across agencies. The National Park Service, for example, requires its volunteers to sign a form acknowledging that the park will cover any medical expenses, while other agencies take the opposite approach and require their volunteers to sign a liability release form.

Leave a paper trail to ensure accountability. Most agencies experience frequent turnover in field staff positions, so you may have to work with new people every year who are unfamiliar with your project and the history of your relationship with the agency. A paper trail can help bring them up to speed. In the unlikely event of conflict, you will feel much more comfortable if you have documented everything—permits, waivers, releases, date and time of work parties, maps and photographs demonstrating accomplishments, plans, and so on—in writing.

In dealing with the public or the media, identify yourself as a volunteer working on behalf of the agency. If you receive public recognition for your weed work, be sure to acknowledge the land manager. When working on public land, it's often important that people know that you are working with the consent of the public's representative, the agency that owns the land in question. It helps to wear a shirt, cap, or even a patch that identifies you as a volunteer working for the park or open space, especially when working in remote areas.

KNOW HOW TO DISTINGUISH AMONG THE INVASIVE WEEDS AND THE NATIVE PLANTS

Your knowledge of plants doesn't have to be perfect. There's not a single weed worker who isn't still learning. The best thing you can do is to get really good advice early in the process. Go on a walk with the local plant experts. Ask them what the worst weeds are. Ask them what other plants can be confused for that weed. When possible, visit proposed work sites with them and ask them to help you identify plants in the vicinity, particularly ones that you should be sure not to disturb (like rare ones).

As a leader, it's up to you to make sure your volunteers aren't removing the wrong thing. Your best strategy for working with volunteers may be to focus on just one or two weeds at a time that are easy to distinguish.

KNOW ALL ABOUT POISON OAK

It is especially important that you are good at identifying poison oak, which is common (and native) in many plant communities throughout the Bay Area. The consequences of exposure to poison oak can be severe. Roughly 10 percent of the population is extremely sensitive to poison oak and may require medical

intervention (steroids or hospitalization) if their skin is exposed to it. Another 10 percent is apparently immune, but most of us exhibit a wide range of sensitivity to urushiol, the rash-causing compound found in poison oak leaves and twigs.

Many California residents can identify poison oak when its shiny and oily red or bright green leaves announce its presence. But when its deciduous leaves have fallen, or when it adopts one of its other forms—it can be a vine, a tree, or even an ankle-high shrub in grasslands—it can be hard to recognize. As a coordinator of volunteer work parties, you should become a practiced observer of its many forms.

Before selecting a work site, carefully scout the area for poison oak. If poison oak is common, the site may be unsuitable for a volunteer workday. If it is uncommon, flag the areas with poison oak and caution people to stay away from them. We recommend that you work only in areas where poison oak does not occur, unless you have an experienced team of folks who are used to working around poison oak. At the beginning of each workday make sure that every participant can recognize poison oak in its various forms and that they know how to stay out of it.

Sometimes, despite all precaution, volunteer leaders and their weed workers are exposed to poison oak. Here are some measures that you can take to minimize the impact of accidental exposure.

Wear long pants and long-sleeve shirts to limit direct exposure to the skin. If gloves have an elastic cuff, shirt sleeves can be tucked into the glove. Likewise, tucking pants into socks or boot tops can help limit contact.

Remove and wash clothing immediately after the event. This will prevent the oils from migrating to couches, clothes in the hamper, and other surprising locations. Clothing and gloves exposed to poison oak should be washed; cold water and regular detergent work just fine. Take caution with boots and tools, which can become vectors for spreading urushiol, poison oak's irritant.

Use a barrier lotion like Ivy Block to protect exposed skin, especially the gap between glove and sleeve.

Use an oil remover like Tecnu to wash skin immediately after potential exposure. Many weed workers find this to be effective in reducing the extent and intensity of poison oak rashes. It seems to be less effective when the urushiol has already permeated the skin after a long day in the field.

Take a cool shower with a non-moisturizing soap. Laundry detergent bar soap like Fels-Naptha also helps to remove urushiol from the skin. Hot water and moistur-

izing soaps open up the pores on your skin, making them even more receptive to urushiol, so stick with cold water and non-moisturizing soap at first.

If a rash has developed, there are ways to minimize its impacts. A new product called Zanfel is advertised as being able to remove urushiol after it has penetrated the skin and developed into a rash. It's expensive (nearly $40 for a one-ounce tube that's good for about fifteen treatments), but some urushiol-sensitive weed workers swear by it. For severe cases, consult a doctor, who may prescribe cortisone shots that reduce swelling. That's the only treatment available when the rash becomes systemic.

KNOW ABOUT POSSIBLE WASP DANGER

Some weed workers feel that wasps are an even more serious issue than poison oak. Unlike poison oak, wasps seldom provide any advance warning—their nests are much more difficult to spot than poison oak bushes. Encounters with wasps don't happen often, but they are worth mentioning during your safety talk at the beginning of every work party.

For most people, being stung by a wasp is a painful annoyance, but for others it can trigger a serious allergic reaction called anaphylaxis. Those with the most severe reactions require treatment within minutes in order to avoid anaphylactic shock. Such people often carry a portable device that administers epinephrine, the most common being the EpiPen. As a work party leader, you should make sure that your volunteers, particularly those with severe allergies, are familiar with the risks involved. (For legal reasons, you can't administer the EpiPen, otherwise it would be a good thing to carry with you in your emergency medical kit.)

If your group encounters a wasp nest, mark the surrounding area with caution tape to keep people away from it. If people get stung, you're better off bringing the work party to an end and getting them home (or to a hospital if the allergic reaction is really serious) as soon as possible. There's no sense in putting people at risk by trying to get a bit more work done.

KNOW ABOUT TOOL SAFETY

As a work party leader, you must not only know how to use every tool safely, but also how to instruct all your volunteers in their safe use. Treat the subject seriously and forthrightly at the beginning of the work party, demonstrate how to use the tool properly and safely so that everyone can see how it works, and also demonstrate unsafe practices as well. Remind people how to work with tools in a group setting—such things as carrying tools low, not on your shoulder, and maintaining a safe distance between yourself and other volunteers. If you're

going to have your volunteers work with tools that require safety equipment, don't rely on them to bring safety gear. You should provide it yourself and require them to use it. This includes having leather gloves for volunteers working with sharp tools like pruners or loppers.

Be prepared for minor injuries by carrying with you, to every work party, a full first-aid kit and a cell phone. If cell phone reception is not good at your worksite, know where the closest phone is and how to reach park rangers and other emergency personnel. Some weed workers who regularly lead work parties have chosen to take CPR and EMT training courses so that they are even better prepared in the event of an emergency.

CALL IT A WORK PARTY! FACILITATING COMMUNITY PARTICIPATION

Who knew that there would be so many things to think about when working on weeds! So take a deep breath and say, "I'm a volunteer. I'm interested in doing this because I love this place and I love being outdoors." You don't have to obtain degrees in botany, interpretation, volunteer management, and medicine in order to make a difference.

It's helpful to know your limits. If you're a volunteer just getting started, don't try to take on too much. In our experience, coordinating anything more frequent than a monthly work party is too much for most volunteers. Only paid coordinators, or those rare volunteers who have fifteen to twenty hours a week to dedicate to stewardship, are able to handle the complex logistical details associated with more frequent work parties or with organizing dedicated work parties for school or corporate groups.

Assuming, then, that you know the limits of your ambition, here are a few tips about running successful work parties. One golden rule: long-term sustainability depends on short-term enjoyment. If it ain't fun, it ain't going to last. Work parties can involve challenging labor, but volunteers won't return if they don't get something positive and meaningful out of it. A few volunteers are drawn to weed work primarily for the exhausting physical labor, but they won't give you a broad base from which to grow. Reaching out to all kinds of people and accommodating their diverse needs and interests—even if you don't achieve quite as much on any given work day—is often critical to the long-term success of a weed program.

Below is a listing of the tasks to do before, during, and after a work party. The list will help you plan your own event. And here are several key things to remember for improving your success in attracting and sustaining a dedicated group of volunteers: first, maintain your enthusiasm! Nothing kills the spirit of a work party like a leader who isn't enjoying herself. Second, identify tasks that can be

achieved during a single work party—"Let's remove every broom plant between here and that tree today." And finally, offer a range of tasks that will provide variety for returning volunteers—"Who wants to pull broom? Who wants to collect native grass seed?"

Before the Day of the Work Party

- Coordinate everything with your park liaison.
- Scout the work site carefully, paying particular attention to poison oak and where the closest bathrooms are.
- Take "before" photographs while you're there.
- Borrow sufficient tools and gloves, and get a first-aid kit from the park or other sources.
- Develop an elevator talk that succinctly introduces yourself and the project to workday participants.
- Advertise the workday in appropriate venues (posting flyers, placing articles in the local community newspaper, etc.).
- Be realistic about the duration of the event. Don't try to fit too much in. In our experience, the ideal work day lasts two to three hours (10:00-12:30, for example) with a break in the middle or toward the end for goodies. Weekend mornings are best, particularly Saturdays.
- Arrange for donated goodies (or purchase them).
- See if others will help you lead the event; review with them the goals and tasks for the work party.
- Identify extra work in case too many people show up for the work party (this can actually happen!).

On the Day of the Work Party

- Arrive early, and be friendly and welcoming, particularly with people you haven't met before.
- Have attendees sign liability forms and waivers while waiting for the group to assemble.
- Pass a sign-in sheet so you have everyone's contact info for future work parties.
- Deliver your elevator talk and go over workday logistics (timing, tasks, poison oak, tool safety, bathroom location).

- Ask knowledgeable weed workers to team up with new volunteers or to circulate and make sure everyone is getting started.
- Seize teachable moments (with your workers or members of the public) that illustrate why we're engaged in this work.
- Take "during" photographs.
- Take a break for goodies!
- Quit working, gather up tools, and return to initial assembly site (parking lot, for example). Make sure that all tools and volunteers are accounted for.
- Thank everyone for coming and let them know how important their help is—and how welcome it would be in the future.
- Write some notes about who attended the work party, what was accomplished (number of person-hours, area of particular weed removed).
- Assess the work party itself: what worked, what could be improved, what follow-up is required with any of the volunteers.

After the Work Party

- Return tools.
- Report back to your park liaison.
- Take "after" photographs.
- Post signs at the work site if it's highly visible.

Ways to Improve Community Participation in Volunteer Work Parties

- Have a consistent schedule (e.g., 10:00 A.M. on the first Saturday of every month).
- Use dramatic before-and-after photographs to demonstrate the impact of volunteer labor.
- Print and distribute flyers for your monthly work party.
- Produce a calendar of upcoming work parties and post it in appropriate newsletters, list serves, and Web sites.
- Offer other educational opportunities to your volunteers (field trips, walks with experts).
- Cultivate fellow volunteer leaders who can help lead work days in your absence.

- Develop a Web site for your project and keep it up to date.
- Have a presence at appropriate community events (e.g., neighborhood street fairs).
- Honor frequent volunteer participants with a gift (mug, T-shirt, cap).
- Find ways to celebrate successes.

5

TOOLS AND TECHNIQUES: MANUALLY CONTROLLING WILDLAND WEEDS



There is no single right way to control weeds. Although there are many things to think about when deciding which method to choose, three factors are especially important: the nature of the infestation, the tools and techniques available to you, and the biology of the target. The first two issues are discussed in this chapter, while the third is covered in detail in the next chapter.

For various reasons, including liability and union issues, volunteer weed workers in the Bay Area tend to rely on manual techniques using hand tools. Even if you rely exclusively on such techniques in your own work, it's still quite useful to know about the wide range of other techniques that are employed. This chapter provides a broad overview of many control techniques followed by more specific details about manual techniques.

NATURE OF THE INFESTATION

Not all invasive plant infestations are the same. Some contain only a few plants, while others cover acres. Pulling the weeds out by hand might make sense in the former situation, but if the population is large, other techniques, like mowing, might be more appropriate. Terrain is another factor. Mowing works fine on level ground, but it isn't an option on steep or uneven terrain. Proximity to trails and buildings is yet another important thing to think about. Girdling a small invasive tree may make sense if you are working in a wilderness area far from trails or buildings, but it's not the best technique to use in less remote situations

where the invasive tree might present a potential hazard to people or structures or where a dead tree might trigger adverse publicity.

In general, removing large trees is a job that should be left to expert arborists and foresters. When removal isn't an option, populations of invasive trees like blue gum eucalyptus can be contained using hand labor. Removing seedlings and saplings on the edges of the infestation will prevent it from spreading into adjacent native plant communities while you marshal support for the eventual removal of the larger trees.

It's important to keep these considerations in mind when choosing which tool to use. There are no hard and fast rules, so use your common sense, rely on your own experience with the land, and talk with seasoned weed workers if you're feeling particularly uncertain.

TOOLS OF THE TRADE

Relying on a single tool can get you in trouble. It's okay to develop a favorite tool, of course. The Bay Area weed workers who were consulted in writing this handbook each had their own favorite. Some singled out large tools like the Pulaski, with an ax and a hoe on the business end, while others picked much smaller tools such as the soil knife as their favorite. Between these two extremes there were many other preferences, which suggests that there is no single most useful tool for Bay Area weed workers.

They may have made different choices about their favorite tools, but they all shared an intimate familiarity with dozens of tools and techniques. They had avoided the common pitfall of tool users everywhere: if all you know is a hammer, then everything looks like a nail. Focusing on a single tool or technique just won't work when it comes to weeds. It's important to step back from the technology and think about the broader strategy.

INTEGRATED PEST MANAGEMENT

During the last few decades, farmers, ranchers, gardeners, landscapers, and land managers of all types have moved toward a comprehensive strategy for controlling weeds and other pests. This approach, called Integrated Pest Management (IPM), stresses the inclusion of all relevant factors in deciding which techniques are best for dealing with a weed problem. Thus, it is important to consider factors such as the technique's effectiveness in accomplishing your goal, potential disturbance to the environment, the period of time required for effective control, and the direct cost of a treatment technique. It is also important to note that weed workers and land owners may weigh these factors differently depending on their land management goals and policies, the environmental setting, and personal val-

Some General Comments about Weed Control Techniques

The following general considerations apply to all of the control techniques discussed in this chapter:

Minimize soil disturbance. Many invasive plants rapidly move into disturbed areas. In sensitive areas, particularly those that haven't experienced much disturbance, choose control techniques that minimize the level of disturbance. The number of volunteers you are expecting at a work party will affect your choice of site, target, and technique. You don't want lots of people working in a sensitive area with digging tools. The disturbance and trampling could outweigh the gains from removing the invasive plants.

Avoid disturbing wildlife. Limit cutting trees, tree limbs, or very large woody shrubs during bird nesting season as this could disturb or destroy nests. For this reason, the local units of the National Park Service generally do not work on selected weeds in forested, riparian, grassland, and scrub habitats during the nesting season, roughly March 15 to September 1. In some cases, however, where the invasive plant threats are high, park managers conduct nesting surveys prior to removal activities. If nests are found, the project is often placed on hold until after the nesting season is over.

Anticipate erosion problems. Rice straw, wood chips, or permeable landscape fabrics may help reduce erosion problems in areas where weed removal techniques like digging or scraping will leave bare ground. Wattles combined with organic materials such as jute can also be effective. This is particularly important when banks or slopes are exposed. For steep slopes and creek banks it is important to outline an erosion control strategy prior to removing weeds. This strategy should also be approved by the landowner.

Revegetate when appropriate. Cleared areas may need to be revegetated with native plants, but it might not make sense to do so until the infestation is well under control. If the site will require intensive weed control following initial treatment, it may make sense to wait a little bit longer before replanting. The new plantings will be vulnerable to damage during weed control operations. This is particularly true when working with sites infested with Cape ivy or French broom, both of which can require extensive follow-up treatment to deal with resprouting vine fragments or dense seed flushes. In the case of controlling annual grasses, planting shrubs (if appropriate to the environmental setting) can suppress weeds over time as the shrubs establish. Revegetation with locally appropriate plants is an art in itself and is not covered in this handbook.

ues and preferences. Consequently, they may ultimately choose different strategies for controlling the same weed problem.

How might this work with wildland weeds? Let's say you have a big, long-standing patch of French broom. You might use Weed Wrenches to remove the "old-growth" French broom, but that's just the first step. All that newly exposed ground will come up thick with broom seedlings during the next spring. Using a Weed Wrench on the seedlings would be impractical, and it would take a lot of volunteer labor to remove thousands of little seedlings by hand. So your next step might be to use a hoe or McLeod to cut back the seedlings or to ask park staff to spray the dense patch of broom seedlings with herbicide, or to flame it using a propane torch. Do this a couple of years in a row, and the density of broom seedlings might fall low enough for you to rely on hand labor again. An exclusive reliance on a single tool would be less effective in this case. An integrated approach, relying on multiple methods, best addresses the problem and helps native plants reclaim the area.

The four main methods used in IPM are cultural control, mechanical control, biological control, and chemical control. In general terms, cultural control is the least disruptive to the environment. The impact on the environment depends on the circumstances—all four control methods can cause significant impacts. You can minimize such impacts by learning which tools and techniques work best in particular situations. As someone who will be working mainly with volunteers, you may focus exclusively on mechanical control, but it's important to know what other methods are available as well.

Cultural Control

Cultural control refers to cultivation practices that limit weed populations. In traditional IPM, with its focus on cultivated environments like gardens and fields, cultural control includes a wide range of important techniques that help reduce pest problems: choosing pest-resistant plants, choosing the right plants for the right soil and water conditions, rotating crops, and companion planting. Other agricultural practices such as grazing, burning, flooding, mowing, disking, and mulching are examples of cultural control that can address wildland weeds. These cultural techniques can play an important role in an IPM approach to invasive plants in the Bay Area, but for the most part they're beyond the scope of this handbook.

Nevertheless, it's important to point out how effective cultural control techniques can be. Grazing, for example, is considered by some to be the only effective management tool for controlling annual ryegrass in large areas. Goats are often used in such situations. Utilizing goat grazing requires extensive planning. Will you manage them using fencing or herding? Are you willing to sacrifice any of the native plants in the area to be grazed? How long should the

animals graze? The goats will eat almost everything. Other things to think about: the biology of the targeted weeds, the size and density of the infestation, and site conditions, particularly topography. Such considerations are important not only for goat grazing, but also for nearly every other control technique, including cultural ones.

Mechanical Control

For thousands of years, perhaps since the dawn of agriculture, humans have been using simple hand tools to remove weeds or simply pulling them by hand. Such methods can be very effective in controlling small populations of invasive plants, particularly where the weeds are intermixed with native plant communities, or adjacent to sensitive water bodies or rare plant populations.

There are other ways to physically remove weeds. In addition to the hand tools discussed below under "Key control techniques," large machines may be used to remove weeds. Special harvester boats gather up aquatic weeds and heavy-duty mowers have been designed to move through woody brush. Common construction tools like backhoes and bulldozers are sometimes used to pluck out large plants. Commercial logging equipment can be used to remove invasive trees. However, mechanical control, especially using heavy equipment, is not without risk. It can cause significant disturbance to soil and vegetation and can also introduce weed propagules and pathogens such as the one that causes Sudden Oak Death.

Biological Control

In a farm or garden, biological control can involve releasing beneficial organisms like ladybugs or lacewings that can reduce insect pest numbers. Biological control can also mean creating habitat for such beneficial organisms so that they can keep pest populations in check.

In the case of wildland weeds, classical biological control refers to the importation of host-specific insects or pathogens from the native range of introduced pest plants. (The lack of predation from such co-evolved species is one of the chief reasons that invasive plants can so effectively outcompete native plants.)

Once such organisms are located, extensive research is undertaken to ensure that they will feed only on the targeted weed and not on native plants or crop plants. There have been cases where classical biocontrol organisms have dramatically reduced invasive plant populations, but there are also a few cases where the introduced organism has expanded beyond controlling the intended weed and now affects native plant populations. Researchers at a USDA lab in the East Bay city of Albany are evaluating biocontrol agents for yellow starthistle, brooms, and Cape ivy.

Chemical Control

Herbicides are chemicals—usually synthetic—that kill plants or stunt their growth. Some herbicides are selective (clopyralid, for example, is used to kill yellow starthistle without harming grasses and most other forbs), while others are more general. Herbicides can be applied in many ways at many scales, from aerial spraying over large infestations to discrete brushing on individual plants. Extensive permitting regulates the use of herbicides, especially around surface water.

Liability concerns and state laws and regulations limit the unsupervised use of herbicides by volunteers, but a few Bay Area weed projects have set up programs in which supervised volunteers do use them. Whether operating in a voluntary capacity or for hire, on public or private lands, those using herbicides for wildland weed control must know all state and local regulations. You must understand how to read herbicide labels, the legal description of how the herbicide may be used. You must have landowner permission for the application. And on public lands, you must be trained by an applicator licensed by the state's Department of Pesticide Regulation. Some basic information on common herbicide treatments that have proven useful to some Bay Area weed workers is provided later in this chapter and also in the species accounts in the next chapter.

Environmental toxicologists study how herbicides and other chemicals behave in the environment, including their adsorption to soil particles, their ability to get into groundwater, their influence on other nearby plants through their roots, their rate of decay, and their level of toxicity to humans and wildlife. A good compendium of such information can be found in the Weed Control Methods Handbook on the Web site of the Nature Conservancy's Wildland Invasive Species Team.

KEY CONTROL TECHNIQUES

There are perhaps hundreds of tools that have been used by weed workers at one time or another, but they can be classified into fewer than a dozen major categories. In this section, we describe the fundamental techniques that Bay Area weed workers find most useful.

Pulling

Hands and strong backs are great "tools" for pulling weeds. The human body, despite thousands of years of experience pulling weeds by hand, is nevertheless susceptible to injury when doing so. The back is particularly vulnerable. Protect it using the technique you learned while hauling heavy boxes: lift with your legs, not your back. Wrists and forearms are also sensitive to injury. You can avoid repetitive stress injuries by varying your technique: switching from arm to arm, shifting from kneeling on one leg to the other leg, etc.

There is no single right or healthy way to pull weeds by hand, but you can encourage your volunteers to pay attention to their backs and other sources of discomfort. If it's uncomfortable, they should try another position or use a different tool.

Specialized tools like the Weed Wrench rely on leverage to help you pull woody stems right out of the ground. The Weed Wrench has a tall vertical handle connected to moveable jaws set on a base that rests on the ground. As the handle is pulled back, the jaws close around the woody stem and the base becomes a fixed point against which the plant can be levered out of the ground. These come in several sizes. The ones with longer handles and bigger jaws are needed to pull larger plants, but they are much heavier and awkward to carry very far.

Sometimes, in order to pull larger weeds out of the ground, you will rely on other types of tools to help you gain access to the roots or to loosen the surrounding soil. Shovels, mattocks, hand picks, and Pulaskis can be used to loosen a root ball and to sever tough roots. Pruners, loppers, saws, and other cutting tools can be used to cut roots or to trim branches that block access to the base of the plant.

