

Arundo— A Landowner Handbook

This Handbook provides information about Arundo, an invasive non-native plant that is taking over streams across California. The eradication of Arundo depends on the participation of property owners. Arundo has become so widespread that government agencies and citizen groups cannot eliminate it alone. If we are to be good stewards of the land, we must take on the task of fending off non-native invasive species. This Handbook includes help with identifying Arundo, the reasons for eliminating the plant from our watersheds, techniques for Arundo eradication, and contact information. Please use this Handbook as a reference for your own eradication efforts. Thank you for your participation!

A. What is Arundo?

Identification

Arundo donax is a thick-stemmed plant in the grass family, resembling bamboo, that grows up to 30 feet tall. It forms many-stemmed clumps, spreading from thick, knotty roots called rhizomes (RYE-zomes) that grow horizontally, not downward. The root masses can spread over several acres, quickly forming large colonies that displace other plants. The stems of Arundo are tough and hollow, divided by nodes like bamboo. The pale green or blue-green leaves clasp the stem with a heart-shaped base. They are up to 1 foot long. They are arranged alternately along the stem (not opposite each other), each leaf pointing 180 degrees from the next one. In many areas, Arundo produces a tall plume-like flower-head at the top of its stems. Its stems often fade to brown during winter or drought. Arundo can be confused with bamboos and corn, and young stems can resemble some large grasses such as ryegrass and common reed (*Phragmites*).



Arundo typically grows in riparian areas and floodplains. It can be found on wet streambanks, gravel bars, or dry banks far from permanent water. It prefers gently sloping streams over steeper, smaller, creek channels. Scattered colonies can be found in other moist sites such as springs, upper areas of coastal watersheds, drainage ditches, along rice field levees, and residential landscaping.

The Problem of Non-Native Invasive Species. "The invasion of noxious alien species wreaks a level of havoc on America's environment and economy that is matched only by the damage caused by floods, earthquakes, mud slides, hurricanes, and wildfire." US Secretary of Interior, Bruce Babbitt.

Arundo is just one of many aggressive plants and animals introduced from elsewhere that have negative and sometimes disastrous effects on local ecosystems. These pests are extraordinarily successful at spreading because they often have no local predators or diseases. Their overwhelming abundance can greatly upset the balance of ecosystems. They cost billions of dollars annually by impacting waterways, competing with or preying on commercial fish species, and decimating crop plants. As of February 1999, by executive order of the President of the United States, the federal government has committed to fighting invasive species. The order sets in motion federal efforts to intercept introduced species at our borders and to eradicate the infestations already here.

A History of Arundo's Expansion

Arundo donax is the scientific Latin name for this pest plant. It is commonly called Arundo, giant cane, giant reed, carrizo, and other names, including "the Weed from Hell!" We will refer to it as Arundo or Arundo donax.

Arundo probably originated in India. In ancient times it was transplanted to the Mediterranean region, and later to the Americas. Today it is an invasive pest throughout the warmer coastal freshwaters of the United States, from Maryland around to northern California. Arundo came to southern California with early Spanish settlers. It now occurs in most regions of California below approximately 1,000 feet. Without human efforts to stop it, Arundo would almost certainly continue its invasion of the state and occupy thousands of miles of stream channel.

Important Biological and Ecological Facts About Arundo

In North America, Arundo is not known to produce fertile seed. It nonetheless spreads very rapidly by vegetative means. One method involves the rhizomes, which grow outward to expand a colony's size. The most common method is when rhizome fragments (as small as a few inches) are dispersed downstream during high stream flows. Fragmented pieces of rhizomes and stems take root, forming new plants and colonies. Removal efforts should begin upstream and work downstream to eliminate re-infestation of cleared areas.

Arundo is one of the fastest growing land plants in the world. During warm months with ample water, Arundo stems may grow up to four inches per day! It may grow year round in mild coastal areas.

Arundo is highly flammable during most of the year, creating a fire hazard for other vegetation, buildings, and people. It is fire-adapted, meaning it resprouts from its roots after fire. Thus, Arundo encourages fire along streams, and fires then spread Arundo further through the landscape, displacing other plant species.

Arundo provides virtually no food or habitat for native species of wildlife. The stems and leaves contain several toxic or unpalatable chemicals which probably protect it from most native insects and other grazers. Therefore, areas taken over by Arundo harbor very few native animals. Because they cannot eat it, native animals do not help control the spread of Arundo.

"Riparian" refers to the ribbon of land along-side a stream, river, or creek that is influenced by the presence of stream water. Under natural conditions, the riparian zone usually contains a lush forest of many species of trees, shrubs, vines, and ground-level plants. Since it has such a great number and diversity of species that depend on it, the riparian zone is considered the most ecologically productive part of California's landscapes.

Uses

Far from being a purely noxious plant, Arundo has many practical uses. For centuries it has been used for reinforcing adobe, for musical instruments—from ancient pan-pipes to reeds for more recent wind instruments—for fencing, roofing, and basket-making. It can be harvested for paper and fiber production. Arundo is also commonly employed as an ornamental plant in landscapes, or used as a fast-growing privacy screen. Arundo has been widely planted for erosion control, but is not effective for this purpose except in the short term. Invasive populations of Arundo almost certainly resulted from plants that escaped into waterways from planted landscapes.



B. The Effects of Arundo Infestation

Problems on the Stream and Stream Bank

Photos by
Rachel Werling

For an individual landowner, an Arundo infestation creates several problems.

- Arundo root masses are large but brittle. The lack of long roots makes the root masses susceptible to under-cutting by streamflows. It is common to see thick rhizomes hanging precariously over the stream. When the root mass gives way, it frequently pulls a chunk of stream bank with it. Not only does this process cause erosion onsite, it spreads the rhizomes downstream where they can take root again.
- Arundo canes grow packed together, sometimes so densely that it is almost impossible for people and animals to move through it. The weed crowds out native trees, shrubs, vines, grasses, and wildflowers by out-competing them for light, soil moisture and nutrients. Mature Arundo's dense shade prevents the germination and development of emerging native plants. Over time the weed converts the formerly diverse riparian vegetation into a pure stand of Arundo. Arundo is highly flammable, so an infestation poses a fire hazard