To minimize soil disturbance when working with small plants, use one hand to hold the soil in place around the base of the plant while pulling with the other hand. Clumps of invasive grasses can be gathered into one hand while you use a soil knife in the other to cut an ice-cream cone shape around the base of the grass. Whenever a plant comes up with soil attached to the roots, shake it gently, preferably close to the ground and right above where you removed the plant. Don't forget that invasive plant seeds thrive in disturbed soil! So minimize disturbance when you can.

Digging

Digging is often done in combination with pulling. When removing yellow starthistle by hand, for example, it often won't come up until you use a digging tool to loosen the plant's roots from the soil. This may also be true when pulling large broom plants with a Weed Wrench. Digging tools from hand trowels to large shovels are useful for such tasks.

For the smaller plants, digging tools like trowels, soil knives, dandelion diggers, and even old screwdrivers and paring knives can be useful. Here your weed work most closely resembles gardening: weeding a newly planted area, attempting to eradicate an invasive plant population (that is, when you have to get every last plant and seedling), or the like. Using such techniques can be quite labor-intensive, so be sure that you will have enough labor to achieve your goal. If not, it may be better to choose a different goal, for instance, trying to control the yellow starthistle by mowing instead of trying to pull every last one. But that's not

to be discouraging! Steady and persistent hand weeding over time can lead to dramatic success.

The most tenacious plants may not respond to pulling or cutting. Sometimes you just have to dig them out. Weed workers sometimes dig out big pampas grass clumps, for example, or the rhizomes of pepperweed or periwinkle. If the digging is extensive, it's wise to talk with the land manager's environmental compliance specialist. There may be archeological concerns that will limit the amount of digging you can do, particularly in areas of known archeological significance. Digging can cause irreparable harm to artifacts.

Long-handled tools like shovels or spades may tempt you to pry weeds out of the ground using leverage rather than digging them out. This may work in some conditions, but it can cause greater soil disturbance and damage the tool. Many shovels aren't sturdy enough to handle being used as a lever. There's a reason Tom Ness used steel in his Weed Wrench! (He developed the Weed Wrench while working on French broom in the Marin Headlands.) Consider using a long steel pry bar if you want to pry stubborn weeds out of the ground, limiting your use of shovels to lighter duty.

Picks and mattocks can be useful in rocky soils, or when the target plant has thick roots. Safety is particularly important with such tools. They should be carried head down, not over the shoulder. Keep well clear of others as you work. Swing the tool with knees bent and feet apart, so that you cannot slice into your shin. Swing from just above shoulder height and let the weight of the falling tool do most of the work.

When digging out plants, it's best to leave the soil on-site by shaking it gently from the roots and to avoid leaving large holes. Digging can cause considerable disturbance, so be certain that you have a plan to deal with the other weeds that may come in following disturbance. Visit the site again every few months to remove any weeds that have colonized the disturbed soil. If you stay on top of it, you can keep the early successional weeds under control relatively easily.

Scraping

Scraping tools are used to target seeds and small weeds or to create containment lines. Like digging, scraping is a form of soil disturbance, so make sure to deal with weeds that establish following scraping. Scraping tools can again be useful in that regard. Pattern hoes and oscillating hoes can be used to cut invasive plant seedlings and other small weeds just below the surface of the soil. McLeods and mattocks can do the same job. Tools with claws are especially useful for removing shallow roots from loose soil or duff.

Scraping is often undertaken to prepare a site for revegetation. Scraping a wild radish patch early in the season, not long after the radish seeds have germinated, will kill that batch of new radish plants and give you time to plant native

plants instead. Some prefer to scrape the area twice or three times in a season to reduce the weed seedbank before planting natives in the scraped area. Take steps to minimize the potential for erosion during the critical time between scraping and planting. If there are native plant seedlings or plantings in the area, hoeing should be done by more experienced volunteers who can recognize the native plants.

Cutting

For some plants, cutting them off at or near ground level is the best way to kill them. This way you avoid soil disturbance and don't have to mess with tenacious roots. This works best with species that don't resprout, but there are techniques that work with those that do. A tree can be cut at the base with pruners (if it is a small sapling), with loppers (a bit bigger), with a pruning saw (bigger still), or with a chain saw (much bigger). You might use all of these tools in a single day. Your choice about which tool to use will depend on many variables, particularly safety issues.

There are lots of different cutting tools and each one has an important role to play in your toolkit. Choosing the right one often depends on biological considerations, safety issues, and efficacy. Over the years, weed workers have developed several key techniques that involve cutting woody plant tissue in some manner. Here are some of the most useful ones.

Cutting. For some plants, cutting them off at ground level is sufficient to kill them. Monterey pine trees, for example, do not resprout as long as they are cut low enough. Cutting can also be a first step in preparing a plant for complete removal later. For instance, weed workers may use a chainsaw to trim back pampas grass to a point where they can dig it out of the ground. Infestations of weedy vines, which twine through woody thickets but are rooted in the soil, often require extensive use of cutting tools to clear away the thickets before the vines can be completely removed.

Grinding or macerating a cut stump. Stump grinding or macerating can also be used to prevent stump resprouts. Though grinding machines are expensive to rent and can be awkward to use in wildlands, some Bay Area weed workers have used them. Stumps are typically ground to a depth of about two feet below the ground. If only a few stumps need grinding, some weed workers remove enough soil around the base of the trunk so that they can cut it just below ground level without getting the chainsaw bar in the dirt. Some practitioners macerate cut stumps to inhibit resprouts. They do this by using a chainsaw to make cuts in a grid pattern (one- to two-inch squares) approximately two to four inches deep in the cut surface of the stump.

Tarping a cut stump with landscape fabric or black plastic. In this treatment, the stump is cut low and level, then covered tightly with landscape fabric to prevent it from getting any sunlight. The fabric is spread at least two to three feet beyond the edges of the root crown to prevent resprouts from photosynthesizing. Care is necessary to make sure that individual pieces of fabric have enough overlap so that resprouts can't squeeze up between the seams. Because seams tend to be a source of failure, avoid using tarps with seams if you can. The fabric is staked down every few feet—or even every six inches—with U-shaped wire staples to make sure the tarp is securely fastened. Some weed workers even dig a trench around the target and completely bury the edges of the tarp. Covering stumps is feasible only for small areas and needs to be checked two to three times a year to make sure that sprouts haven't burst through the fabric or emerged around the edge. Cut stumps may require up to a year or more of covering to prevent resprouting. The fabric can also be covered with mulch to improve the aesthetics.

Treating a cut stump with herbicide. Many plants, including blue gum eucalyptus and acacia, resprout vigorously after being cut. Repeated cutting may eventually sap the plant of its vigor, but it requires intensive follow-up work, and is seldom efficient unless you have extensive volunteer resources available to prevent resprouts from establishing. That's why many weed workers treat the cut stump with an herbicide such as triclopyr or glyphosate. Practitioners use a high concentration of herbicide—no more than 50 percent, according to some—and apply it immediately upon cutting since the plant tissue heals rapidly, inhibiting uptake of the herbicide. The herbicide needs to be applied only to the exposed cambium, the living tissue in the trunk. It's wasted anywhere else. Unless aesthetics or safety are problems, cut the stump flat at a height of eight to ten inches. Then if it resprouts even after treatment, the stump can be cut again and retreated with herbicide. If aesthetics are a concern, stumps can be cut low and level and, once the herbicide has had a chance to work, covered with a thin layer of mud or brush to reduce the visual impact of newly cut trees.

Girdling, frilling, and drilling. These techniques all take advantage of the vulnerability of the cambium in order to kill a standing tree without felling it. The plant will die if this narrow band of living tissue encircling the entire tree just under the bark is damaged in such a way that it cannot transport water and nutrients between the roots and the rest of the tree. If a small section remains uninjured, however, the plant will keep growing and perhaps even heal the wound over. In most cases, it is preferable to cut down trees, but girdling and the like can be useful in relatively inaccessible areas where the dead tree will become a snag that will be useful to wildlife. These techniques should not be used if the standing dead tree will become a safety hazard or an aesthetic problem, or if it is in an urban

setting that could generate controversy. Girdling involves cutting through the bark and the cambium all the way around the trunk, and is often done using a chainsaw. Frilling accomplishes the same goal without using power tools. Cut long slices downward through the bark to the cambium and then peel them downward. Frilling tends to lose its effectiveness on trees larger than two feet in diameter because their bark becomes too thick for peeling. Another technique, which can be even more efficient and effective, involves drilling small holes in the bark and injecting herbicide. You need to know the proper herbicide type, concentration, and amount. Some practitioners have found that when drilling and injecting herbicide, a 50 percent solution of glyphosate works best. As with all herbicide treatments, this treatment requires supervision, training, and a prescription from a state-certified applicator.

Weed whipping. The next two techniques rely on power tools to increase the number of plants you can cut. As a result, they can be more effective and efficient in certain situations, but also more dangerous. Weed whipping offers the cutting power of a lawn mower but can reach tight spots a mower won't. It relies on a more powerful version of a tool familiar to many homeowners and known variously as a weed whip, weed whacker, or string cutter. A brushcutter, a larger and more powerful version of the weed whip, can be fitted with nylon string, rigid plastic cutting blades, or a wide variety of steel blades ranging in suitability from brush to small trees. A gas-powered motor spins a cylinder at the end of a long metal tube. When a canister containing nylon string is attached to the cylinder, the brushcutter can be used for cutting grasses, seedlings, or herbaceous plants like yellow starthistle. The nylon string doesn't work very well when the vegetation is wet. If the area is perpetually damp, or the vegetation is thicker than can be cut using nylon string—even the newer versions that are reinforced with steel or Kevlar—consider using other techniques. The rigid plastic blades can be very effective with tougher herbaceous weeds or small brush seedlings.

Brushcutting. When fitted with a metal blade, a brushcutter can be very effective in opening up areas covered by tall stands of woody invasive species up to two inches in stem diameter. Brushcutting tends to be used with larger infestations and in places where plants have become overgrown. This can be used as a way to prepare a site for pulling plant roots with a Weed Wrench—in which case, don't cut the stems so low that the Weed Wrench won't be able to grab them—or treating the cut stumps with herbicide. It is sometimes a challenge to move plants that you have just cut so that they are not in your way for cutting other plants. A second person can help with this, but it presents obvious safety concerns. The engine is often loud and the metal blade can throw stones and other debris, so

operating a brushcutter (or working near one) requires extensive protective gear and safety training. For the operator, chaps, helmet, face screen, and ear protection are *de rigueur*. These hazards, particularly the noise, require you to be very sensitive to the safety and comfort of park visitors as well. Using a brushcutter along a busy trail is to be avoided. The metal blade can also throw sparks when it hits rocks, so avoid its use in dry conditions when the fire hazard is high; use plastic blades or string in such conditions.

Mowing. Gas-powered mowers, especially the heavy-duty types used by maintenance divisions in park and open space agencies, can provide some control of certain invasive plants in grassland situations. Yellow starthistle, for example, when mown just as it begins to flower, can be knocked back significantly if done for two to three years in a row. Mowing to prevent seed set can keep some invasives from spreading while you reduce the size of the infestation with other methods. Timing is key. Mowing after invasive annual grasses have gone to seed obviously won't help. Mowing can also present problems if the target plant's seeds can continue to ripen even after being cut off (many thistles) or will reroot or resprout from cut stems (Cape ivy). A tractor-mounted mower can be effective on large parcels. Many different sizes can be rented and delivered to the site. A trained operator is required, as is a site that has been cleared of barbed wire, rocks, and other things which could get caught in the blades. Mowing is often best done in combination with other techniques, like hand pulling subsequent seedlings if they're not too numerous.

Applying Herbicides

There are several simple techniques for weed workers applying herbicide in situations where the landowner or manager has established the appropriate protocols and procedures to comply with pesticide regulations. These techniques require training and supervision by a licensed applicator and should not be undertaken without landowner approval and training certification. Before using such techniques, consider posting signs notifying the public that herbicides are being applied in a particular area. (Depending on the jurisdiction, this may be required by law or regulation.)

Cut-stump treatment. The role of this technique is described in the cutting section above. Herbicide at high concentration is applied to the cut face of the stump either by painting it on with a small brush or by spraying it on using a small bottle like those used to mist houseplants. Because you have direct access to the cambium, the amount of herbicide required is low, especially given the size of the plant. There is little danger of the herbicide contacting other plants directly when using this treatment.

Foliar spray. This technique delivers herbicide to a plant through its foliage, so it uses herbicide less efficiently than in the cut-stump treatment. Because the herbicide is being sprayed, there is the possibility of contacting non-target plants, which can result in undesired damage if you're using a non-selective herbicide like glyphosate. Many applicators use a backpack sprayer, which typically carries several gallons of diluted herbicide. The sprayer tank is kept pressurized by pumping a lever, and herbicide is sprayed from a wand. Wind conditions are always measured, because you are prohibited from spraying in any breeze over a low threshold to avoid drift. To ensure sufficient uptake into target plants it is necessary to cover their leafy surfaces thoroughly. This is easy on small plants, and harder on larger plants. Foliar spray tends to be ineffective on plants that have leaves with thick waxy cuticles.

Wicking. A wicking wand has a sponge on the end that is used to wipe herbicide onto a plant. This can be used for a foliar treatment, in which it has the advantage of getting less herbicide on non-target plants, but the disadvantage of taking more time to coat all surfaces. Wicking wands can also be used for basal bark treatments on woody plants, where herbicide is painted around the bark at the base of the main trunk. This treatment uses special additives that allow the herbicide to penetrate the bark and move into the root system.

A Few Other Techniques

A few additional control techniques are hard to classify. These include:

Solarizing. This technique takes advantage of the vulnerability of plant tissue to extreme heat. A clear plastic tarp allows sunlight to penetrate but traps the heat. In sunny climates the heat can be high enough to kill the plants under the tarp. In practice, the technique is identical to that used in covering a cut stump with landscape fabric, but in this case a clear plastic covering is used. (See Tarping treatment for details.) Solarizing may require up to a year or more of covering to kill the plants underneath the tarp. This technique is ineffective in foggy coastal areas, but weed workers in the East Bay and other areas with hot summers may find it useful for controlling small infestations of certain herbaceous weeds. Some practitioners prefer black plastic, finding it more effective than clear plastic even in inland areas as well as along the coast.

Flaming. Like solarizing, this treatment also relies on the vulnerability of plant tissue to heat. In this case, a propane torch is used to speed up the process. Some weed workers have found that it can be quite effective in controlling the thousands of French broom seedlings that emerge after a large stand has been

removed. Others have recently cited success with poison hemlock. However, its true potential is yet unknown, since this agricultural weed control technique is only now being adapted to wildland weed species and conditions. Stay tuned! As experience accumulates, it's likely to become an important and effective tool for controlling herbaceous invasive plants or small shrub seedlings. Flaming has several advantages, including avoiding ground disturbance, extending the season to include wet and cold weather (using it keeps you warm), and providing greater selectivity than herbicides (it works only on very young plants). Technique, timing, and safety issues are key concerns. The seedlings are not actually burned, but rather heated to the point at which the water in the plant cells boils and ruptures the cells. (Some weed workers describe this technique as "blanching" rather than "flaming," and if you know your cooking terms you know why.) This stage is not always obvious to the torch operator, so it can be a difficult technique to learn properly. It is best to learn from someone practiced in the art. This treatment should be used only when it is raining or immediately thereafter. For obvious reasons, a propane torch should not be used in wildlands when there is any risk of fire whatsoever. Like many of the techniques described in this book, it is important to gain approval from the land owner or manager prior to implementation, and in this case consultation with your local fire department is a wise precaution.

Mulching. Mulching can be effective for smothering small infestations of herbaceous weeds like kikuyu grass or Harding grass that are hard to control using other techniques. Cover it first with a weed barrier—landscape fabric, nylon, plastic, even cardboard or old carpet—and then place three to six inches of rice straw or wood chips on top of that. Some people prefer fabric over plastic because of its superior ability to let water infiltrate into the soil and prevent erosion problems. Be sure to get *weed-free* mulch. Once the plants underneath are dead, removing the weed barrier will allow you to revegetate the area with native plants. If the barrier material is biodegradable, you can also plant directly into the fabric, cutting small holes to insert plants. Using an organic mulch can alter soil conditions, so this treatment should be used only in areas that have been highly altered already.

Managing Debris Appropriately

Whether pulled, dug, or cut, invasive plants are still invasive plants. Dealing with such debris is an important and often underestimated dimension of weed work. This is especially true for plants like Cape ivy, which has an almost miraculous ability to regenerate from the smallest bits and shreds. (It's so tough that it's been known to resprout even after being bagged in black plastic and left in the sun for months in the heat of a Central Valley summer!) When making plans about how to manage invasive plant debris, take into account considerations like the plant's biol-

ogy, vehicular access to the site, available resources, and site aesthetics. Before embarking on a weed project, always ask yourself: what am I going to do about the debris? Here are some common techniques for dealing with invasive plant material:

Leaving on-site. This is the simplest method. Pull up the plant and leave it right there. It works only if your target plant cannot reroot or resprout, occurs in low densities, and decomposes quickly, as is the case with many herbaceous plants. If you're working on small, dispersed pioneer populations, this strategy often makes good sense.

Piling on-site. This treatment is commonly used for dense stands. By piling the debris in a few stacks rather than scattering it across the entire site, you will free up space for native plants to begin regenerating. (Building high stacks can also provide you and your volunteers with a visible sense of accomplishment—take pictures of your group in front of the debris pile at the end of the day!) Some weed workers pile debris in such a way that they can burn the stacks later in the year, during late fall or early winter, for example. (As with all land management involving prescribed fire, it's important to consult with the local fire department and obtain all appropriate permits.) Others have found that wood and brush piles can provide valuable habitat for wildlife. Aesthetic concerns may compel you to stash debris away out of sight, but this can lead to new infestations if you're not careful. Debris piles often need to be monitored for resprouts and hiding them can make them hard to relocate. If your target is a resprouting vine like Cape ivy, it is often best to cut a containment line around the debris or pile it in the middle of a large tarp. Bucking and tarping on top can also help. In such situations you can separate clean, completely uninfested woody debris (which won't resprout) from herbaceous debris containing Cape ivy. This will reduce the number of Cape ivy-infested piles, and it will be easier for you to deal with resprouts if they're not entangled with branches. Whatever approach you use, monitor regularly for resprouts for several years.

Avoid piling dead plant material in areas where target weeds are likely to grow. For example, if the target quickly colonizes moist soils, consider placing debris in upland areas.

Hauling off-site. This treatment is feasible only when the site is easy to access by vehicle. It is a useful option when working with tree debris or weeds like Cape ivy that have the ability to resprout from the tiniest stem. Hauling and dumping fees can be quite expensive, so be sure to estimate accurately the volume of debris before choosing this technique. For plants that spread by seed, you can reduce the amount of debris by cutting and bagging the seed heads from the invasive plant before removal. This is sometimes done with pampas grass, but only in outlier popula-

tions. When invasive plants are still in the early stages of invasion, it is also often worthwhile to bag plants that may contain viable seeds. Better to haul a few bags away than to take a chance that the viable seeds will reinfest the site. And of course, you want to make sure that the destination site for your hauled debris is not likely to be the source of further infestations (landfills are generally fine, as are composting operations as long as they are hot enough to kill weed seeds or fragments).

Chipping on-site. This treatment can be useful if you are dealing with tree debris and the site is easy to access by vehicle. Branches up to three to four inches in diameter can be chipped into the back of a truck or, if ecologically appropriate, left on-site. Larger pieces of wood can be hauled away for lumber or firewood or left on-site. Like chainsaws and brushcutters, using a chipper requires training and careful safety practices. Make sure you have trained operators prior to using chippers.

TOOL SAFETY, CARE, AND SELECTION

Using a tool safely depends on knowing how to use it properly. Some tools, like a trowel or a dandelion digger, are easy to figure out on your own. Even if you don't quite get it right the first time, you can't inflict much damage on yourself (though one weed worker reported getting a bad blister on his palm the first time he used a dandelion digger without gloves!). Your margin of error for safety is much smaller when working with power tools or tools with sharp blades. That's why it is best to insist on proper training in tool use and safety.

Those working with volunteer weed workers often rely on manual tools because it is possible to train volunteers to use them safely and properly in a relatively short time. Teaching someone how to use a Weed Wrench takes no more than five minutes. Using a Weed Wrench is not without risk, but the infrequent injuries that can occur are relatively minor—bruises, bumps, and backaches mostly. As this example illustrates, many manual tools have two important advantages over other tools: they are relatively simple to use and the risks of their use are relatively minor. (That said, even simple tools like hand picks can be quite hazardous in the hands of a rambunctious crowd of teenagers. Remember one of the ABC lessons in chapter 3: know your Audience!)

It is true that volunteers can be taught how to safely use manual tools with sharp blades. Using a machete is straightforward—it's a simple and very effective tool in brush—but the consequences of an accident are much more severe than they are when using other tools. That's why very few weed workers who work with volunteers use machetes. They choose tools more appropriate for the skill level of their volunteers, even if this means avoiding tools that may be more effective in objective terms (that is, when used by an experienced worker).

Choosing the right tool for the job is not just a decision about technology, but also about sociology. Chapter 4 contains additional considerations about tool safety and use when working with volunteers.

All weed workers using power tools should receive careful training in tool safety, use, and care. For public agencies who are willing to allow volunteers to use power tools—and such agencies are in the minority—this often takes the form of an all-day or half-day workshop.

A well-made tool can last a long time if it is cared for. And a well cared-for tool is also a safer tool. Tool care is often a neglected art, though, which has led exasperated managers to take several approaches for dealing with the problem. One approach is to dedicate the last fifteen minutes of a work party to tool care and cleaning. (Removing seeds and soil from tools and boots is important when dealing with invasive plants because otherwise there's a chance that you and your tools will be transporting invasive plant seeds.) Or you can set aside one work day every few months to paint, repair, and sharpen your tools. Some programs find dedicated volunteers or staff members who enjoy tool care to take responsibility for tool maintenance.

If you have responsibility for choosing tools, choose high-quality ones. Cheap tools usually fall apart rapidly under the stress of vigorous weed work. (On the other hand, you may be better off with relatively lightweight tools, especially if you work with children.) You may choose to purchase or borrow a variety of tools for your work parties—all kinds of volunteers are then likely to find something they're comfortable with—or focus on just a few types of tools, simplifying your planning and training.

WEED WORKERS' TOOLS EXPLAINED

Tool	Target	Considerations
PULLING		
Weed Wrench	tap-rooted shrubs, small trees	works best in winter and spring when soil is moist; can cause soil disturbance; works best with vertical rather than horizontal taproots
pliers	seedlings, narrow-stemmed plants	easy to carry; easy to lose
McLeod, rake	vines	
DIGGING		
round-point shovel		standard multi-purpose shovel; long handles increase leverage; some may prefer short handles
spade		flat-edged, short-handled shovel; only marginally useful
transplanting spade, or sharpshooter		long narrow-bladed shovel, effective on deep root systems; forged steel work ones are much better than cheap stamped steel; if careful, can be used to lever plant out of the ground
trowel	small plants	useful for planting or transplanting small plants; good tool for children
soil knife	small, tap-rooted plants	point penetrates pliable ground easily; serrated blade lets you cut what you can't dig; creates less soil disturbance than trowel
dandelion digger	small, tap-rooted plants	
mattock	deep-rooted plants	requires proper training
Pulaski		a favorite all-purpose tool for many weed workers; useful for grubbing out or cutting down almost any plant; can be used for frilling and girdling; light-weight versions available
hand pick		one-hand tool for smaller scale weed removal
digging bar, rock bar		useful for loosening hard soil and rocks deep below the surface; can bend if used for prying
pry bar		useful for prying up roots

Tool	Target	Considerations
SCRAPING		
McLeod, cultivator fork, other tools with tines	mats of invasive perennials in monoculture, including grasses	McLeods are a good multi-use tool for scraping surface debris fromthe ground, hacking out small roots, and raking small brush; requires follow-up for resprouts and seedlings; requires some training
pattern hoe	seedlings and small plants	requires basic training
oscillating hoe	seedlings and small plants	can push or pull, providing versatility; requires basic training
CUTTING WOODY PLANTS		
pruners	woody stems <½ inch in diameter	anvil pruners (one sharp blade and one flattened one) require less force to cut the same stem than bypass pruners (sharpened blade slides past curved blade); inexperienced users can ruin bypass pruners by twisting them in the cut; bypass pruners can make cleaner cut
loppers	woody stems ½–2 inches; tree and shrub limbs; stalks of large herbaceous vegetation	loppers come in two basic types too: anvil and bypass (see above); longer handles allow for greater leverage when cutting through woody stems; can be ruined if used inappropriately; requires some basic training
pruning saw	woody stems <10 inches in diameter	some come in a folding version; a favorite tool for many weed workers; can get pinched in large branches if not careful
hatchet, ax	large shrubs, small trees	useful when you don't have access to a pruning saw or chain saw; let the falling weight of the tool do the work; position your feet so that you won't accidentally hit your legs if you miss; dangerous tool in inexperienced hands; also used for frilling and girdling
Pulaski	large herbaceous plants, large shrubs, small trees	can be used like an ax to cut, frill, or girdle, can be used to hoe out root pieces; requires training for both safety and technique
bow saw	woody stems <18 inches in diameter	available in many sizes; useful for sawing through limbs and small trees; used primarily for large blocks of wood like logs; commonly used in trail work
limbing saw	woody stems <18 inches in diameter	mostly used by arborists for small limbs

Tool	Target	Considerations
chainsaw	woody stems	versatile but noisy and requires extensive safety training; helpful and safer to work with a swamper to remove debris and provide assistance when required
brushcutter	woody stems <4 inches in diameter using steel blade	versatile but noisy and requires safety training; helpful and safer to work with a swamper to remove debris and provide assistance when required; should not be used on steep or very rocky slopes
CUTTING HERBACEOUS PLANTS		
weed whip	small areas of grasses, herbaceous annuals, or perennials	versatile but noisy and requires safety training; useful for light-duty selective mowing in grasslands
brushcutter	grass or seedlings using nylon string or rigid plastic blades; vines or groundcover using toothed steel blades	versatile but noisy and requires safety training; helpful and safer to work with a swamper to remove debris and provide assistance when required; should not be used on steep or very rocky slopes
mowers	grass or herbs	useful in large, flat areas
machete	almost anything	too dangerous for common use; requires proper training in both sharpening and user technique; must be regularly and expertly sharpened; a dull machete is more likely to cause injury
scythe	grass	not commonly used anymore, but can be a very effective tool, if sharp and used properly, in uniform grasslands; difficult to learn proper techniques for sharpening and use
hand scythe	grass; inflorescence removal before seed dispersal	relatively safe, good for cutting grass in sensitive areas; not appropriate for large-scale control
Swedish brush ax	brush and small woody stems < 4 inches diameter	relatively safe, but any sharp-edged tool entails risk; requires proper training
Japanese sickle		relatively safe, but any sharp-edged tool entails risk; requires proper training
pocket knife	shrubs and small trees	can be used for girdling when no other tool is available; versatile multi-use tool that can come in handy
OTHER		
flaming equipment (propane torch and portable tank)	small seedlings, soon after germination	safety an issue; best conducted in wet season; may require multiple treatments in one season as germination is staggered

Tool	Target	Considerations
landscape fabric, black plastic (6 or 10 mil)	clonal mats of vines and grasses	use plastic rather than fabric when moisture barrier is needed; use fabric to allow moisture percolation into the soil; 6 mil breaks down in about a year in sun; 10 mil lasts at least twice as long
wire staples		staples can be used for securing fabric edges when the ground is pliable; otherwise dig a trench and bury the edges; requires long-term commitment of 1–2 years; must be well-fastened to endure weathering 1–2 years; not for use in high-wind environments; aesthetics may be an issue
wheelbarrow, plastic bag, woven polypropylene bag, tarp		all can be used for hauling vegetative material; wheelbarrows can be bulky and unwieldy to handle on pickup trucks; plastic bags rip easily; some prefer to use strong tarps, which can be lifted at the corners and dragged or carried
rake		useful in areas with high visitor use; flexible rakes useful for cleanup; hard rakes useful for piling debris
push broom		useful in areas with high visitor use
hay fork, scooping fork, ensilage fork		great for loading or unloading vegetative material
static kernmantle rope		knowing a few basic knots turns a length of rope into an assist for short climbs, a loop for dragging brush, and a multitude of other uses

WEED WORKERS' TOOLS ILLUSTRATED

(note: drawings are not to scale)

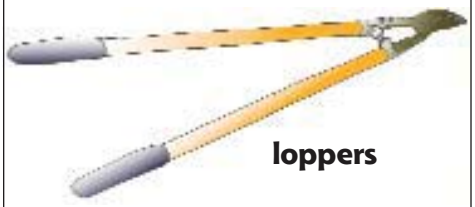




Pulaski



hand pick



loppers



small loppers



hand saw

hedge trimmer

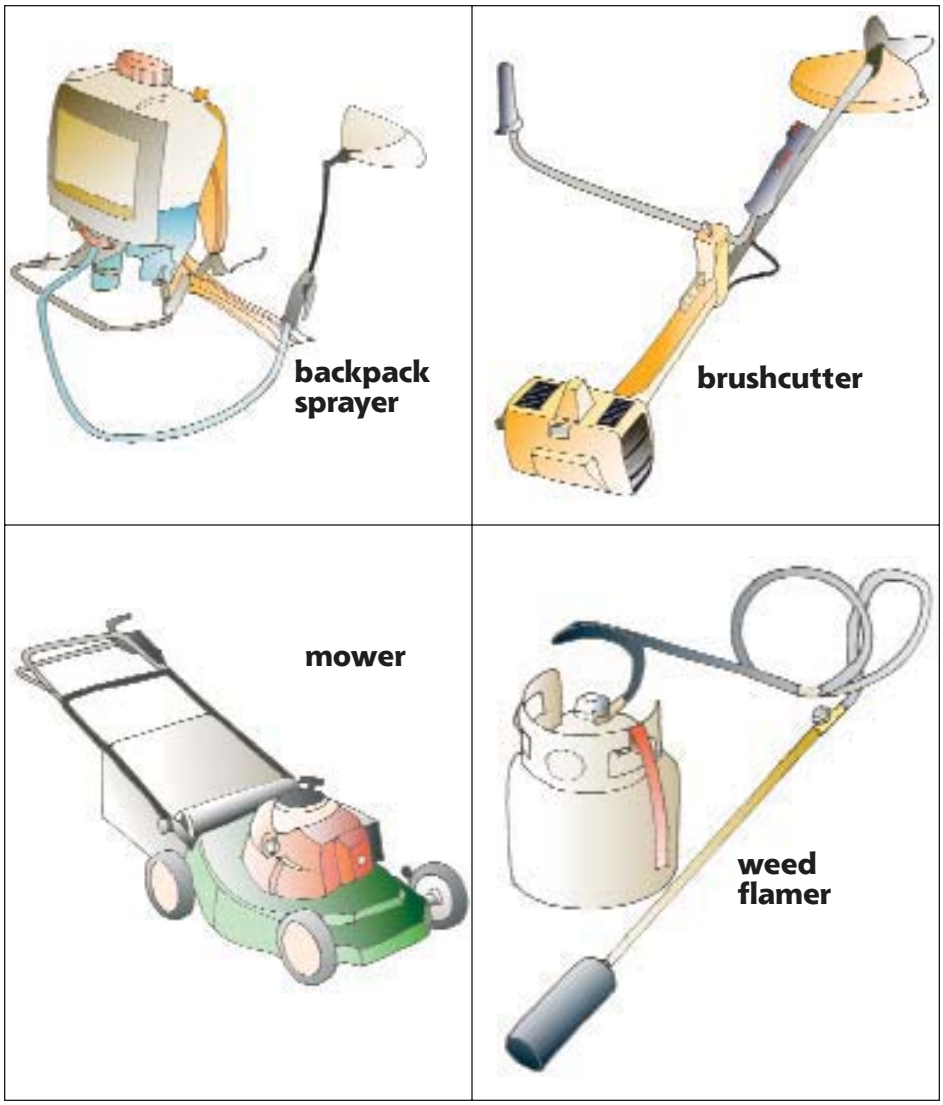




machete



soil knife


backpack sprayer
brushcutter
mower
weed flamer

6

THE PLANTS: HOW TO REMOVE BAY AREA WEEDS



The weeds presented in this chapter are significantly affecting Bay Area ecosystems. Local landowners, conservation organizations, and volunteer weed workers have identified these plants as important to control in Bay Area watersheds. While other weeds also affect local natural areas, we have chosen to provide a comprehensive resource for these species in this book.

Each species account includes a description of the plant and its modes of reproduction, followed by its ecological impact, treatment options for removal, and notes on disposal and follow-up. A wide range of treatment options is presented so that you can select the approaches best suited to your site and resources. (Refer to chaper 5 for detailed descriptions of each of the control treatment options.) Each account also lists key factors of the plant's biology that are important to consider when planning a control program.

Following is a discussion of how biological characteristics—modes of reproduction and life cycles—affect choices and strategies for effective weed control efforts.

REPRODUCTION: HOW IT AFFECTS WEED REMOVAL

By definition, weeds are plants that reproduce very successfully in the habitats they invade. We should note that weediness is not a fixed characteristic of a plant, but a reflection of its impact in a particular environment. Some invasive plants are prolific seeders and early colonizers even in their native range, while others are surprisingly rare in their native range. For these plants, the absence of predators and diseases, recent or historical habitat alteration, or other ecological circumstances enable them to invade where they are introduced. In such cases weed removal may be only one component of habitat restoration. Whatever the factors that enable a plant to become a weed, understanding its modes of reproduction

and its life cycle will help you choose techniques, evaluate progress, and follow up appropriately until you succeed in controlling it.

Some plants reproduce exclusively from seed. Some are equally prolific by sexual and vegetative reproduction. Others reproduce almost exclusively vegetatively, and either rarely produce viable seed, or their seeds rarely encounter the right conditions to germinate. In sexual reproduction, male and female gametes combine and produce genetically different offspring through flowering, pollination, and seed production. In asexual (or vegetative) reproduction, new individuals—clones—can grow from a part of a plant, such as a node or a root.

Sexual Reproduction

Evolution has produced myriad ways by which seeds—those precious packets of genetic information—are dispersed. Some seeds drop close to the parent plant, while others are carried a considerable distance on the wind; some are eaten by birds and dropped even greater distances; others still are transported by flowing water. Perhaps the greatest aid to seed dispersal, however, is the movement of humans. (This is how many weeds were introduced in the first place!) Some seeds are transported by clothing, boots, and vehicles from mountain bikes to earth-moving equipment.

Effective control techniques are linked to these means of seed dispersal. For example, if a seed is transported by water, consider trying to control upstream infestations first to prevent continual re-invasion. If seeds come packaged in fruits that are eaten and dispersed by birds, consider trying to remove the plant before fruits ripen. When you don't have the resources to remove entire plants before seeds are produced, you may chose to remove just the seeds for that season if practical. Another important consideration is seed viability. Knowing how long seeds can persist as a viable seedbank will help you decide how many years you will need to follow up on removing seedlings after the initial removal of an infestation.

Vegetative Reproduction

Plants can produce new individuals by many means other than seed. Vines can cover a lot of ground simply by vegetative growth—not technically reproduction—before they ever flower. Bulbs, rhizomes, stolons, and runners are not roots, but shoot (stem) tissue that can give rise to new plants. Tillers and suckers are shoots that emerge directly from a part of the root, growing adjacent to or at some distance from the main stem of the parent plant. Some plants can produce shoots and roots directly from stem nodes or branch tips that touch the ground. Others can regrow from a cut stump or from parts of roots left in the ground. For our purposes, such regeneration can be considered vegetative reproduction, because without follow-up, it can produce a whole plant.

The amazing array of possibilities for vegetative reproduction gives rise to a long list of considerations for treatment and follow-up. Can the target weed

resprout from a cut stump? If so, you may choose to implement one or more of the following options until the species is controlled: cutting resprouts until energy resources are depleted, covering the stump with landscape fabric, treating with herbicide, or removing the stump and roots entirely. Can a patch continue expanding outward via rhizomes or tillers? If so, you may try to control the perimeter until you can remove the whole patch. Can small fragments of stems that contain a node produce an entire new plant? If so, you may find yourself regarding weed debris as hazardous waste when you contemplate disposal.

Life Cycles

In addition to differences in modes of reproduction, plants have different life cycles: annuals complete their life cycle in one year, biennials in two years, and perennials live for three or more years.

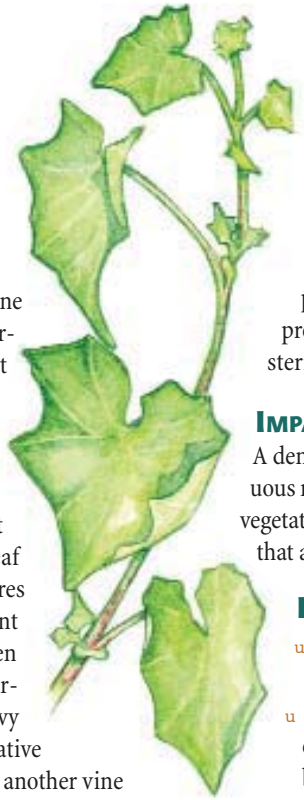
- **Annuals** reproduce exclusively by seed. An example is yellow starthistle, a winter annual that produces copious amounts of seed. (Winter annuals germinate in the fall, overwinter as seedlings, and die in the spring or summer soon after setting seed.) Because individual plants do not persist beyond one year, the main control concern with annuals is preventing seed production to minimize the number of future plants.
- **Biennials** develop strong roots during their first year, storing the energy they need to survive the winter. Bull thistle, like many biennials, overwinters as a basal rosette of leaves. This is a good time to pull plants up by hand as the taproot is relatively weak. In the second year, biennials bolt and flower. By this stage, not only is the taproot stronger and the plant more difficult to pull up, but soon the plant will produce seed.
- **Perennials** often reproduce both sexually and vegetatively, thus requiring a range of treatments to control or remove them. Perennials can be divided into woody perennials (trees, shrubs, and some vines) and herbaceous perennials (forbs, grasses, and some vines). Woody perennials have persistent, hardy stems. Herbaceous perennials often have stems that die back during the winter but roots that persist, with new stems growing from the root crown each spring. Treatments for perennial weeds are often designed to make an impact on their most resilient part—the roots. If the plant can regrow from stumps or roots, the control strategy may also include repeat treatments to exhaust the plant's energy stores.

The species accounts that follow are grouped by growth habit (vines, shrubs, trees). Herbaceous plants are further divided by life cycle (perennial or biennial forbs, annual forbs, perennial grasses, annual grasses.) Within each section, the plants are ordered alphabetically by common name. The illustrations that accompany each description are not to scale.

CAPE IVY

Delairea odorata

(formerly known as German ivy, *Senecio mikanioides*)
Sunflower Family (Asteraceae)



Description

Cape ivy is a climbing perennial vine usually found in coastal and riparian areas and on disturbed moist sites. However, it is a highly adaptable species that will proliferate in a wide range of ecosystems.

Both the leaves and stems store water, making the plant drought-tolerant. A single leaf grows from each node and measures 1–3 inches long. The succulent leaves are smooth and bright green with pointed lobes. The underground stolons are purple. Cape ivy is commonly confused with native wild cucumber (*Marah fabaceus*), another vine with similar leaves. Unlike Cape ivy, however, wild cucumber has thicker stems, spiraling tendrils, hairs on the leaves, white flowers that bloom in spring, and spiny fruits.

Reproduction

Cape ivy grows vigorously, particularly from February to June. It reproduces vegetatively by rooting from stem, stolon, or petiole (i.e., any part of the plant except the leaf blade) that touches the ground. Infestations can be spread by a variety of means, such as machinery or water, which carries fragments downstream. Cape ivy has no taproot, only shallow adventitious roots that grow to 4 inches deep in the soil. In areas with little summer moisture or with frost Cape ivy will experience some dieback, only to resume growth with the fall rains. Small, yellow flowers with green tips bloom between December and February. Cape ivy seeds have a hairy apex and are wind-dispersed. However, most seeds produced in California appear to be sterile.

Impact

A dense, sometimes heavy, and continuous mat of Cape ivy can blanket native vegetation. Cape ivy contains alkaloids that are potentially toxic to fish.

Key Factors

- Reroots from fragments left in the soil.
- Frequently grows among poison oak, stinging nettle, and blackberry.
- Thrives near moisture.

Treatment Options

Removing Cape ivy requires precision, as every little part of the stem needs to be removed. Given the time and resources that controlling Cape ivy demands, practitioners have found it is sometimes advantageous to focus on removing the Cape ivy around the perimeter of a patch, rather than all-out removal. The control method chosen depends on patch size and isolation, the resources available for control, and the threats posed by Cape ivy to valued resources.

- **Cut** a containment line by clearing a strip of bare earth around the entire perimeter of a Cape ivy infestation, as if you were cutting a fire break. The strip should be roughly 1 yard wide, depending on site factors such as public visibility and soil moisture. This helps to prevent spread as Cape ivy grows more slowly on bare

soil. Begin from the edge of an area and work your way inward. You can sometimes peel back the edges of an infestation, where the vine is more lightly rooted, and roll the vegetation like a carpet. Tease or dig out stolons with a small Pulaski, fork, McLeod, or hand mattock if needed, following the runners to their source. Many hand tools work well. You can rake the soil surface several inches deep to comb out any remaining stems and roots fragments. Check the line periodically (4–6 times a year at moist sites; at least 2 times a year elsewhere) for Cape ivy spreading.

Some practitioners have used a more intensive approach—especially in riparian and dense scrub habitat—by clearing both native and invasive vegetation to establish initial containment/removal lines and access Cape ivy resprouts. This requires chainsawing limbs off trees and shrubs to about breast height. Make sure limbs are removed from the area as Cape ivy may also reestablish in debris piles. Rakes or McLeods can help to pull loosely attached vines climbing up a tree, or you can cut the vine with loppers and leave the ivy to die in the tree.

Sites cleared of Cape ivy may be vulnerable to erosion or colonization by other invasive species. When working next to a creek or river, work your way from upstream to downstream to prevent recolonization by stem fragments transported by water.

- **Cut and treat.** Cut climbing vines with loppers and paint stems with herbicide. Because Cape ivy nodes break easily, it may help to place tarps on the ground around trees in order to catch any stem fragments that break as you work.
- **Graze.** Some land managers have attempted using goats as a pretreatment. Audubon Canyon Ranch grazed 60 small female goats for 1 week on a half-acre site; the goats grazed the foliage but not the stolons.

Disposal

Some practitioners pile the plant material on a tarp to dry out in the sun, making sure no roots touch the ground. The Cape ivy should break down quickly, especially if the piles are turned frequently. However, there is a chance that Cape ivy will sprout even after long drying. Establish and maintain a containment line around larger debris piles. As a final measure you can spray the piled debris with a weak glyphosate solution. Alternatively, bag all parts of Cape ivy and remove them from the site. You may also need to remove parts of native vegetation that have become entwined with the vine. Pile thoroughly cleaned woody debris separately, and chip it for mulch.

Follow-Up

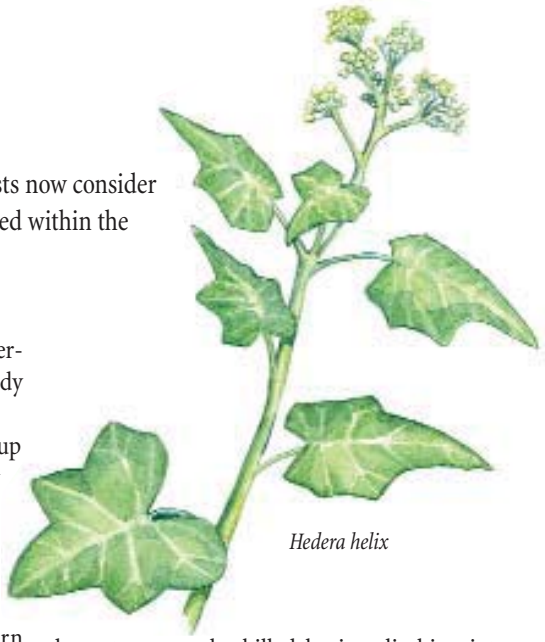
Some practitioners recommend revegetating immediately with low-growing species (if appropriate to your restoration project) in order to deter Cape ivy reinfestation. Return to the site as needed: more frequently for moist sites—approximately every 4–8 weeks—and perhaps as little as every 6 months for dry sites. Small Cape ivy plants can be hard to spot when growing in thick undergrowth and therefore easily overlooked, so check often. The strategy is to be responsive to regrowth and be persistent. Expect an eradication program to require 3–4 years when working on patches of less than an acre.

Interesting Facts

Native to South Africa, Cape ivy was introduced to the US during the 1850s as an ornamental, and has since been used in landscaping and possibly erosion control.

IVY SPECIES

English ivy ***(Hedera helix)***
Algerian ivy ***(Hedera canariensis)***
Ginseng Family (Araliaceae—some botanists now consider members of this family to be properly classed within the family Apiaceae.)



Hedera helix

Description

Both English and Algerian ivy are woody evergreen vines commonly found in moist, shady woodland areas.

Ivy grows as a vine and groundcover for up to 10 years before flowering. English ivy leaves are alternate, dark green, and leathery. They usually have 3–5 lobes, white veins, and aerial rootlets that secrete a sticky substance, enabling ivy to climb up tree trunks. Older plants capable of flowering can turn increasingly shrubby, with leaves that are more oval and measure 2–4 inches long. Algerian ivy is distinguished from English ivy by its 3-lobed leaves, pink to reddish stems, and white flowers.

Reproduction

In mature plants, terminal clusters of small, yellowish-green, and inconspicuous flowers appear in fall; blue-black berries appear the following spring.

English ivy spreads primarily by rhizomes, but it can also reproduce from seed. Seeds are disseminated by birds whose digestive tract scarifies the hard seed coat. Algerian ivy is a relatively new invader, so less is known about its reproduction. It is, however, reported to produce a large quantity of viable seed and to have a large root system.

Impact

Ivy vines form dense carpets of vegetation that can cover native vegetation as well as open soil. This dense groundcover can deprive native plants of light and nutrients and reduce germination of the native seedbank. Evenually even large trees can be killed by ivy climbing into their canopies. Algerian ivy is considered more invasive than English ivy because it is rapidly invading relatively undisturbed forest understories. The leaves and berries are toxic.

Key Factors

- Seed longevity not known, but reported to be quite viable.
- Shallow root system, but resprouts from cut roots (typically more than a half-inch) left in contact with the soil.

Treatment Options

Removing ivy can increase the potential for erosion on creek banks and slopes, so have an erosion control strategy in place prior to removal.

- **Pull** vines climbing into trees and along the ground by hand or with rakes and McLeods. Ivy can sometimes be rolled up like a carpet and piled or hauled off-site.
- **Cut** woody stems with pruners or loppers, and **dig** up the roots with a shovel to prevent resprouting.

- **Cut and treat** vines that are well established or climbing into trees. Make two cuts to remove a 12- to 16-inch section of the vertical stem. The portion of the vine remaining in the tree, without access to the roots, will eventually die. To prevent resprouting from the lower portion remaining in the ground, the stump can be treated with herbicide (some land managers use a 50 percent solution of glyphosate) or cut out with a Pulaski or shovel.

Disposal

Pulled ivy roots left in contact with soil may reroot. Piles may be left to decompose on a tarp on-site or hauled off-site and disposed of as green waste.

Follow-Up

Check for resprouts or new seedlings 3–4 times a year. These are easy to remove by hand. If piles are in contact with soil, check for rerooting and regrowth.

Interesting Facts

English ivy is native to Europe, was most likely introduced to the US as an ornamental in colonial times, and has been used to control soil erosion. Algerian ivy, as its name suggests, is native to northern Africa and southwest Europe. English ivy has been used since the time of the Ancient Greeks to treat a range of health complaints, including rheumatism, toothache, and even cellulite.

Notes

HIMALAYAN BLACKBERRY

Also known as Armenian blackberry

Rubus discolor

Rose Family (Rosaceae)



Description

This perennial shrubby vine is common in riparian woodlands, disturbed open areas, and along streams.

Himalayan blackberry forms mounds up to 10 feet tall, with arching or trailing, thorny stems that become woody and reach up to 40 feet long. These areas are often impenetrable. The canes (stems) are green to deep red, turning woody with age. The leaves are toothed or serrated along the edges and have a mat of fine hairs underneath that give a whitish appearance. Leaves on flowering stems have 5 leaflets. To distinguish Himalayan blackberry from the native species, look for hooked or curving thorns, 3–5 leaflets, and larger fruits that ripen later than the native blackberries. Native blackberry (*Rubus ursinus*) has just 3 leaflets and fine prickles rather than single thorns. Thornless elm leaf blackberry (*Rubus ulmifolius* var. *inermis*) is another invasive blackberry species to look out for. This species is thornless and produces no fruits, only flowers.

Reproduction

Himalayan blackberry reproduces in a variety of ways. It can spread vegetatively by rooting from the cane tips or from nodes along the canes, from rhizomes or root fragments, and from the root crown. Canes bear fruit in their second year and then die. Every year the crown produces new canes that replace the dead ones. White (or sometimes pinkish) flowers with 5 petals and many yellow stamens bloom from June to August. Bumblebees and honeybees pollinate the flowers. Edible berries ripen and turn black in August to September. Seeds are viable and tend to be dispersed by mammals or birds whose digestive tracts scarify the hard seed coating and promote germination. Seeds germinate in the spring and fall, but can remain viable for several years. An individual plant can live 25 years.

Impact

Once established, the plant's dense mounds displace native vegetation by shading out light. Individual canes are relatively short-lived (2–3 years), so a build-up of dead canes and abundant leaf litter gradually increases the risk of fire. Himalayan blackberry reduces access to water for wildlife, degrades pasture, and is sometimes a nuisance to recreationists seeking access to natural areas.

Key Factors

- Stout thorns necessitate the use of leather gloves and protective clothing.
- Abundant seed production.
- Seeds viable for several years.
- Fast-growing stems.
- Resprouts from the crown and root fragments left in the soil.
- Thrives in moist areas.

Treatment Options

- **Cut** stems with loppers close to the ground. **Dig** out rootball with a Pulaski or shovel, and

remove as much of the root as possible. Interconnecting roots reaching over 30 feet long and 2–3 feet deep make pulling up *all* roots extremely difficult. Realistically, you should aim to remove the main rootball and the large lateral roots. Dense thickets and thorns also make working with blackberry labor-intensive and uncomfortable, so control may be feasible only in sensitive habitat or small infestations working from the outside in.

- **Brushcut** the canes; use McLeods to clear the vegetation. The best time to do this is when flowers are in bloom but before the fruit sets. Cutting encourages new growth but may be effective if repeated over a number of years.
- **Cut and treat.** Some practitioners cut stems to about 1 foot and treat stumps with 25–50 percent concentration of glyphosate immediately after cutting. Don't use herbicide on or near plants from which people may pick and eat the berries.

Disposal

Transfer stems and roots to a site where they can be left to decompose, making sure that all berries have been removed. Alternatively, burn the debris or trim it into pieces small enough for bagging and disposal.

Follow-Up

Regardless of the method used, follow-up is essential. Some land managers recommend immediate revegetation with quick-growing shrubs and trees, with periodic visits to the site to check for seedlings or regrowth. After you've removed the canes, one option is to hoe the soil or use a rototiller. This will clear out any roots, but is practical only for small infestations. Goats will also graze on younger plants.

Interesting Facts

Native to Eurasia, Himalayan blackberry was introduced to the US in the late 1800s as a cultivated crop. The berries make great pies and jams!

Notes

PERIWINKLE

Vinca major

Dogbane or Milkweed Family (Apocynaceae)



Description

Periwinkle is a spreading perennial vine most commonly found in shaded riparian and disturbed areas.

The leaves are opposite, 2–3 inches long, broadly oval in shape, and pointed at the tip. They are glossy, dark green, and have tiny hairs along the leaf margins and a waxy coating. Flowering stems grow erect to about 1.5 feet, while non-flowering stems become long and trailing. The plants can die back in hot, dry weather.

Reproduction

Periwinkle spreads vegetatively by arching stolons that root at the tips, and by vigorous underground growth of stolons. Like Cape ivy, it also roots from fragments of the stem. The roots are fibrous and form shallow-growing mats typically 6–12 inches below the soil surface. This weed can tolerate a range of soils; wet conditions trigger spurts of vegetative growth. Single, blue-purple, tubular flowers with 5 flattened petals bloom between March and July. It is not clear whether periwinkle can produce viable seed in California.

Impact

Periwinkle forms a dense carpet of both aboveground vegetation and matted roots that excludes native groundcover species and prevents seedlings of trees and shrubs from establishing. Periwinkle can also contribute to soil erosion along streambanks.

Key Factors

- Resprouts from root fragments (typically greater than a quarter-inch in diameter) left in the soil.
- Rapid growth.

Treatment Options

- **Pull** up the dense vegetation and underlying stolons using a McLeod. Pull the roots up from the base of the stems. If working in clay or dense soils, roots may break off, and follow-up grubbing may be required to ensure removal.
- **Pull** periwinkle by hand if it is a very small patch in sandy or loamy soil. Generally, this method only works if the roots are within 1–2 inches of the soil surface or if the soil is loose and very moist.
- **Brushcut** the vines close to the ground and then cover the area with weed fabric, black plastic, or cardboard. Leave for at least 1 year, possibly 2. Some practitioners use a combined treatment by cutting back the aboveground vegetation, grubbing out the roots, and then covering. Weed fabric is expensive and may be practical only for small infestations. You may want to consider using layers of cardboard or carpet instead.
- **Dig** a trench around the patch, 6 inches deeper than the stolons, and line it with fabric to temporarily contain periwinkle. This will prevent the root system from expanding until the patch can be further controlled.

- **Foliar spray.** Some practitioners report excellent results with spraying and no cutting. Others cut the plant close to the ground in spring when periwinkle is actively growing, using a brushcutter, scythe, or weed whip, and then, within 1 minute of cutting, spray a 2 percent solution of glyphosate onto the cut stems. The purpose of cutting the vines beforehand is to break up the waxy cuticle and improve absorption of the herbicide. Spring is the most effective time for this treatment.

Disposal

As with Cape ivy, it is important to remove any larger broken stems and root sections from the site as these will resprout. The cut vines can be piled on a tarp and left to decompose. Turn the piles periodically, making sure no stems come in contact with soil or water. Alternatively, bag the vines and dispose.

Follow-Up

Monitor the site at least every 3 months for resprouts, depending on how moist the site is. If you use landscape fabric, check that it is still held firmly in place, and pull up or grub out any escaped plants.

Interesting Facts

Native to Mediterranean Europe, periwinkle's use as a medicinal plant goes back hundreds of years. The leaves have traditionally been used as an astringent and to reduce hemorrhages, and magicians added them to love potions! It was probably introduced to the US as an ornamental.

Notes

BROOM SPECIES

French broom ***(Genista monspessulana)***
Scotch broom ***(Cytisus scoparius)***
Spanish broom ***(Spartium junceum)***
Legume or Pea Family (Fabaceae)

Description

These three broom species are invasive shrubs that grow in grasslands, scrub, and woodland habitats. Once introduced, they can quickly colonize disturbed areas, trailsides, and streambanks, and sometimes spread into wildlands along roads. Broom species are somewhat shade tolerant, though in general Scotch broom is found in drier, sunnier locations. Individual shrubs have been known to live up to 17 years.

French broom usually grows 6 to 10 feet tall, but can grow as tall as 15 feet. Mature plants are evergreen, especially along the coast. Leaves grow in groups of three. Each leaf is about a half-inch long, or larger in shadier woodlands.

Scotch broom also grows 6 to 10 feet tall. Young plants are easily distinguished from French broom by the flowers (see below) and by the ridges on their dark green stems. Scotch broom leaves are smaller and fewer than French broom, giving the plant a wiry look.

Spanish broom is distinguished from the other types of broom by its smooth, round stems, single leaves, and large flowers. Leaves are shed during summer drought, giving a very stick-like appearance. Its taproot can reach depths of 6 feet, making Spanish broom the hardest of the three brooms to remove.



Genista monspessulana

Reproduction

French broom flowers start to appear in March (earlier in sunny locations) and continue to bloom through May or even July. They are yellow, less than a half-inch in size, and have the familiar pea flower shape with banner, wing, and keel petals. The flowers grow from the main stem in bunches of 4 to 10. In June and July, inch-long fuzzy green seed pods appear, turning dry and brown in late summer. Each pod bears several to many shiny black seeds.

Scotch broom flowers are similar to those of French broom, but they are larger and deeper yellow. Seed pods are similar, too, except that they have hairs only on their seams, instead of being fuzzy all over.

Broom seed pods, when ripe, burst open explosively and propel seeds up to 12 feet from the plant. Starting in the second year of growth, seed production is prodigious; in a single square-meter plot, researchers have counted more than 6,700 seeds! Furthermore, the seeds persist, remaining viable for at least 5 years and potentially for decades. Broom seeds often germinate with early winter rains, establishing a flush of new seedlings from December through July.

Impact

Dense stands of broom change the structure of the invaded plant community, often increasing fire hazards by creating a "ladder" of woody material that can carry fire into trees. Brooms provide poor forage for native wildlife. The leaves and seeds are toxic. As nitrogen-fixing legumes, they can enrich soil nitrogen, which in turn can promote the growth of other weedy plant species once the broom has been removed.

Key Factors

- Prodigious seed production.
- Seeds remain viable for many years, potentially decades.
- Resprouts from stumps and root crown when cut.

Treatment Options

- **Pull** shrubs by hand or with a Weed Wrench, or **dig** with a Pulaski, pick, or shovel between January and May, when the moist ground makes it easier to remove the roots, and before another generation of seeds has developed. Repeated pulling of successive generations is currently thought to be the single most effective method of removing broom.
- **Cut** shrubs to just above ground level using a pruning saw, loppers, or brushcutter, ideally during the dry season so that the stumps become more stressed. Cutting, rather than pulling, has the advantage of minimizing soil disturbance. Untreated cut stumps *will* resprout and must be cut repeatedly (see Follow-Up, below.) Alternatively, cut the stems about 2 inches above ground level, then **girdle** the stump by peeling the bark off the stems—like peeling a banana—down to ground level. This reduces resprouting and works best on medium to large French broom plants.
- **Cut** stems, using loppers, to about 2 inches above ground, and grub out the roots.
- **Cut and treat** the stumps with herbicide.
- **Girdle** the trunk of large broom plants with a small hand tool such as a paint scraper. (Warning: while girdling minimizes soil disturbance, standing dead broom will increase, not reduce, fire hazards. Also, broom left standing will be in the way when you return for follow-up.)
- **Scrape** seedlings with a hula hoe.
- **Flame** seedlings in monoculture with a propane torch (weed blancher). This is most effective and efficient when the seedlings have only their two seed-leaves, but can also work on seedlings with true leaves, up to a few inches tall. (See Follow-Up for more on flaming.)

Follow-Up

Wherever mature plants are removed, emerging seedlings will also have to be removed for *at least* the next 5–8 years and probably longer. In the first year after removing mature plants, the next generation will be too small to pull, but this dense flush of seedlings is effectively controlled by flaming with a propane torch. A single pass with the torch will wilt and kill seedlings. Controlling broom plants when they are seedlings will spare you a great deal of work in pulling plants the second year after removing mature broom.

Broom is not eradicated from your site until the seedbank is exhausted, so be vigilant to prevent subsequent generations from producing seed. Broom is easiest to spot when the bright yellow flowers are present, but be sure to remove it before the seed pods mature.

Broom resprouts from the base when cut: all except seedlings and old, senescent plants can resprout after cutting if not treated with herbicide. Resprouting stump shoots can be cut or weed-whipped the following year, either in late spring or in the dry season. Repeat this treatment annually until the plants' energy resources are depleted.

Disposal

Pulled plants that have not produced seed can be piled on-site to decompose. Alternatively, they can be hauled off-site and chipped or recycled as green waste. One innovative use of broom waste has been to bundle the pulled plants to create 8- to 12-inch wattles that can be secured to slopes to prevent erosion.

Plants that have gone to seed should be piled on tarps or bagged to reduce the number of seeds falling to the ground and germinating. Putting broom-with-seed piles in deep shade will also help inhibit germination. Tarps should be visited annually, and eventually removed when materials have decomposed.

Interesting Facts

French broom originates in the Mediterranean and was reportedly introduced to the Bay Area as an ornamental in the mid- to late 1800s. Scotch broom is native to much of Europe and the foothills of North Africa.

Notes

Notes

COTONEASTER SPECIES

Cotoneaster franchetii
Cotoneaster pannosa
Cotoneaster lactea

Rose Family (Rosaceae)

Description

Cotoneasters (pronounced co-TONE-e-aster) are evergreen shrubs that grow in grasslands, shrublands, forests, and open areas, and can form dense thickets.

They are either sprawling or erect to about 10 feet tall. The branches criss-cross one another. The leaves are simple, elliptic-ovate, dark green to gray-green, and hairy beneath. They grow up to three-quarters of an inch long. The leaves of *C. lactea* are larger.

Reproduction

Clusters of white to pink 5-petaled flowers bloom between June and September, followed by showy crops of orange or red berries September through February. Seeds are produced in great numbers and do not require fertilization. They drop near the parent plant but are readily eaten by many bird species, which increases the distance over which seeds can be dispersed. Seeds germinate during the rainy season. Cotoneaster can also spread vegetatively by root sprouting and by branches rooting at the nodes.

Impact

Cotoneaster is thought capable of invading intact ecosystems, where it competes with native vegetation for water, nutrient, and light resources. This is seen particularly in plant communities where the native toyon (*Heteromeles arbutifolia*) is found. The root system grows rapidly, making removal difficult. In addition, the dense shrubs frequently grow under trees and can facilitate the spread of fire by forming a fuel ladder.



Key Factors

- Produces many stump sprouts after cutting.
- Root system is extensive and difficult to remove.
- Abundant seed production and bird-dispersed fruits.
- Seed longevity is not known, but may be several years.

Treatment Options

- **Pull** seedlings a half-inch or less in diameter with a mini-Weed Wrench or by hand. Pulling is practical for small plants only, as cotoneaster develops multiple stems from a large root mass, making it difficult to grasp the base.
- **Cut and treat.** Cut stumps close to the ground during the fall and winter. Practitioners using herbicides apply a 50 percent concentration of glyphosate to the stumps. Painting stumps with glyphosate is effective on large shrubs

but becomes more difficult on the smaller ones, as the many small stems can be hard to see. For smaller plants, it may be preferable to spray the herbicide.

- **Cut and cover.** Remove all branches of mature shrubs with loppers or a pruning saw, then cut the trunk back to about 1 foot in height. If you cut much shorter, the plant may produce a significant number of sprouts from the root and trunk. Recommendations vary on when to cut, but research suggests cutting just after the shrub has produced fruit (when its energy reserves are at their lowest) but before fruit has dropped, thus minimizing the risk of mature berries germinating. Cover stump and surrounding ground (1–2 feet all the way around the stump) with landscape fabric for at least a year.

Follow-Up

Return to the site at least once a year to check for resprouts and seedlings. If you use landscape fabric, check periodically that it hasn't been moved by animals or hikers. You can also remove the fabric twice a year to cut back any growth that has resulted despite the lack of sunlight. Make sure you reposition the fabric securely.

Disposal

Individual plants can be piled on-site. For larger infestations you might want to chip the debris.

Interesting Facts

Native to China, cotoneaster was introduced to the United States as an ornamental most likely during the mid- to late 1800s.

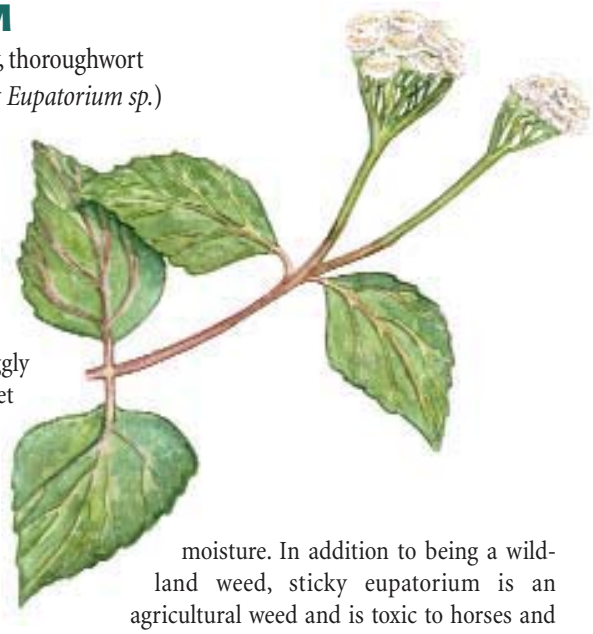
Notes

STICKY EUPATORIUM

Also known as Crofton weed, eupatory, thoroughwort

Ageratina adenophora (formerly *Eupatorium sp.*)

Sunflower Family (Asteraceae)



Description

This perennial herb or semi-shrub is found on moist, exposed slopes and disturbed areas, particularly in riparian habitat and in forest clearings.

Sticky eupatorium often has a straggly appearance and typically grows 3–5 feet tall. The stems are long and dark red with downy hairs, and woody at the base. Sticky eupatorium grows rapidly, its shoots and branches forming dense thickets. Leaves are opposite and triangular-ovate with toothed margins. They are about 2 inches long, dark green, and glossy.

Reproduction

Sticky eupatorium spreads primarily by asexual seed production. Small, white or pinkish inflorescences resembling pincushions appear in terminal clusters in March. From April to mid-June each plant produces 7,000–10,000 tiny black seeds, although up to a third of these are not viable. Each seed is topped with fine hairs that aid in wind dispersal. The seeds are easily airborne or dispersed by water, but they can also stick to clothing, footwear, or passing vehicles and animals. Most germination takes place in August and September, and seedlings are capable of reproducing vegetatively within 8 weeks of germination. The plant can also reproduce from the roots and through parts of the stem that touch the ground.

Impacts

Sticky eupatorium crowds out native plants after fire disturbance or flooding, and is very competitive with natives in areas with summer moisture. In addition to being a wildland weed, sticky eupatorium is an agricultural weed and is toxic to horses and unpalatable to cattle.

Key Factors

- Prolific seed production and rapid growth.
- Seed viability thought to be 2–3 years.
- Thrives in moist drainage areas.
- Resprouts from roots and from stems in contact with soil.

Treatment Options

- **Pull** plants by hand or **dig** them out with a Pulaski when the plant is in flower but before it has gone to seed. Removing sticky eupatorium by hand is time-consuming. Although the root system is shallow, stems break easily, especially on drier soils, so care should be taken to pull from the base of the stems so as not to leave root fragments. In moist drainage areas, you might find yourself pulling up heavy, sodden clumps of root mass and soil. Often you'll find that the roots form a continuous mat. However, it's important to get the root mass, as the plant will otherwise resprout.

- **Brush cut** sticky eupatorium on dry, steep slopes and in drainage areas, using a rotary slash brushcutter. Some practitioners then follow up by digging out the roots; others, by spraying the cut stems with herbicide. In the Marin Headlands repeated brushcutting at monthly intervals in the drier months has proved unsuccessful in exhausting the root system and preventing the stems from resprouting, perhaps because of the additional moisture supplied by summer coastal fog.
- **Foliar spray.** Some practitioners have have had success by spraying a weak solution of glyphosate in infestations on dry slopes away from water. Spray the tops and undersides of the leaves (either before or just after the plants begin to show buds).

Disposal

Stems will easily reroot in water, so make brush piles well away from wet areas. Piles can be left to decompose on site.

Follow-Up

If the infestation is a manageable size, follow brushcutting with removal of the roots. Alternatively, if it is safe to use herbicide, you can wait for lush growth to return after brushcutting and spray the plants in order to finally kill them. Return to the site 2–3 times after the initial visit (at 6-month intervals) to scrape off any new seedlings from the soil surface with a McLeod or hula hoe. Mulching the weeded area with a 1- to 2-inch-thick layer of straw or covering with landscape fabric will help prevent the seedbank from germinating and will make follow-up much easier.

Interesting Facts

Originating in Mexico, sticky eupatorium is considered a major agricultural weed around the world. It may have been introduced to California as an ornamental plant. In India the plant is being used to produce a green commercial dye, while in Nepal the plant juice is applied to cuts and injuries. Studies show that composting sticky eupatorium for approximately 2 months eliminates its toxins.

Notes

ARTICHOKE THISTLE

Also known as cardoon, wild artichoke

Cynara cardunculus

Sunflower Family (Asteraceae)



Description

Artichoke thistle is a perennial herb commonly found in disturbed grasslands where it can form dense stands. It also invades chaparral and riparian woodland habitats.

Growing up to 5 feet tall, its erect stems are thick, coated with downy hairs, and ribbed like celery. The leaves are silvery or grayish-green on the upper surface, and whitish beneath due to the presence of white hairs. The leaf margins have one-eighth to one-quarter inch spines. The leaves form a basal rosette.

Reproduction

Artichoke thistle reproduces primarily by seed but can also resprout from the roots if cut back. One or more flower heads bloom at the tip of stems from April to July and are pollinated by bees. Occasionally flowering occurs in the first year, but more often in the second. One plant can produce up to 15 or so flower heads (or cardoons) with pinkish-purple or blue flowers. A single flower can produce hundreds of seeds. The seeds are brown to black, roughly a quarter-inch long, and have feathery bristles at the tip. Being too large and heavy to travel far by wind, the seeds generally drop near the parent plant. Seed that has travelled farther afield is usually spread by birds, animals, and water. Research suggests that seeds remain viable up to 7 years.

Impact

Artichoke thistle competes with neighboring vegetation for moisture and nutrients, and once established will shade out other plants to form monocultures. Thick stands of the plant inhibit the movement of wildlife. The plant is not poisonous but may injure grazing livestock and humans who come into contact with it.

Key Factors

- The spines necessitate wearing heavy leather gloves, long sleeves, and even protective clothing such as chainsaw chaps when removing this plant.
- Abundant seed production.
- Seed longevity reported to be at least 5 years.
- Prolonged germination period (from first rains to as late as July).
- Resprouts vigorously from deep taproot (up to 8 feet deep).

Treatment Options

- **Pull** or **dig** plants out. In theory, most of the taproot needs to be removed to prevent resprouting, but some land managers have been able to kill artichoke thistle by digging up only 12–18 inches of the root. The taproot's brittleness may make removal difficult, so pulling during the rainy season is best.
- **Cut** and bag flower stems before they open, to reduce seed production if you do not have time to remove plants. Some practitioners have also found grazing by goats helpful in reducing seed spread.

- **Cut and treat.** Some weed workers using herbicide prefer to apply it to the base of a cut plant rather than covering the large leaves. They cut the stems close to the base with loppers and apply herbicide to the base.
- **Brush cut** every 3 weeks between December and March, and then every 4 weeks until the plants died during the summer drought. For heavily infested areas, a tractor with an attached flail mower has been used.
- **Foliar spray.** Seedlings may need to be sprayed just once, but larger plants may require 3–4 sprays in one season. Some practitioners spray as plants begin to bolt (at the end of the first year of growth).

Disposal

Seed heads should be disposed of (if flowers are developed or seeds are present, place in plastic bags), together with any roots, and taken off-site. It's important to destroy as much of the root system as possible, either by herbicide or physical removal and proper disposal.

Follow-Up

Return periodically to the site to check for seedlings coming up from the seedbank. Some have also carried out surface tilling as a follow-up treatment after mowing or brushcutting.

Interesting Facts

Native to the Mediterranean, this plant was introduced to the US in the mid-1800s for use as a vegetable (the inner leaf-stalks, taproot, and base of the flower head are edible). It is related to the commercially grown globe artichoke (*Cynara scolymus*), and the two will hybridize. The commercial variety of cardoon has fleshier flower heads, and the leaf lobes and inner flower bracts are without spines.

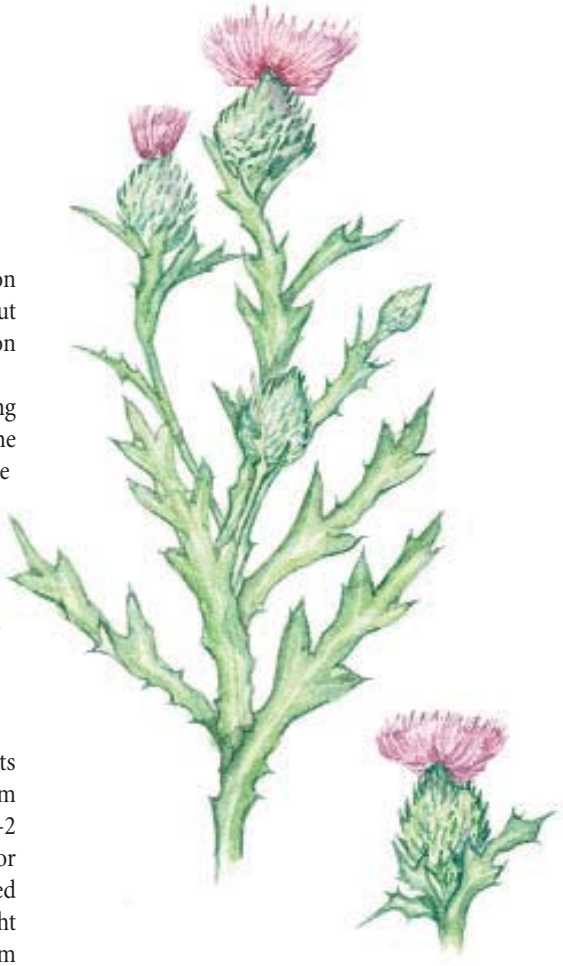
Notes

BULL THISTLE

Also known as spear thistle

Cirsium vulgare

Sunflower Family (Asteraceae)



Description

Bull thistle is a biennial commonly found on recently disturbed sites and forest clearings, but it also invades native grasslands. It thrives on moisture.

Bull thistle's erect spiny stems and spreading branches reach 2–5 feet. The upper surface of the leaves is grayish-green with short, stiff hairs; the undersides are a woolly gray. The leaves are alternate, stout, and have a winged appearance, with pointed lobes and a long yellow spine at the tip. Bull thistle produces a rosette of low-growing leaves in the first year. A fleshy taproot can grow up to 30 inches long.

Reproduction

Bull thistle reproduces solely by seed. It bolts and flowers generally in the second year, from June to September. Flowers are terminal, 1.5–2 inches across, and rose-colored to magenta or purple. The base of the flowers is cone-shaped and densely covered with green spines. Light brown, oblong seeds are ripe for release from July to October. Each plant produces seed only once before dying, but can produce thousands of seeds. The seeds are wind-dispersed, although research suggests that most drop within a few feet of the parent plant. Seeds germinate in spring and fall.

Impact

Bull thistle can establish in grassland and scrub habitats, quickly colonizing open patches. It also reduces the value of forage lands.

Key Factors

- Spines necessitate the use of heavy leather gloves when working on this plant.
- Copious production of wind-dispersed seeds.
- Seed longevity thought to be at least 10 years.
- High germination success rate.
- Resprouts from taproot unless removed from below crown.

Treatment Options

- **Pull** bull thistle by hand before the flowers open. To spare yourself the spines, step on the stem so that the thistle leans over to one side before you bend down to pull it. If the ground is hard, loosen the soil with a pick and then pull up as much of the taproot as possible. Clip any flower heads that are beyond the bud stage if population size is small.

- **Cut** the stems to at least 1–2 inches below ground with a sharp-edged shovel before the flowers bloom. Remove flower heads when feasible, i.e., in small populations. The plant may continue resprouting if the root is left in the ground, so follow-up is important.
- **Mow** after the thistles have bolted but before they flower. A second mowing one month later is usually necessary. Thistles must be cut close to the ground. Yosemite National Park has had some success using this technique.

Disposal

The stems can be left to decompose on-site. Any clipped flower heads should be removed (and bagged, if plants are on the cusp of developing seed), as thistle flowers can mature and produce viable seed even after being cut off the stem.

Follow-Up

Not all bull thistles flower in the second year, so follow up for several years to catch those plants still in the rosette stage. Dig up rosettes each year or chop out 1–2 inches below ground. Replanting the area with native species will discourage bull thistle, which thrives more on open, exposed sites with little competition from other species. There is also evidence to suggest that bull thistle does not tolerate deep shade, so you might have success using a weed fabric barrier in dense patches as a follow-up treatment. Clean equipment before leaving the infested site to prevent the spread of viable seed.

Interesting Facts

Bull thistle is native to Europe, western Asia, and North Africa, and reached the United States as a crop seed contaminant during the colonial era. The taproots at the rosette stage are edible if cooked.

Notes

FENNEL

Foeniculum vulgare

Carrot or Parsley Family (Apiaceae)



Description

Fennel is an erect perennial herb commonly found in annual and perennial grasslands, open, disturbed areas, chaparral, and along watercourses and roadsides.

Fennel grows 4–10 feet tall and smells like licorice. The branching stems are stout, grayish-green, and marked with long vertical grooves. The stems are jointed and sheathed by leaves at the nodes. The leaves are dissected into fine, feathery strands like dill leaves, with each division measuring up to 5 inches long. Fennel has a stout taproot.

Reproduction

Fennel reproduces by seed and, after cutting, by regenerative root crowns. Flowers first appear 1.5–2 years after germination. Small, yellow flowers in umbrella-shaped clusters (umbels) bloom between April and August. Aromatic seeds are produced in pairs during summer until September. These are light green to brown, flattened and ribbed, measuring a half-inch long. Within 2 years, one plant can produce over 100,000 seeds. Seeds are commonly spread by water, or by coming into contact with clothing, animals, vehicles, and machinery. Seeds will germinate at almost any time of the year. Soil disturbance may trigger higher rates of germination.

Impact

Fennel can form dense monospecific stands by competing with other plant species for light, water, and soil nutrients. Research suggests it may also have an allelopathic effect on other species.

Key Factors

- High seed production.
- Seeds remain viable in the soil for several years.
- Resprouts from roots when cut.
- Mowing can stimulate increased growth if performed too early in growing season.
- Seedlings need light to grow.

Treatment Options

- **Pull** small seedlings by hand when soil is soft and moist. You can also use hand tools, such as a soil knife or trowel, to uproot seedlings. A thick taproot frequently makes pulling mature fennel impracticable.
- **Dig** out individual plants with shovels, hand picks, and Pulaskis, preferably when the soil is still moist. If you cannot get the whole root, remove the upper portion of the root crown (generally the top 3–6 inches). Cutting into the root just before the plant sets seed reduces the number of resprouts. If you don't plan to

follow up with herbicides, dig only in light infestations, because the soil disturbance will expose seeds and increase germination. The deep taproot and bulb store the plant's energy and will regenerate quickly if cut. Cutting alone will not kill fennel, so follow up on resprouts frequently to exhaust the roots.

- **Mow** fennel 4 times a year, about every 3 months, beginning in March–April. Some seed heads lie prostrate and are therefore easier to miss. Mowing *during* seed set encourages seed spread and should therefore be avoided. Mowing too soon before seed set appears to increase vegetative growth. Reports suggest that this repeated mowing technique can eradicate fennel within 4 years.
- **Mow and Foliar spray.** Some weed workers mow fennel and wait for resprouts to appear, then apply glyphosate to the bushy resprouts.
- **Foliar spray.** A 2 percent solution of glyphosate can be sprayed on the leaves of green seedlings emerging after dormancy (March–May). Spray before the plant bolts (around June). Repeat application may be needed. For fennel growing near water, use a suitable glyphosate product.

Follow-Up

Remove any ripe seeds from the site by brush-cutting and bagging the flower heads. This is also a useful stop-gap measure to contain the spread of fennel on sites where elimination is not possible. In chaparral, revegetate with native shrubs immediately to discourage fennel from re-establishing and prevent colonization by other invasive species. Check for seedling growth twice a year, particularly in late winter/early spring, and follow up on resprouts to exhaust energy stored in the roots.

Disposal

Fennel stalks without seed heads can be piled or even composted in large piles on site.

Interesting Facts

Fennel originally comes from the Mediterranean region where the seeds and tuberous roots have been used in cooking at least since the Roman era. There is little information on its introduction to California, but it most likely escaped from cultivation. In medieval times, the seeds were eaten to suppress the appetite, while the raw bulb is still eaten as a digestive in southern Italy. Wild pigs will forage for the roots, which furthers invasion through soil disturbance, while birds and rodents reportedly eat the seeds. Fennel is attractive to Anise Swallowtail butterflies as a source of nectar, but generally speaking, fennel tends to displace other animal species by reducing habitat diversity.

Notes

PERENNIAL PEPPERWEED

Also known as tall whitetop

Lepidium latifolium

Mustard Family (Brassicaceae)



Description

This versatile, rapid-growing perennial herb forms dense stands, commonly in or adjacent to salt marshes and freshwater riparian areas as well as hay meadows and even roadsides.

An erect and branching plant, perennial pepperweed reaches 3 feet or taller in moist conditions. The alternate leaves are lanceolate, toothed or smooth-edged, typically gray-green, and waxy; lower leaves are larger. The thick roots look like weedy parsnips and grow to a length of 10 feet, making removal extremely difficult. Pepperweed often grows near and is confused with Grindelia. Grindelia stems are reddish, while pepperweed stems are not.

Reproduction

Perennial pepperweed spreads primarily from underground roots, in addition to root fragments, which can float in water for long periods and still sprout. It also spreads from abundant seeds, with a single plant producing thousands of seeds each year. Tiny, white 4-petaled flowers bloom in terminal clusters from June to September. The seed pods, maturing in August and September, are tan to red-brown, rounded, slightly hairy, approximately ⅛ inch long, and bear 2 tiny, flattened seeds. Seeds are dispersed by water, machinery, and passing animals or people. Their longevity is not known, but is probably no more than 2 years.

Impact

Pepperweed tolerates salty soils and can invade intact ecosystems. A vigorous root system allows it to compete for water and nutrients with native species, such as pickleweed, which the threatened salt marsh harvest mouse requires. Pepperweed also degrades habitat for the California clapper rail. The woody stems can shade out sunlight needed for growth. The roots of pepperweed do not hold the soil well and allow increased erosion on riverbanks after flooding. Pepperweed is also an agricultural weed of hay meadows and is toxic to horses.

Perennial pepperweed is considered one of the most difficult invasive plants to remove. If you see a new infestation, act immediately! Most non-chemical methods are reported to have little impact on controlling this weed once it has become established.

Key Factors

- Large, deep, and vigorous perennial root system.
- Resprouts from small root fragments (of less than an inch) left in the soil.

- Produces thousands of tiny, viable seeds, although they appear to be short-lived.
- Accumulates thick layer of debris.

Treatment Options

- **Pull** plants by hand, preferably when the soil is moist and loose, and grub out as much of the root as possible. Hand pulling is feasible only for seedlings of young infestations. There are no easily pulled individual roots, but a continuous mass of deep, interconnecting roots that frequently break. Mechanical removal is not recommended given the plant's ability to spread easily from root fragments, but it will temporarily stop seed from spreading.
- **Cut and cover.** It may be possible to cut this plant back prior to flowering, and then cover the root system with cardboard or landscape fabric to reduce the plant's ability to resprout, though it may be difficult to hold the covering in place along shorelines.
- **Mow** or **brush cut** plants close to the ground when flower buds appear. (Removing only the top growth will stimulate regrowth.) Let the pepperweed grow back and bud again, then mow a second time. Some practitioners have followed this by immediately applying a 2 percent solution of glyphosate to the cut stems. *Note:* glyphosate is not reported to be effective as a foliar application (skipping the step of mowing or brushcutting) because the leaves have a waxy coating. In riparian or wetland habitat, use a suitable glyphosate product—one that is not toxic to aquatic organisms—and apply with a wick-type applicator to prevent herbicide drift.
- **Graze.** Sheep and goats will graze on perennial pepperweed if the leaves are still young and there is nothing else to eat.

Disposal

Keep roots away from waterways to minimize further infestations downstream. Wash equipment and the tires and undersides of vehicles after leaving the site. Bag and dispose of pulled plants as household garbage or take them to a green waste facility. Alternatively, dispose of the plants through hot compost with grinding (but not ordinary compost, as very small fragments will reroot).

Follow-Up

Regular follow-up is essential as the roots can lie dormant underground for several years. Return to the site in early spring and late summer to check for regrowth and to remove rosettes. Scrape litter from the soil surface to allow other species to grow. Soil remediation may be required before planting native species. Any revegetation should be carried out as soon as possible. Natives with creeping perennial roots may be best.

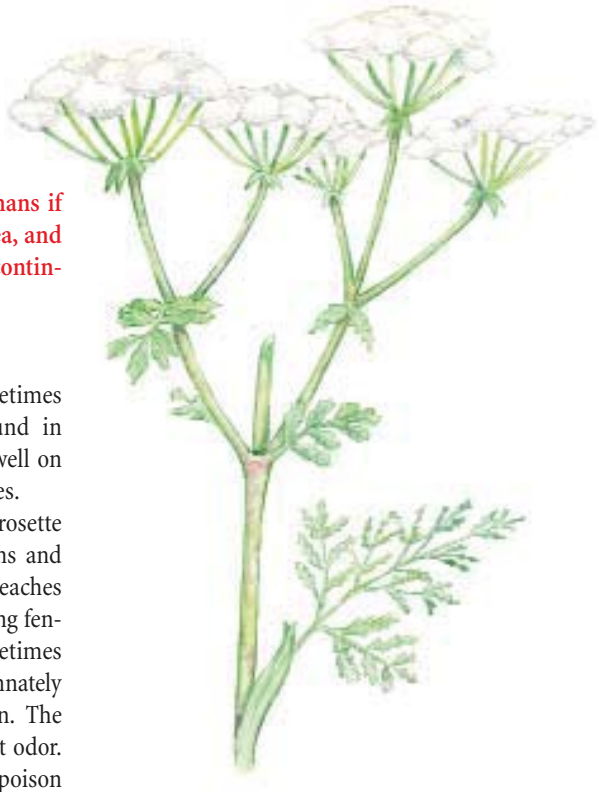
Interesting Facts

Perennial pepperweed is thought to originate in southwest Asia and to have spread to Europe many centuries ago. It came to California sometime in the 1930s, possibly as a contaminant of shipped seed. It seems likely that in ancient times the young leaves were served as a spicy salad green. In medieval Britain the seeds were "poor man's pepper" and the roots were a substitute for horseradish. Perennial pepperweed has been used to treat medical conditions such as skin disorders and painful joints, and may contain insecticidal properties. The flowers are still used in dried flower arranging.

POISON HEMLOCK

Conium maculatum

Carrot or Parsley Family (Apiaceae)



Warning! Poison hemlock can kill humans if eaten and may cause dermatitis, nausea, and headaches if touched or inhaled after continual cutting or mowing!

Description

Poison hemlock is an erect biennial, sometimes perennial, related to fennel, often found in scrub, riparian areas, and wetlands, as well on open slopes, disturbed sites, and roadsides.

Poison hemlock grows from seed to a rosette in the first year, then develops tall stems and flowers in the second year. It generally reaches 3–8 feet in height. The stalks—resembling fennel—are tall, ribbed, hollow, and sometimes purple-spotted. Leaves are opposite, pinnately compound, triangular, and bright green. The foliage, when crushed, has an unpleasant odor. Unlike wild carrot (Queen Anne's lace), poison hemlock has no hairs on its leaves and stems.

Reproduction

Poison hemlock reproduces by seed only, with each plant producing roughly 1,000 of them. Small, 5-petaled, white flowers appear in umbels mainly in June–July, although there are reports of poison hemlock flowering almost year-round in the East Bay. Fruits generally set in August–September. The seeds are spread most effectively by birds, animals, and water, but passing machinery and vehicles also aid seed spread. Dispersal occurs between September and February, and germination takes place from late summer to early spring.

Impact

A fast-growing species, poison hemlock can reduce native plant cover by shading other species. It is poisonous to wildlife and can cause paralysis and death in livestock.

Key Factors

- Poison hemlock is toxic to the skin and respiratory system, so wearing gloves and a mask is advised. One recommendation is to take frequent 5-minute breaks because of the potential for irritation. Some people feel ill even with protective gear!
- Usually a biennial, so no need to remove entire root system.
- Seeds are thought to be viable for up to 5 years.
- Grows best in rich soils in moist conditions.

Treatment Options

- Practitioners have reported difficulty in removing large stands of poison hemlock by hand and have tended to focus on small infestations. Some practitioners advise removing hemlock before seed set, while others remove poison hemlock year-round.

- **Pull** plants by hand, preferably during the rainy season when moist soils allow you to get more of the root. (You can use a soil knife or trowel to minimize direct handling of the plant.) Large clumps can be dug with a shovel.
- **Cut** using a hand pick to hit below the root crown and remove the upper portion (as opposed to the whole root).
- **Mow** to height of 3–4 inches in early April and then repeat a month later to follow up on any regrowth and new seedlings. Repeat for several years. Mowing won't eradicate poison hemlock, but it will help reduce the size of infestations by weakening the plant. It can deplete the seedbank if pursued regularly.

Follow-Up

Some practitioners have reported little success with mulching in areas where plants have been pulled, as large seedlings can bolt straight through. Others recommend laying a thick mulch (about 4 inches deep). Follow up on any regrowth, pulling seedlings by hand or with hand tools. Flaming with a propane torch during the rosette stage is another technique that deserves experimentation.

Disposal

Cut vegetation may be left on-site. However, cut and wilting hemlock plants can be palatable to wildlife and yet remain poisonous. Some attention to disposal or fencing may be necessary to protect deer and other animals.

Interesting Facts

Native to Europe, West Asia, and North Africa, poison hemlock was introduced from Britain as an ornamental in the late 1800s. It is a plant traditionally associated with European witchcraft. The Ancient Greeks used poison hemlock to execute political prisoners, including Socrates.

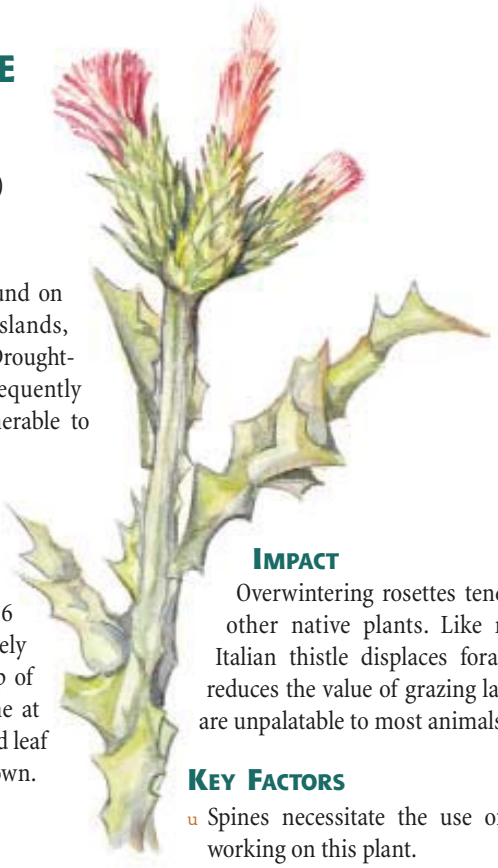
Notes

ITALIAN THISTLE

Also known as slender thistle

Carduus pycnocephalus

Sunflower Family (Asteraceae)



Description

Italian thistle is commonly found on disturbed sites, annual grasslands, pastures, and riparian areas. Drought-stressed, overgrazed, and frequently disturbed sites are more vulnerable to Italian thistle invasion.

Italian thistle is a winter annual or biennial broadleaf plant. It grows 1–6 feet tall and has erect, spiny-winged stems. The leaves are lanceolate, up to 6 inches long, and pinnately divided, with a spine at the tip of each lobe and the largest spine at the tip of the leaf. The stems and leaf undersides have a cobwebby down.

Reproduction

From September to December, pink to purple (but rarely white) flowers bloom in composite inflorescences borne terminally in clusters of 2–5. Italian thistle inflorescences measure only a half-inch across, smaller than those of bull or artichoke thistle.

Italian thistle reproduces only by seed. Inner (disk) seeds are cream-colored, sticky at first, striped, and have bristles. Outer (ray) seeds are yellowish to brown, smooth, and have no bristles. Most disk seeds are wind-dispersed and can travel several hundred feet. Disk seeds also have a thin gummy coating, which allows them to attach to animals and machinery. The germination rate is high, and germination typically takes place in the fall. Ray seeds generally remain in the flower head until it drops. These seeds persist in the soil for up to 10 years.

Impact

Overwintering rosettes tend to shade out other native plants. Like many thistles, Italian thistle displaces forage plants and reduces the value of grazing land. The spines are unpalatable to most animals.

Key Factors

- Spines necessitate the use of gloves when working on this plant.
- Very high seed production.
- Seed longevity up to 10 years.
- High germination rate.
- Resprouts from root portions left in the soil if not cut below root crown.

Treatment Options

- Unless you have a lot of volunteers to help, controlling Italian thistle by hand methods (pulling, digging, cutting) may be feasible only for small infestations. Digging is reported to be effective at killing Italian thistle, but will cause considerable soil disturbance, often resulting in seed germination or recolonization.
- **Pull** individual plants by hand once the flowering stems have bolted but before flowers are produced.

- **Dig** the plants out with a pick or shovel.
- **Cut** just below the crown with a small pick or trowel. This is a useful option in summer when the ground is too hard for pulling stems by hand.
- **Brush cut** or **weed whip** before the thistles begin to flower. Repeat the treatment into early summer to ensure energy reserves have been reduced.
- **Graze.** Sheep and goats will graze on thistles, especially in the early spring when they have reached 4–6 inches in height. Graze the animals for roughly 2–3 weeks in large numbers.
- **Foliar spray.** Some practitioners apply glyphosate to the plants before they go to seed, generally around mid-spring.

Disposal

Seed heads should be removed from the site and bagged or burned. The stems can be composted.

Follow-Up

Whichever treatment you choose, return to the site at least twice a year for a period of several years to monitor seedling growth and prevent further seed production.

Interesting Facts

Native to the Mediterranean, Italian thistle appeared in California in the 1930s, but it is not clear how it was introduced.

Notes

MUSTARD SPECIES

Black mustard ***(Brassica nigra)***
Field mustard ***(Brassica rapa)***
Mustard Family (Brassicaceae)

Description

Black mustard and field mustard are annual or biennial herbs that can reach up to 6 feet tall. The leaves are slightly hairy. The taproot is white and fleshy in maturity.

Reproduction

Mustards produce bright yellow, 4-petaled flowers from March to June. The small seeds are brown to black.

Impact

Mustards grow profusely and reportedly produce allelopathic chemicals that inhibit germination of native plants.

Treatment Options

See wild radish, below.
Note: Mowing is reported to be ineffective at eradicating mustard.

Interesting Facts

Both mustard species are thought to be native to Eurasia, where they have been in cultivation for thousands of years. Black mustard may have been introduced to the US as a contaminant of cereal grain. Field mustard is the wild ancestor of turnip, and its roots are often fed to livestock. Mustard greens are highly nutritious, and have been used in traditional medicine for cancer. The flowers are edible but may be allergenic to some people.



Brassica rapa

WILD RADISH SPECIES

Cultivated radish or wild radish ***(Raphanus sativus)***
Wild radish ***(Raphanus raphanistrum)***
Mustard Family (Brassicaceae)



Raphanus sativus

Description

These two radish species are herbaceous annuals (sometimes perennials) that frequently invade grasslands and open, disturbed areas, including roadsides. Wild radish, *Raphanus raphanistrum,* may also be found in wetland areas.

Although both species grow wild and both are commonly called wild radish, *Raphanus sativus* is the (escaped) cultivated plant, while *R. raphanistrum* is its wild relative. (*Sativus* means "cultivated" in Latin.)

Both species can grow to 3 feet or taller. The plants are erect, with branching stems that typically give mature plants a bushy appearance. The leaves are alternate, with lower leaves pinnately compound.

Reproduction

Raphanus sativus has 4-petaled flowers that range from white to pink, and bloom mostly between April and June, or almost year-round in the East Bay. *R. raphanistrum* has 4-petaled pale yellow and white flowers with dark veins, and blooms later in the year. The flowers are pollinated by bees and butterflies. Seed pods (siliques) are dark green or occasionally dark red, ribbed, and either smooth or downy. *R. sativus* may have only up to 5 seeds per pod, but *R. raphanistrum* pods contain up to 10 seeds. The seeds are dark, oval, and hard.

Wild radishes reproduce only by seed. Seeds can remain viable for at least 5 years and reportedly up to 20 years. Seeds are generally wind-dispersed, but are also spread by water and machinery. Germination takes place in spring and fall.

Impact

Wild radishes are capable of excluding native plant species. Both radish species are also agricultural weeds. *R. raphanistrum* seeds in large quantities may be poisonous to livestock.

Key Factors

- High seed production.
- Long seed dormancy.

Treatment Options

- **Pull** individual plants by hand or with a Weed Wrench before seed pods develop. Given the stout taproot, it's best to do this after a heavy rain. The taproots in mature plants make hand removal more difficult.
- **Cut** plants below the root crown with a pick or shovel before seed pods develop.

- **Mow** or **brush cut** wild radish if it covers a large area. It's important to do the first mowing before any seed pods develop. Mow as close to the ground as feasible, as the plants often resprout.
- **Foliar spray.** Some weed workers spray a 1 percent solution of glyphosate on the leaves before the plant flowers. However, wild radishes are reportedly developing resistance to several herbicides. Glyphosate application might best be reserved for follow-up spot treatment.

Disposal

Plants with seed should be bagged and removed from the site whenever feasible or composted on-site in a small area that will be maintained (for example, by follow-up weeding). Plants without seed can be left to decompose on-site.

Follow-Up

Given the high seed production and long seed viability of wild radishes, it is important to return to the site several times a year to check for seedling germination.

Interesting Facts

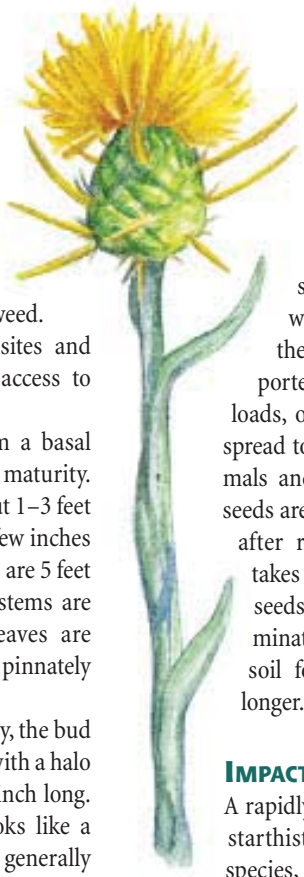
Radishes are native to the Mediterranean.

Notes

YELLOW STARTHISTLE

Centaurea solstitialis

Sunflower Family (Asteraceae)



Description

This winter annual (or sometimes biennial) is considered to be California's worst rangeland weed. It is also found on disturbed sites and annual grasslands, and affects access to recreation areas.

Yellow starthistle plants form a basal rosette as juveniles, then bolt in maturity. Flowering plants are usually about 1–3 feet tall, though some may be only a few inches and single-stemmed while others are 5 feet tall and branching. Leaves and stems are downy and gray-green. The leaves are alternate, 2–3 inches long, and pinnately lobed with triangular tips.

The flowers develop terminally, the bud appearing like a small scaly ball with a halo of stiff yellowish spines up to 1 inch long. The composite inflorescence looks like a fuzzy ball of tiny petals. Flowers generally bloom from May to September, but in the Bay Area a few plants bloom at any time of year.

Reproduction

Yellow starthistle reproduces solely by seed. The plants produce two kinds of seeds: plumed and plumeless, both measuring roughly a quarter-inch. Most seeds are plumed with a tuft of soft, white bristles that aid in wind dispersal. These seeds are pale (cream to tan) and develop on the inner (disk) part of the flower. The plumeless, outer (ray) seeds are darker brown. They remain attached to the flower head until it drops on the ground.

Large plants can produce as many as 1,000 composite flower heads which together can produce almost 75,000 seeds in a single season. Most seeds are wind-dispersed, but they spread the greatest distance by being transported in contaminated hay or seed loads, or attached to vehicles. They are spread to a lesser degree attached to animals and humans. About 90 percent of seeds are ready to germinate immediately after release. Germination frequently takes place after the first fall rains, as seeds need moisture and light to germinate. Seeds can remain viable in the soil for 3 years and possibly much longer.

Impact

A rapidly growing taproot enables yellow starthistle to outcompete native plant species, including purple needlegrass, for summer soil moisture. Yellow starthistle may also produce allelopathic compounds that give it another competitive edge. The current level of infestation in California (estimated at 22 million acres) has brought agricultural and economic loss by reducing the quality and yield of forage. It can be fatally poisonous to horses and its spines deter other livestock from grazing.

Key Factors

- High seed production.
- Seed longevity is at least 3 years.
- Fast-growing and deep taproot.
- Seedlings are somewhat shade-intolerant.

Treatment Options

- **Pull** or **dig** individual plants by hand in May–June, when plants are bolting or as soon as possible afterwards. (Rosettes often break off from roots, which resprout.) Grasp the plant at the base and pull steadily, straight up. Where several plants grow close together, digging or pulling smaller ones often makes it easy to pull others. Cutting lateral roots and loosening the soil around the base also make it easier to pull. If you cannot pull up the plant, cut it or twist if off at the base.

  Hand pulling is often difficult if plants have stems more than a quarter-inch in diameter. Use a narrow spade, soil knife, or other tool to help free or cut the root. Given that this weed is an annual, most of the taproot can be left in the soil, especially if you manage to get a quarter- to a half-inch of the root below the root crown.

  Continue to recheck and pull emerging plants through August, preferably even later. Hand-pulling can be done in conjunction with mowing: mowing can keep plants from setting seed until you have time to pull.

  Heavy leather gloves are a must! Working with yellow starthistle, the chemicals eventually soak into skin and can be tasted. Although the toxins are not known to harm humans, wash hands after working with this plant.

- **Mow** (or cut with a hand scythe, brushcutter, or any cutting tool) after the plants have bolted and a small fraction of the buds (about 2 percent) have started to bloom. Make sure you mow close enough to the ground to get the lowest buds. Aim to leave 1–2 inches above ground. You may need to mow a second or even a third time at 4–6 week intervals.

  Mowing too early can encourage greater seed production, so it's crucial to time the removal carefully. If there are no buds, it's too early, but if the flowers have mostly bloomed and are losing their bright yellow color, it's too late. Occasionally starthistles bolt sideways with flower heads much closer to the ground, or mowed plants may rebloom very low. You can take the tops off these with a shovel, hoe, or mattock, if in small numbers. Cutting is most effective on dry soil, otherwise a repeat treatment is necessary roughly 4 weeks later.

- **Graze** with cattle, goats, and sheep to help contain plants and reduce seed production. Cattle don't eat mature spiny plants, but goats and sheep are less picky! Best results come from intensive grazing by a large number of animals for a short period of time, preferably from the end of May to June, just after plants have bolted. Research suggests grazing at the rosette stage is counterproductive, leading to an increase in yellow starthistle. This weed is toxic to horses.

- **Foliar spray.** A 1 percent dilution of glyphosate can be sprayed on plants at the bolting stage. You might use this for spot application.

Disposal

Some practitioners advise leaving the clippings from each mowing on-site (as long as they do not contain seeds) to protect the soil from reinfestation by other invasive species, and also to discourage yellow starthistle seedlings by providing extra shade. Plants with only buds and young, pale yellow flowers can be left on the ground. Once flowers turn darker yellow, pulled plants should be bagged, as they may produce viable seed. Dispose of the bags off-site where seeds can't disperse elsewhere. East Bay Regional Park District uses clear plastic bags and leaves the plants in them for a few years.

Follow-Up

A removal program should last at least 3 years and probably longer, though at lower intensity. Watch for new infestations in nearby areas. Mulching may be helpful in shading out seedlings. Some experiments show that a 5-inch

layer of wheat straw (or rice straw) stops all regrowth. This level of coverage might be expensive, however, and therefore only an option for small patches.

Interesting Facts

Native to the Mediterranean, yellow starthistle was introduced to the US in the mid-1800s, probably as part of a shipment of contaminated grain or other crop seed. Beekeepers find it to be a valuable source of nectar for honeybees, which account for a large proportion of the thistle's pollination.

Notes

EHRHARTA

Also known as panic veldt grass

Ehrharta erecta

Grass Family (Poaceae)



Description

Ehrharta is a slender, clumping perennial grass found in both disturbed sites and wildlands, particularly in moist, shady areas. It tolerates a variety of soil types.

Ehrharta has semi-erect stems up to 2 feet tall. The leaf blades are broad, green, flat, and 2–5 inches long. The fibrous root system has filaments that sprawl downwards. Fire and drought may spur additional growth. The plant can die back during the dry season, leading to an accumulation of leaf litter.

Reproduction

Ehrharta reproduces by tiny seeds that are easily dispersed by wind, water, human activity (e.g., gardening equipment or clothing), and possibly birds. Seeds germinate with the start of the winter rains and into late spring. Ehrharta can also spread vegetatively by tillers.

Impact

Ehrharta competes with native grass species, such as Torrey's melic, which has a similar appearance. It can form a continuous carpet of vegetation in moist soil, preventing establishment of other species, particularly annual wildflowers and grasses.

Key Factors

- The same plant can reseed repeatedly throughout the growing season.
- High seed production.
- Seedbank thought to persist for several years.
- Resprouts from stem nodes and tips.

Treatment Options

- **Pull** individual plants and clumps by hand 4–6 times a year, starting at the onset of the rainy season when seedlings first emerge, and continuing until the start of the dry season. (Before pulling, you can flag outlying individuals that could be easily overlooked. Some practitioners have found that as Ehrharta is difficult to see under larger plants, one option is to trim shrubs to expose those grasses growing near the base.) Grasp firmly, making sure you pull below the nodes. If part of the root crown breaks off, dig out the remaining portion.

  If hand removal is your main approach, make sure you get the entire root and all the stems. Hand pulling is feasible in light or patchy infestations, where native species remain. It can be a successful technique if carried out persistently over several years, but may work best in conjunction with other treatments.

- **Cover** dense patches with weed fabric (preferably a permeable barrier to reduce water runoff on slopes) to suppress germination of seedlings.
- **Foliar spray.** Herbicide may be the best option for dense stands of Ehrharta. Given the plant's tendency to grow under other species, make sure you choose a selective herbicide so you don't kill the overlying vegetation.

  Several experimental treatments for mature Ehrharta are underway at Audubon Canyon Ranch in Marin County. These include hand pulling clumps of grasses before the grass starts to flower; covering the infestation with a black polyethylene tarp to solarize the weeds; or applying 1–2 percent glyphosate during senescence (after seeds have set and when the grass is dying back). Initial results suggest glyphosate is effective on mature grasses without prior cutting, although an even weaker concentration may be equally successful. Experimental methods to kill seeds and seedlings include mulching; flaming with a torch; or the use of pre-emergent herbicide. Results are not yet conclusive.

Disposal

Ehrharta seeds germinate readily on contact with water or moist soil, so any seed heads should be bagged immediately and removed from the site.

Follow-Up

Success lies in persistent follow-up, whichever treatment you choose. New seedlings grow very densely and can be tilled with an oscillating hoe. Scrape seedlings off the soil surface and leave them to dry out. If you are covering the Ehrharta, you can cut holes in the tarp and plant native species.

Interesting Facts

Ehrharta is native to South Africa. It became established in California during the 1930s.

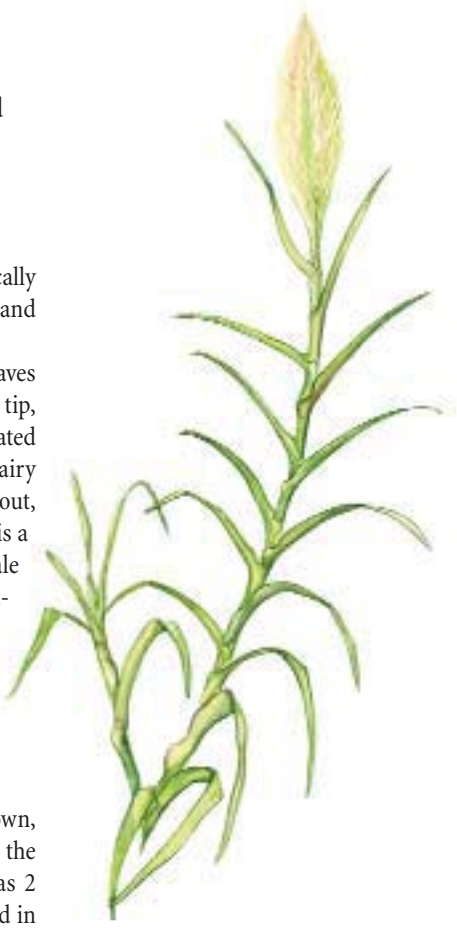
Notes

GIANT REED

Also known as arundo grass, bamboo reed

Arundo donax

Grass Family (Poaceae)



Description

Giant reed is a tall perennial grass that typically forms dense stands on disturbed sites, sand dunes, riparian areas, and wetlands.

Giant reed grows up to 30 feet tall. The leaves are alternate, up to 1 foot long with a tapered tip, slender, and smooth, but with coarsely serrated margins. They are gray-green and have a hairy tuft at the base. The leaves point straight out, droop, or lie folded, and at the base of each is a hairy tuft. As the leaves dry, they turn pale brown like papyrus. The hardy stalks are hollow, about 1 inch in diameter, and resemble bamboo canes. The roots are tough and fibrous and form knotty, spreading mats that penetrate deep into the soil.

Reproduction

The inflorescence is cream to yellowish brown, and appears from March to September in the form of upright, feathery plumes as long as 2 feet. Giant reed does not produce fertile seed in California. Instead, it reproduces vegetatively, by underground rhizomes. Riparian flooding dislodges clumps of giant reed and transports it downstream, where it can root from broken stem nodes and rhizomes. Fire appears to stimulate new growth.

Impact

Giant reed is threatening California's riparian ecosystems by outcompeting native species, such as willows, for water. Its rapid growth and high water uptake allow it to outcompete native vegetation and form monocultural stands. Noxious alkaloids contained in the plant deter wildlife from feeding. Stands of dry leaves and canes are flammable.

Key Factors

- Resprouts from roots and 2-noded stem fragments left in moist soil.
- Roots can reach as deep as 10 feet.
- Rapid growth.

Treatment Options

- Giant reed can be successfully removed only by completely killing the root system, either by thorough physical removal or with herbicide. Pulling and cutting can both be effective techniques if *all* of the rhizomes and aboveground vegetation are removed. Herbicides are often applied as a follow-up to pulling or digging, but the more thoroughly the rhi-

zomes are removed, the less follow-up herbicide will be needed.

- **Pull** or **dig** plants, from seedlings to 6 feet tall, ideally after heavy rains loosen the soil. It is important to pull up and remove the roots.
- **Cut** the stems of larger plants with a chainsaw or brushcutter, and dig up the roots with a shovel, pickax, or Swedish brush ax. Alternatively, use heavy equipment, such as an excavator.
- **Cut** the stems as close to the ground as possible in May, and cover the clump with a very thick tarp or with several tarps for an entire growing season. This should prevent light from reaching the plant (reducing its ability to photosynthesize), and keep resprouts from tearing the tarp. The lack of light will eventually deplete the plant's energy reserves and it will die back.
- **Foliar spray.** Some practitioners have sprayed a 2–5 percent dilution of glyphosate onto the leaves after the plant has flowered but before summer dormancy.
- **Cut and treat.** As an alternative to foliar spraying, a stronger concentration of glyphosate can be applied to stems immediately after cutting. Make sure that where necessary, you choose an herbicide product suitable for use near water.

Disposal

Both treated and non-treated stems can be left on-site to decompose, although they break down very slowly. If left to compost, the essential point to remember is to keep the debris well away from water. For stems that have not been chemically treated and in areas where it is feasible, the debris can be burned. Otherwise, the canes can be chipped into very small pieces for mulching. The stems are easier to chip when dry, and you will need a heavy-duty chipper to handle the plant's tough fibers. Chipped material can be disposed of either in green waste containers, or spread out to dry and possibly sprayed with herbicide if any regrowth occurs from chipped debris. Stem pieces that have no nodes or only one node won't reproduce.

Interesting Facts

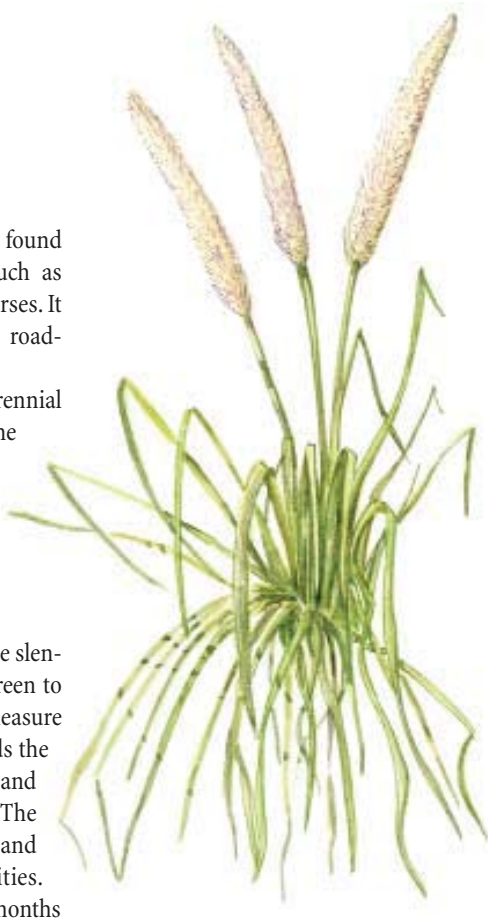
Thought to originate from the Indian subcontinent, giant reed was introduced to California from the Mediterranean in the 1820s for roofing material and erosion control along drainage ditches. It has been cultivated on other continents for thousands of years. Ancient Egyptians wrapped their dead in the leaves. The canes contain silica, perhaps the reason for their durability, and have been used to make fishing rods, walking sticks, and paper. Giant reed is still used to make reeds for woodwind instruments. It continues to be planted for ornamental purposes and erosion control.

Notes

HARDING GRASS

Phalaris aquatica

Grass Family (Poaceae)



Description

Large clumps of Harding grass can be found growing in coastal areas, open sites such as grasslands and rangelands, and watercourses. It also moves into disturbed sites such as roadsides and trails.

Harding grass is an erect, tufted perennial with short rhizomes around the base. The gray-green, hairless leaf blades grow to 15 inches long, and the stems are hollow. Its deep roots allow it to tap into water reserves and withstand drought.

Reproduction

Flowering stems grow up to 4 feet tall. The slender, compact inflorescences turn from green to creamy white in May and June. They measure 2–5 inches long and taper slightly towards the tip. Seed production tends to be high, and occurs between May and September. The seeds are carried short distances by wind and animals and farther by human activities. Seeds can remain dormant for 1–4 months before germinating. Harding grass also spreads vegetatively by sending out tillers or shoots.

Impact

Growth is slow at first, but once established, Harding grass can form dense patches and deprive native species of water and nutrients. During summer drought, the dormant grass increases the risk of fire. Prolonged grazing on Harding grass can cause the potentially fatal staggers disease in sheep.

Key Factors

- Seed longevity is thought to be 1–3 years.
- Removal is easier before large stands are established (the seedlings are less aggressive and do not compete well with other species).
- Resprouts from roots left in the soil.

Treatment Options

- **Cut** around the base of the clump with a Pulaski and dig out the roots. All roots longer than 2 inches must be removed, or the plant could reestablish. Then **mulch** with a thick layer (about 6 inches) of rice straw to discourage resprouts.
- **Mow** close to the ground late in the growing season (generally late spring). Alternatively, mow repeatedly (at least 3 times), ensuring that plants do not flower. Cutting when the grass is at the flowering stage suppresses shoot formation.

Research points to greater success with repeated mowing, although there's no clear consensus on when during the active growth period this should take place. Multiple mowings weaken the grass and reduce the seedbank, but other methods are needed to prevent new growth; mowing alone will prevent expansion but will not kill Harding grass. However, some land managers believe mowing can actually spread seed; instead, they are disking and reseeding with natives.

- **Brush cut** small patches and **cover** with landscape fabric. Check the fabric monthly to ensure that it is still tightly secured. Alternatively, after brushcutting, **mulch** with a 6-inch layer of rice straw, and pull any emerging plants the following year.
- **Mow and treat.** After mowing the grass close to the ground, some practitioners have experimented with applying 1–2 percent glyphosate using a wick-type applicator after plants have begun to grow back.

Disposal

Bag and dispose of the debris, especially any seed heads, or pile for composting.

Follow-Up

After mowing and covering with landscape fabric, some practitioners have planted native shrubs and trees into the fabric to shade out any Harding grass resprouts that come through.

Interesting Facts

Harding grass is native to Mediterranean Europe. It may have been introduced to the US from Australia for grazing. Its high protein content makes it a valued source of forage for livestock. However, it contains quantities of DMT, a hallucinogen federally classified as a controlled substance. This may explain the sometimes fatal illness it causes in sheep. It has also been used for post-fire revegetation.

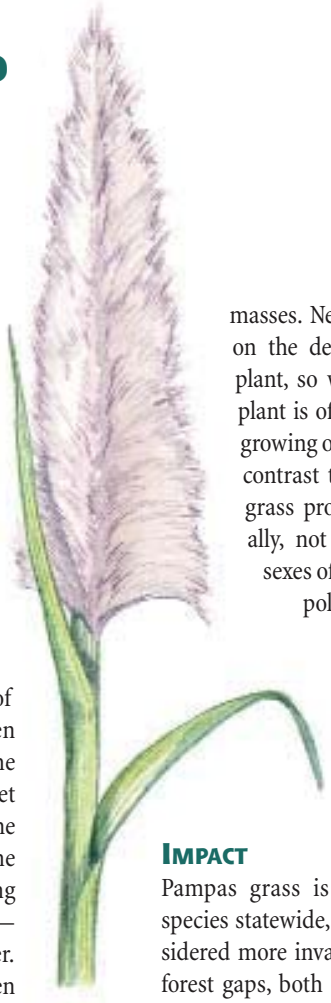
Notes

PAMPAS GRASS AND JUBATA GRASS

Cortaderia selloana

Grass Family (Poaceae)

Cortaderia jubata



Description

Pampas grass is a common name used for both *Cortaderia* species. For clarity in this discussion, *Cortaderia jubata* will be called jubata grass, while pampas grass will refer only to *C. selloana.* Both species are rapid-growing perennials that form large clumps. Jubata grass is found only in coastal areas, but pampas grass also infests more inland locales. Both are found in disturbed areas, slopes and cliffs, coastal scrub, and forest clearings.

Jubata grass leaves reach a height of 5–7 feet at maturity. The dark green leaves have sharply serrated margins. The flowering stalks can tower up to 20 feet above the mass of spreading leaves at the base. The inflorescence—a showy plume ranging from pink to violet, turning creamy white or golden in maturity—typically appears from July to September.

Pampas grass leaves are gray-green and narrower than those of jubata grass. The leaves tend to curl at the tips. The flower stalks grow only a little taller than the mound of leaf blades, giving pampas grass are more rounded appearance than jubata grass. The plumes are paler (generally pale pink to silvery white) than those of jubata grass.

Reproduction

Female jubata grass plants produce seed asexually by apomixis. Thousands of seeds that are genetically identical to the parent plant are then wind-dispersed. Plants live for over a decade, and within their lifetime will develop huge root masses. New seedlings often grow on the dead mass of the parent plant, so what appears to be one plant is often several generations, growing one on top of the other. In contrast to jubata grass, pampas grass produces seeds only sexually, not apomictically, so both sexes of plants are necessary for pollination and seed production. Both grasses can spread vegetatively from tillers or fragments of a mature plant that root in moist soil.

Impact

Pampas grass is the more widespread species statewide, but jubata grass is considered more invasive in coastal areas. In forest gaps, both species can prevent the growth of saplings by limiting available water and nutrients. Both readily establish in disturbed areas including landslides, road cuts, and cliff faces. Seeds are wind-dispersed and populations expand quickly in coastal areas, significantly reducing grassland, scrub, and rocky outcrop habitats. The sharp, sawtooth-edged leaves can cut human skin. Both grasses increase the risk of fire when leaves dry out or die back.

Key Factors

- Serrated leaves require the use of gloves and protective clothing.

- Resprouts from roots left in contact with soil.
- Thrives in moist areas: keep pulled vegetation away from water.
- High seed production.
- Seeds remain viable approximately 9–12 months.

Treatment Options

- **Pull** seedlings by hand or with the help of a pick, Pulaski, or shovel.
- **Cut** larger plants and remove the root mass. First, carefully cut and dispose of all seed plumes, including immature ones that have yet to emerge from their sheath, because they may be able to mature.

  Next, cut stems and leaf blades to near ground level with a Pulaski, Swedish brush ax or chainsaw. Some practitioners prefer to use a chainsaw to remove the mass of leaves, while others caution that this is dangerous (the chainsaw user must kneel and cannot see the blade) as well as slow (the grass quickly clogs the chainsaw guard). An expertly sharpened machete is also effective, but like a chainsaw, is an appropriate tool only for experienced professionals.

  Finally, remove the root mass. If it is very large, use the ax side of the Pulaski to chop it into 4- or 5-inch squares, then use the flat side of the Pulaski to hoe out the pieces.
- **Pull** very large plants with a truck hitch. This is possible if the pampas or jubata grass is near a road and a strong truck is available. Place a choker cable around the plant, digging it into the ground a little behind the plant so it won't slip off. Secure the cable to the truck hitch, and pull the plant out easily. This is very impressive to volunteers!
- **Cut** the plumes of plants you are unable to remove, as a temporary containment measure. Cut the plumes while they are still pink or purple (prior to producing seeds)—typically August to October near the coast, earlier inland and in hotter areas. Note, however, that cut plumes can produce another seed plume from the same stalk in as little as 1–2 weeks.
- **Foliar spray** 2 percent glyphosate on all green growth during the active growth period (November–July, or even August–September along the Central Coast). Spraying minimizes soil disturbance, but the herbicide must contact the entire leaf surface, a difficult task for large plants. An additional caution: plants that appear dead soon after spraying may survive and regrow the following year.
- **Cut and treat.** As an alternative to foliar spraying, you could cut away the stems and leaves and then apply herbicide to the cut stems near the root mass. Practitioners report mixed results with this technique.

Disposal

To prevent resprouting, turn the whole uprooted mass upside down and leave it in place to dry out. Small, stringy roots left in the soil will not regrow, but all parts of the main root mass must be at least several inches away from the ground.

Place the cut plumes on top of cut grass leaves. To prevent any seeds from being blown away, make a "pampas sandwich" by covering the seed heads with a second layer of foliage. Some practitioners bury the seed plumes under something more substantial than the leaves, as they can dry out and blow away—with the seeds! Finding a way to leave the plumes behind means you won't have to haul heavy bags off-site, especially in steep, remote areas. Given that jubata grass seeds don't need to be pollinated, it's important to cover or remove them as soon as possible.

Follow-Up

Check for resprouts twice a year.

Interesting Facts

Pampas grass and jubata grass are native to South America. No one knows quite when and how jubata grass was introduced to California, but pampas grass was introduced to the state in the mid-1800s. Both grasses were widely planted as ornamentals and have been used to prevent erosion on slopes. *Cortaderia* comes from the Spanish for "cutter" and refers to the plant's sharp leaf margins.

Notes

PERENNIAL RYEGRASS

Lolium perenne

Grass Family (Poaceae)



Description

Perennial ryegrass is similar in appearance to annual ryegrass, *Lolium multiflorum*. To distinguish the two grasses: perennial ryegrass lacks awns (short bristles) on its florets; annual ryegrass has awns on its florets. Perennial ryegrass leaves are folded in the bud, but annual ryegrass leaves are rolled in the bud. Perennial ryegrass has more spikelets than annual ryegrass.

Impact

Perennial ryegrass contains alkaloids that appear to become more toxic when under drought stress. In Australia, prolonged grazing of perennial ryegrass can be fatal to sheep and cattle, and cause a form of staggers disease that is different from that caused by other invasive grasses.

Treatment Options

See Harding grass. Brushcutting and covering is especially appropriate for perennial ryegrass as it is a softer grass and thus less likely to push off the landscape fabric.

Notes

PURPLE VELVET GRASS

Also known as London fog, Yorkshire fog

Holcus lanatus

Grass Family (Poaceae)



Description

Purple velvet grass is a distinctive perennial grass that forms clumps in disturbed areas and, in particular, in moist or mild coastal areas.

The soft, flat, gray-green leaves with velvety hairs grow up to 2 feet tall. The roots are fibrous.

Reproduction

Seed production begins in the plant's second year of growth and tends to be prolific. Dense, purple-tinged inflorescences, reaching up to 3 feet, bloom from May to August. The spikes fade to white once the seeds have ripened, and the grass may go dormant after flowering. The wind-dispersed seeds germinate quickly and seedlings grow rapidly. Purple velvet grass also reproduces vegetatively by producing tillers in late summer.

Impact

Purple velvet grass appears to contain allelopathic compounds that inhibit native plant species. It also has cyanide compounds and may produce an allergic reaction in susceptible people. It dominates an area by forming dense roots that reduce the space available for other species to take up nutrients and water. It also produces significant amounts of thatch.

Key Factors

- Prolific seed production with most seeds germinating rapidly.
- Seeds are not thought to be long-lived.
- Rapid growth.
- Cutting stimulates tillers.

Treatment Options

Except for small, isolated populations, it may be extremely difficult to remove purple velvet grass. Many practitioners have found prescribed burning, brushcutting, and grazing to be ineffective against purple velvet grass.

- **Pull** clumps by hand before seed set, or **cut** them out from around the base with a paring knife. Near Tomales Bay, Audubon Canyon Ranch has had success using these techniques between January and April, prior to when the plant sets seed. The roots are 1½–2 inches on young plants, but can become deep and wide in maturity. Removing seedlings is preferred, because larger roots are more likely to break, especially when soil is dry.
- **Scrape** larger infestations, or chop below the root crown, using the blade end of a McLeod.

Weed whipping the grass first may make scraping easier. Scraping is a control method to discourage seed production, so do it before the grass blooms. Regrowth and new inflorescences will grow close to the ground, so cut the grass as short as you can (1–2 inches off the ground) and be sure to follow up with repeat treatments.

- **Mow** starting in late March before seed set and then repeat monthly until July. Friends of San Bruno Mountain use a high-wheel mower and a string trimmer to crop grasses close to the ground.
- **Cut** small patches of grass back in early spring before bolting and **mulch** with 4–6 inches of rice straw, removing resprouts as they emerge.

Disposal

Bag any hand-pulled grasses and dispose offsite.

Follow-Up

Without constant vigilance, treated areas often become reinfested, so check frequently for seedling growth. Reseed or plant with native perennials: fast-growing bunchgrasses or forbs.

Interesting Facts

This ornamental grass is though to be native to southwest Europe. It was probably introduced to the States either accidentally as a forage contaminant or deliberately as part of a seed mix for meadows. The flowers are used in both dried and fresh flower arrangements. *Lanatus* is Latin for "woolly" and refers to the texture of the leaves.

Notes

ANNUAL RYEGRASS

Also known as Italian ryegrass

Lolium multiflorum

Grass Family (Poaceae)



Description

Fast-growing but short-lived, annual ryegrass is a cool-season grass found particularly in wetlands, grasslands, and disturbed sites.

Annual ryegrass is an erect grass that grows to 3 feet tall. The flat leaf blades are bright green and glossy, taper gradually to a sharp point, and feel slightly rough at the edges. They measure up to 8 inches long and a quarter-inch wide, and display prominent ridges along the upper surface. Stems often have a reddish tint at the base. A collar is formed where the leaf blade joins the stem. Two sets of roots develop: the first set, deriving from the seed, are short-lived; the second set, which grows closer to the soil surface, comes from tillers. The roots are usually shallow and fibrous, but can grow deep in drier soils. The grass dies back by midsummer, turning dry and yellow.

Reproduction

The inflorescence appears at the top of the stem as a single spike up to 16 inches long made up of alternate, pale yellow spikelets. The seeds are small and have a high rate of germination. Seeds germinate within 10 days—usually with the onset of the rainy season. Seed dormancy develops only in cooler, moist areas. Annual ryegrass also spreads by seed and vegetative shoots or tillers.

Impact

Annual ryegrass reportedly contains allelopathic compounds that inhibit the germination of some species of neighboring plants, while its rapid growth deprives them of water. At the Edgewood Natural Preserve, a serpentine grassland in San Mateo county, annual ryegrass has displaced much of the native dwarf plantain (*Plantago erecta*), the main food source for the native bay checkerspot butterfly. During summer dormancy it accumulates thatch that presents an added fire hazard. It is also a weed in cereal crops, particularly wheat.

Key Factors

- Root system can reach 3 feet or deeper on dry sites.
- Seeds germinate quickly, so there is usually no seedbank build-up.
- Tillers profusely.
- Seedlings are shade-intolerant.
- May be developing resistance to certain herbicides, including glyphosate.

Treatment Options

- **Mow** to about 6 inches using a weed-whacker prior to bolting in the spring. This prevents reinfestation of annual ryegrass by depleting the seedbank, and promotes the survival of native perennial grasses and other species. Timing of mowing varies. At the Tina Baumgartner restoration site in Tilden Park, Berkeley, Shelterbelt mows *repeatedly* (2–3 times) at monthly intervals to remove biomass and developing seeds just as they are beginning to ripen. At the Edgewood Preserve in San Mateo, a *single* mowing is performed in early May before the annual ryegrass seeds ripen but after the annual forbs set seed. Both sites have had considerable success with mowing annual ryegrass (unlike other invasive grasses), with reduction rates at 50–80 percent.
- **Graze** goats on the seed heads. Cattle will also graze on annual ryegrass.

Disposal

Cut grasses can be left on-site to decompose, as long as they have been mowed before they go to seed. Some practitioners rake mowed grasses from an area if they contain viable seed.

Follow-Up

Projects need to be maintained over several years. Research suggests that planting coastal scrub species and native trees may help to control annual ryegrass in chaparral and oak woodland habitat, as the seedlings do not grow well in shade.

Interesting Facts

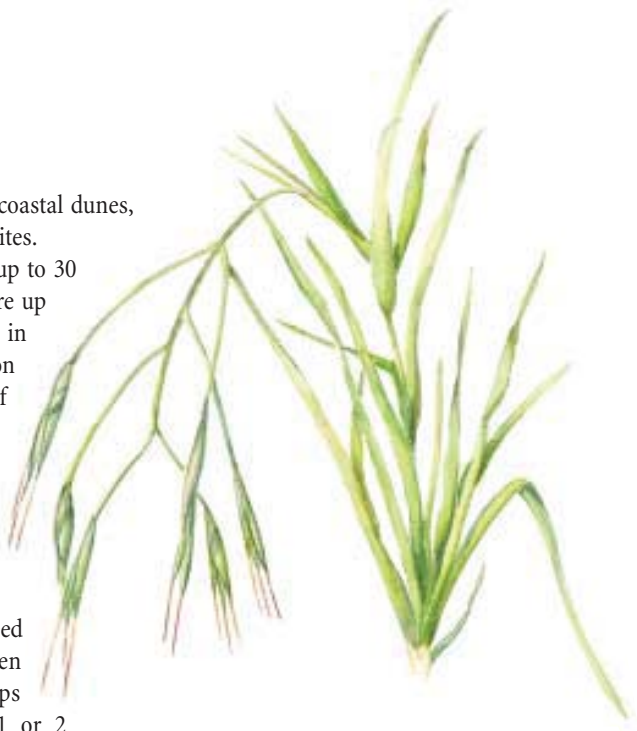
Native to southern Europe, annual ryegrass was introduced to the States for its ability to provide high-quality forage. It is still sown to prolong the grazing season and reduce soil erosion. Research in the South Bay suggests nitrogen deposition from freeway pollution enables annual ryegrass to invade otherwise resistant, naturally nutrient-poor, serpentine soils.

Notes

RIPGUT BROME

Bromus diandrus

Grass Family (Poaceae)



Description

Ripgut brome frequently infests coastal dunes, grasslands, and open, disturbed sites.

The slender stems can grow up to 30 inches tall. The flat leaf blades are up to a quarter-inch wide, covered in fine hairs, and slightly jagged on the margins. The swollen nodes of the stems distinguish ripgut brome from the native purple needlegrass. Ripgut brome has fibrous roots.

Reproduction

Ripgut brome reproduces by seed only. The branched and often drooping inflorescence develops March–June, and consists of 1 or 2 spikelets with stiff, reddish or purple-tipped awns up to 2 inches long. Seed production is high, with a single plant capable of producing up to a thousand seeds. Seeds are usually wind-dispersed and can travel long distances, but they can also become attached to clothing. Germination occurs between November and April. Seeds can persist for up to 5 years.

Impact

Dense stands of dead plant material make this grass very prone to fire during summer drought. In addition, the long, stiff awns are known to cause injury to wildlife. Like many invasive annual grasses, ripgut brome prevents native perennial species from becoming reestablished. For example, research indicates that it outcompetes native oak seedlings for water stored in the soil by means of early germination, sheer volume of numbers, and deep roots.

Key Factors

- High seed production.
- Seed longevity up to 5 years.

Treatment Options

- **Pull** individual plants or small patches by hand in early spring before seeds are ripe. The optimum time for this is when seeds are hanging but while they still contain a milky substance.
- **Mow** or **weed whip** larger infestations. Cut the grass to about 2 inches, making sure you take off the bolting crown. Mowing is usually done from late March to early April before seeds mature.

Follow-Up

Practitioners report considerable success using manual and mechanical methods to eradicate ripgut brome, but sites previously infested by this grass are vulnerable to invasion by species

such as annual fescue (*Vulpia bromoides*), a very dominant grass that goes to seed quickly. Therefore follow-up not only includes removing any overlooked seedlings but also checking for new invasive species.

Disposal

Pulled or cut vegetation can be piled on-site as long as the seeds are still immature and produce a milky substance. Alternatively, the grass can be composted.

Interesting Facts

Ripgut brome is native to parts of Europe, including the Mediterranean, and is thought to have become widely established in California as early as the late 1800s. Cattle will eat the grass early in the season when leaves are still tender.

Notes

ACACIA SPECIES

Blackwood acacia ***(Acacia melanoxylon)***
Green wattle acacia ***(Acacia decurrens)***
Legume or Pea Family (Fabaceae)



Acacia melanoxylon

Description

Blackwood acacia and green wattle acacia are both typically found in disturbed areas and roadsides. Both grow well in moist soils but can tolerate drought.

Blackwood acacia is an evergreen tree that reaches 20–40 feet in height. It has a single trunk with rough, gray bark, and forms a dense pyramidal canopy. Juvenile leaves are finely bipinnately compound, but adult leaves are simple. They are alternate, narrow, straight to sickle-shaped, smooth, and leathery. The leaves measure up to 4 inches long and become a dull, dark green.

Green wattle acacia is a fast-growing small tree or tall shrub that forms dense thickets up to 45 feet tall. The leaves are bipinnately compound, flattened, and dark green.

Impact

Blackwood acacia reportedly has an allelopathic effect, altering soil chemistry and inhibiting germination of native plants. Like many leguminous plants, acacias are nitrogen-fixers, enabling them to establish in nutrient-poor soils. Acacias form dense, monotypic thickets and produce a thick accumulation of leaf litter.

Reproduction

Blackwood acacia reproduces from seed as well as by root suckers and stump sprouting. The roots spread vigorously. Seed production generally begins between 2 and 4 years of age. Clusters of fragrant, pale yellow flowers resembling small pompons appear in January to February. Brown, twisted seed pods, up to 4 inches long, develop in late summer and drop in the fall. Each pod holds 6–10 seeds attached to the pod by pink or red funicles. The seeds themselves are oval, black, and shiny, about a quarter-inch long, and can remain viable for years in the ground. An individual plant can produce 100,000 seeds per year. Seed germination appears to be particularly high following fire.

Key Factors

- High seed production.
- Seeds reported viable for 15–20 years.
- Can sprout from roots and from cut stumps.

Treatment Options

- **Pull** seedlings and small saplings by hand or with a Weed Wrench, preferably when the soil is moist.
- **Cut and treat** with herbicide larger saplings and mature trees.

- **Cut** to 1 foot **and cover** stump with black plastic or fabric shadecloth.
- **Cut** to 1 foot **and macerate** stump.
- **Girdle or Frill.**
- **Drill and inject** with herbicide.

Disposal

Remove seed pods from the site when feasible. The wood can be cut for firewood.

Follow-Up

Return to the site to check for seedling growth and resprouts at least twice a year. Dig out or cut and treat the resprouts.

Interesting Facts

The genus *Acacia* is one of the largest in the world, comprising around 1,000 species. Blackwood acacia is native to Tasmania, an island south of Australia, where marsupials eat the seedlings. Heights of 130 feet have been recorded, while the oldest tree is 230 years old. It produces lumber of commercial value if grown on suitable sites. In some parts of the world, green wattle acacia is used in cosmetics for skin conditioning, while the bark is used to tan leather. Many *Acacia* species can be highly allergenic.

Notes

BLUE GUM EUCALYPTUS

Eucalyptus globulus

Myrtle Family (Myrtaceae)

Description

Blue gum eucalyptus is found throughout California, particularly in cooler coastal areas. It requires moist soils, access to shallow groundwater, or coastal fog drip.

Blue gum frequently reaches 100 feet or more in height. The smooth, straight trunk can grow to a diameter of 7 feet or more. The pale gray-brown bark peels in long, papery strips to expose a smooth, pale yellow sub-surface. Mature leaves are alternate, lance- or sickle-shaped, and 4–10 inches long. They have a leathery texture and are dull green with a yellow primary vein. In contrast, juvenile leaves are opposite, shorter, and more oval in shape. They are waxy and bluish green, and are nearly sessile (with very short petioles) on sharply squared branches. The bluish green leaves give the blue gum its common name, and the drooping foliage together with the peeling bark and irregular crown give blue gum a distinctive appearance. Blue gum is distinguished from red gum (*Eucalyptus camaldulensis*) by having wider leaves and larger fruits.

Reproduction

Blue gum reproduces both from seed and vegetatively from roots and stumps. Dormant buds produce new shoots from the base of a cut stump. At 4–5 years of age blue gum starts to produce yellowish white flowers, about 2 inches wide, between December and May. These develop into fruits almost a year later. The fruit is a conical, woody capsule roughly 1 inch across. It contains numerous dark brown seeds, which are wind-dispersed and capable of germinating within a few weeks.



Impact

Blue gum can form monospecific stands through superior competition for moisture from the soil and water table and by establishing a dense layer of bark and leaf litter on the ground. Blue gum leaves contain phenolic compounds that are thought to alter soil chemistry and inhibit the germination of native plant species. With their abundant leaf litter, peeling strips of bark, and volatile oils in the leaves, blue gum stands are highly flammable, as was witnessed in the Oakland Hills fire of 1991.

Key Factors

- Vigorously resprouts from cut stumps.
- Seed longevity not known.

Treatment Options

Given its sheer size and persistence, blue gum eucalyptus can be very difficult to control. Removing larger trees is dangerous and often requires a professional arborist. However, blue gum can be temporarily managed by containment until volunteer groups have the resources to remove larger trees and stands. The goal of containment is to keep trees from spreading by removing those on the perimeter of the stands.

- **Pull** small saplings by hand or with a Weed Wrench.
- **Cut and treat.** Cut the stump flat and as low to the ground as possible. Practitioners report using a 25–50 percent dilution of glyphosate. Herbicide must be applied within 5 minutes, and preferably within 1 minute after cutting, while the cambium can still transport the herbicide into the roots. Some people find that the higher the cut is made above the main stem, the greater the chance of resprouts growing below the cut.
- **Cut and cover.** Mature trees up to 8 inches diameter at breast height can typically be cut with a hand saw. Larger trees require a chainsaw. Cover the cut trunk and the surrounding ground 3 feet out from the base of the trunk with landscape fabric and leave for 6–12 months. Check periodically to ensure that the fabric is still tightly secured.
- **Cut and grind or macerate.**

Disposal

Blue gum eucalyptus can be cut for firewood, but when burned it can deposit oily soot in the chimney. Allowing the wood to dry thoroughly makes it easier and cleaner to burn. The wood hardens as it ages, becoming exceptionally difficult to cut, so cutting for firewood should be done within 2 weeks of felling the tree.

Follow-Up

Check for resprouts for at least 3 years or more. Those using herbicide cut any resprouts at the base and treat the cambium a second time, or cut the entire stump and treat again. If a new shoot originates from a point high on the stump, the stump can be cut below it, but if the shoot sprouts from near the ground or from roots, it must be cut and treated directly.

Interesting Facts

Native to Australia and Tasmania, blue gum was introduced to California as an ornamental in the 1850s, and was then widely planted for timber, windbreaks, and fuel. Its timber proved unpopular as it twists in the drying process. Nevertheless, blue gum eucalyptus makes good firewood and paper pulp. Glands on the leaves produce the volatile eucalyptus oil, which can be used as a decongestant. The smell is similar to that of camphor or menthol.

Notes

TREE OF HEAVEN

Ailanthus altissima

Tree of heaven Family (Simaroubaceae)



Description

Tree of heaven is a deciduous tree most commonly found in riparian areas and disturbed inland areas.

Tree of heaven grows 30–65 feet tall, while its trunk can reach 2–3 ft in diameter. It has a broad, dome-shaped crown. The bark is gray and smooth, becoming darker and more scarred with age. The twigs are stout and pale chestnut-brown with rounded buds. The leaves are alternate, pinnately compound, and 1–3 feet long. Each compound leaf comprises 11–25 smaller lance-shaped leaflets, which have 2–4 rounded auricles ("ears") near the base. The leaves have an unpleasant odor when crushed.

Reproduction

Tree of heaven reproduces both from seed and by sprouting vegetatively from stumps and roots. Trees reach reproductive maturity between 10 and 20 years of age. Clusters of small, yellow-green flowers appear in June near the branch tips. Female trees bear winged fruits in September and October. The flat, twisted, papery fruits turn from pink to red-brown with age and hang in large clusters that can last through the winter. Measuring 1–2 inches long, each fruit bears a single seed. A single tree can produce over 300,000 seeds in a year. Seeds are wind-dispersed, but can also spread by water, birds, and machinery. Individual trees live to about 50 years, but new root sprouts often prolong the tree's life span.

Impact

Tree of heaven often forms dense monocultures. The bark and leaves reportedly produce allelopathic chemicals that accumulate in the soil and can cause mortality in other vegetation. The foliage is unpalatable to browsing wildlife.

Key Factors

- Rapid growth and spread from lateral root suckers.
- Persistent resprouts from cut stumps.
- Copious seed production.
- Seeds viable for no more than 1 year.
- Seedlings somewhat shade-intolerant.

Treatment Options

- **Pull** seedlings before a taproot is established (roughly 3 months after germination) while the soil is moist and loose. If a taproot has already formed, **dig** around the base of the plant to completely remove the root system and prevent resprouts. Grubbing out the taproot can be an effective way of killing the plant, but is a slow method best used to control small infestations. Make sure you remove the entire root, as any portion left in the soil can produce a new plant.
- **Cut** stems of mature trees (up to 12 inches in diameter) early in the spring. Cut a second time at the end of the growing season around June or July. This strategy aims to prevent

seed production with the first cut and to exhaust the plant's energy reserves with the second cut.

- **Cut and treat** trunks or stems with a chainsaw, preferably during the growing season, and before trees have begun to flower. Some practitioners have had success by painting a 50 percent glyphosate solution on the stump immediately after cutting.

Disposal

Slash from trees that have not produced seed can be piled for wildlife cover. Any seeds present are best collected, bagged, and disposed of. If not, you will need to return to the site to pull any seedlings that have germinated.

Follow-Up

You'll need to cut resprouts repeatedly for 3–4 years to eventually kill off the plant's root system. New seedlings and root suckers can be either pulled or cut and treated with herbicide. Establishing a thick shade over tree of heaven seedlings will slow down their growth.

Interesting Facts

Tree of heaven is native to China and was introduced to America in the late 1700s as an ornamental species. It resembles certain trees native to the East Coast, such as sumacs, ash and black walnut. The wood is weak and of little commercial value, although it can be used to produce paper pulp. It has long been used in Chinese medicine for reproductive disorders and to calm spasms. In France, tree of heaven leaves are fed to the Ailanthus moth caterpillar, which yields a silk cheaper and stronger than the fine mulberry silk of China. Invasive in urban areas, tree of heaven was the tree of fame in the book *A Tree Grows in Brooklyn*.

Notes

Resources

There is a wealth of information available to weed workers. The following is but a brief introduction to the organizations and publications that deal with invasive plants.

BAY AREA WEED MANAGEMENT AREAS

Weed Management Areas (WMAs) are county-based groups composed of diverse stakeholders interested in weed control. Their work focuses on three areas: mapping, education, and on-the-ground control projects. Each has an official memorandum of understanding with the state's Department of Food and Agriculture. Most are coordinated by county agricultural departments. WMAs are often the best place to start when looking for local expertise on weed issues.

Alameda/Contra Costa County WMA: (925) 646-5250
Solano County WMA: (707) 421-7465
Marin/Sonoma County WMA: (415) 499-6700
San Francisco County WMA: (415) 668-4392
San Mateo County WMA: (650) 363-4700
Santa Clara County WMA: (408) 224-7476 x822
Santa Cruz County WMA: (831) 763-8080

General Weed Info

tncweeds.ucdavis.edu
A collaboration between UC Davis and the Nature Conservancy, this site includes detailed information on many invasive species, tools, control methods, events, and a listserv.

wric.ucdavis.edu
The Weed Research and Information Center at UC Davis carries out research and disseminates information on weed management to benefit agriculture and natural areas.

www.cal-ipc.org
The California Invasive Plant Council (Cal-IPC) works to protect California wildlands from invasive plants through research, restoration, and education.

www.thewatershedproject.org
The Watershed Project offers outreach programs on creeks, wetlands, and watersheds to the public and educators in the San Francisco Bay Area.

plants.usda.gov
The US Department of Agriculture has a national plant database that includes invasive species.

www.invasivespecies.gov
This site lists invasive species activities and programs at the federal and state level.

www.ice.ucdavis.edu/nrpi
Co-managed by UC Davis and the California Biodiversity Council, the Natural Resource Project Inventory (NRPI) is a database of noxious weed control projects in California.

Species-Specific Info

ceres.ca.gov/tadn
Team Arundo del Norte is a forum of organizations dedicated to controlling *Arundo donax* (giant reed) in Central and Northern California. Its Web site provides comprehensive information on ways to remove giant reed.

www.noivyleague.com
A Web site dedicated to the control of English ivy.

www.ipm.ucdavis.edu
UC Davis' online IPM web site provides detailed information on removing yellow starthistle, invasive blackberries, and other weeds.

Print Publications

www.cdfa.ca.gov
Noxious Times is a quarterly magazine published by the California Department of Food and Agriculture with information on noxious weed control throughout California.

www.cal-ipc.org
Cal-IPC News is published four times a year by the California Invasive Plant Council.

Tools & Equipment

www.lampedesign.com
The Root Talon is designed for pulling up small tree saplings.

www.canonbal.org/weed.html
The Weed Wrench is suitable for pulling up broom.

www.flameeng.com/Vapor_Torch_Kits.html
The Vapor Torch can be used to kill thistles at the rosette stage.

Organizations

In addition to the few organizations listed below, there are many local groups doing weed removal projects.

www.sercal.org
The California chapter of the Society for Ecological Restoration is dedicated to restoring California's damaged ecosystems and offers conferences, workshops, and educational activities.

www.cnps.org
The California Native Plant Society (CNPS) promotes the preservation of California's native flora. Several local chapters in the Bay Area offer events, including weed removal activities: Yerba Buena (for San Francisco and northern San Mateo County), Napa, Marin, East Bay, Santa Clara Valley, and Santa Cruz.

www.acterra.org
Acterra is a Palo Alto-based environmental group that aims to protect and restore the local natural environment through stewardship, information, and leadership. Web site features a calendar of events for the Bay Area.

www.weedcenter.org
The Center for Invasive Plant Management's Web site includes funding opportunities for groups interested in developing a weed management area.

Agencies

www.nps.gov/goga
The Golden Gate National Recreation Area is the largest urban national park in the United States, and offers many education and volunteer opportunities.

www.parks.sfgov.org
The San Francisco Recreation and Park Department has a Natural Areas Program that offers ongoing volunteer opportunities in habitat restoration.

www.ebparks.org
The East Bay Park Regional District works to increase public awareness of the regional parks system. Volunteer opportunities include invasive weed removal.

www.openspace.org
The Midpeninsula Regional Open Space District seeks to acquire and preserve a regional greenbelt of open space land within the Bay Area for future generations. Volunteer opportunities are available.

www.parks.ca.gov
California State Parks aims to preserve the state's biological diversity and protect its natural and cultural resources.

www.cdfa.ca.gov/wma
Weed Management Areas (WMAs) are local organizations that bring together landowners and managers to coordinate efforts against invasive weeds. WMAs exist in most of the Bay Area counties. The Web site lists weed control projects in each WMA.

www.cdpr.ca.gov
The California Department of Pesticide Regulation's Web site features links on integrated pest management, pesticide licensing, pest management grants, and general pesticide information.

Workshops / Trainings

www.merrittlandhort.com
The Department of Landscape Horticulture at Merritt College, Oakland, offers classes in weed identification and control.

www.thewatershedproject.org
The Watershed Project offers workshops based on this handbook.

Glossary

*Terms in **bold print** within definitions are themselves defined in the glossary. Refer also to separate sections on Leaf Terms and Flower Terms at the end of the general section below.*

Achene—a dry, non-fleshy fruit that contains a single seed and does not break open when ripe.

Adventitious roots—roots originating aboveground on a stem and growing into the ground.

Alkaloid—any of a large number of pharmacologically active, potentially toxic, nitrogen compounds produced by plants.

Allelopathic—producing substances (allelochemicals) that are toxic to or inhibit the growth of other plants.

Annual—a plant whose entire life cycle (**germination**, growth, flowering, setting seed, death) occurs within one year (contrast **biennial, perennial**).

Apomixis—production of viable seeds without fertilization having occurred; **asexual** production of seeds.

Asexual—occurring without sexual union, as in **apomixis** or, more commonly, **vegetative reproduction.**

Biennial—a plant that lives two years, flowering and setting seed in the second year (contrast **annual, perennial**).

Biomass—informally, a volume (not mass) of living or dead organic material (for the purposes of this book, all that "stuff" a weed worker must deal with). Technically, *biomass* refers to the weight of all living matter per given unit area. Weight of dead organic material is most properly called *necromass*.

Bolting—rapid elongation of a shoot just before flowering.

Bract—reduced leaf-like structure at the base of a flower or **inflorescence.**

Bulb—fleshy underground shoot that stores carbohydrates and is capable of **vegetative reproduction.**

Bunchgrass—a **perennial** grass that cannot spread vegetatively; all of the buds are located at ground level, at the base of the stems.

Cambium—a layer of living tissue between the xylem (water-conducting tissue) and phloem (food-conducting tissue); in a tree, cambium is found in the current (outermost) year's growth ring. It is the tissue that one severs when girdling a tree.

Chaparral—vegetation type dominated by evergreen shrubs, found beyond the zone of direct coastal influence.

Coastal scrub—vegetation type dominated by shrubs and found at the coast.

Containment—a control strategy short of **eradication** aimed at preventing or limiting the spread of an invasive species.

Eradication—complete elimination of a species, including seeds, from a given area; local extinction.

Foliar—pertaining to leaves (foliage). Foliar application of an herbicide means the herbicide is sprayed on the leaves.

Forb—any herbaceous plant that is not grass-like (i.e., not a grass, rush, or sedge).

Funicle—the stalk of an ovule or seed.

Germination—sprouting of a seed or spore.

Herbaceous—adjective describing non-woody plants, whether **annual, biennial,** or **perennial** (noun form: herb).

Hybridize—to interbreed with different species or sub-species.

Invasive plant—a successfully reproducing species of plant that is, or has the potential to become, unacceptably abundant in a particular plant community. Invasive plants in native ecosystems may alter plant community composition, structure, and function, and diminish habitat value.

Lateral roots—underground roots spreading outward rather than downward (contrast **taproot**).

Monospecific—single-species; e.g. a stand of a single plant species containing no other plant species (or, containing very few other plant species—the term is often used somewhat loosely, rather than strictly literally).

Native plant—a plant species or subspecies that evolved in its present location or dispersed to its present location unaided by humans.

Naturalized plant—a **non-native plant** species that reproduces successfully and is thoroughly established in its introduced range. Plants considered "naturalized" are usually not considered "**invasive**." They may have minimal ecological impact, or be restricted to disturbed habitats such as lawns and roadsides, rather than able to spread into relatively undisturbed habitat.

Nectar—sweet fluid, attractive to pollinators, secreted by many plants in glands at the base of the flower.

Nitrogen-fixing—incorporating nitrogen gas from air into inorganic nitrogen compounds usable by plants; carried out by soil bacteria, especially by bacteria associated with the roots of legumes (Fabaceae, pea-family plants).

Non-native plant—a plant found outside the evolved or historic range of its species; not all non-native plants are **invasive**. *Note:* plants and seeds may be dispersed to new locations over long distances by wind, water, and birds. Such newcomers could be considered non-native unless and until they survive, reproduce, and over generations, co-evolve with their new ecosystem. For the purposes of this book, non-native plants are those introduced by humans, whether deliberately or unintentionally.

Perennial—a plant that lives more than one year (contrast **annual, biennial**).

Phenolic compounds—secondary metabolic compounds produced by plants; these compounds may attract pollinators or seed dispersers, defend against predators, or be poisonous to competitors.

Photosynthesis—the process by which plants produce sugars (photosynthate) from water and carbon dioxide in the presence of chlorophyll using light energy.

Pollination—transfer of pollen from an anther to a stigma (receptive surface of a

flower); required for fertilization and **sexual reproduction** in plants.

Rhizome—a horizontal stem growing below the soil surface; may store carbohydrates or function in **vegetative reproduction** (compare **stolon, runner**).

Riparian—pertaining to or growing along watercourses.

Rootball—a non-technical term referring to the major bulk of a compact root system, (e.g., the dense mass of roots of *Cortaderia spp*. excluding the slender roots extending from the main mass).

Root crown—a non-technical term referring to the top portion of the underground root system.

Rosette—growth form characterized by a cluster of leaves radiating from a central point, usually close to the ground at the base of the stem (basal rosette); a common growth form of **biennial** plants in their first year.

Runner—a slender **stolon** that roots at the **nodes** or tip, effecting **vegetative reproduction.**

Seedbank—viable seeds in the soil.

Semi-shrub—a generally **herbaceous, perennial** plant capable of developing woody stems.

Senescence—late life stage of a plant (shortly after reproduction in **annuals**) characterized by loss of vigor and gradual death (from the Latin *senex*, old man).

Sensitive habitat—areas of special concern due to the presence of rare, threatened, or endangered species, or of vulnerable features such as watercourses.

Serpentine—soil derived from weathered serpentinite rock, which is low in the nutrients nitrogen, phosphorous, and calcium, and high in magnesium, nickel, and chromium; also refers to the unusual vegetation found on serpentine soils.

Sexual reproduction—process by which new plants arise from seeds which developed from ovules fertilized by pollen (contrast **vegetative reproduction**).

Shrub—a woody, usually multi-stemmed plant, generally smaller than a tree.

Stolon—a stem that creeps along the ground and produces roots at the **nodes** or tip, giving rise to a new plant through **vegetative reproduction.**

Sucker—a shoot originating from below ground, e.g., from a root.

Taproot—a larger, main root, usually vertical, from which smaller roots branch out; typically found in dicots and not in grasses.

Tiller—an erect shoot originating underground; (verb:) to reproduce vegetatively through tiller production.

Vegetative reproduction—process by which new plants arise without **sexual reproduction** occurring, e.g., from **bulbs, stolons, runners, tillers,** or **suckers.**

Viability—ability of a seed to germinate. *Note:* the length of time a seed remains viable varies widely between species and depends on environmental conditions affecting the seed. Plants producing seeds that remain viable for many years in the soil are said to have high **seedbank** longevity.

LEAF TERMS

Alternate—leaf arrangement in which a single leaf emerges from each **node** on alternating sides of the stem (compare **opposite**).

Bipinnate—twice **pinnate**; the primary pinnae (**leaflets**) are also pinnately **divided.**

Compound leaf—a leaf composed of multiple **leaflets** (compare **simple leaf**).

Divided—cut into distinct parts to the midrib or base.

Elliptic-ovate—leaf shape intermediate between elliptic (the shape of an ellipse, a narrow oval) and ovate (egg-shaped, wider at the stem end).

Lanceolate—lance-shaped leaf: longer than it is wide, with the widest point below the middle of the leaf.

Leaflet—single division of a **compound leaf.**

Lobe—rounded segment of a leaf; a leaf may be deeply lobed and yet not truly **divided.**

Node—a joint of a stem; a place where leaves and branches join a stem.

Opposite—leaf arrangement in which two leaves emerge from each **node** on opposite sides of the stem (compare **alternate**).

Pinnate—leaf arrangement of a **compound leaf** with **leaflets** (pinnae) opposite each other like a feather.

Serrate—saw-like leaf margin; having a sharply toothed leaf margin with teeth pointing forward (compare **toothed**).

Sheathed—partly surrounded by another organ, as a stem partly surrounded by the base of a leaf.

Simple leaf—undivided; not composed of multiple **leaflets** (compare **compound leaf**).

Toothed—leaf margin with teeth pointing outward rather than forward (compare **serrate**).

Triangular-ovate—leaf shape more sharply three-angled than strictly ovate (egg-shaped, wider at the stem end).

FLOWER TERMS

Awn—a slender bristle at the tip or on the dorsal (back) surface.

Floret—a small flower; an individual flower within a cluster (e.g., within a **spikelet** of a grass).

Inflorescence—a cluster of flowers on a plant; a reproductive structure with multiple flowers.

Panicle—an **inflorescence** structured as **racemes** that are themselves branched, extending from a central axis.

Plume—an **inflorescence** that appears feather-like.

Raceme—a branched **inflorescence** arranged with flowers attached individually by pedicels (stalks) to a central axis; lower flowers mature earliest.

Spike—an **inflorescence** arranged with flowers attached individually as in a **raceme**, but without pedicels (unstalked).

Spikelet—a small **spike**; the smallest flower cluster of a grass.

Terminal—at the tip, or terminus.

Umbel—an **inflorescence** structured as a condensed **raceme** with elongated pedicels; the flowers form a flat-topped or convex shape like an umbrella (characteristic of the family Apiaceae).

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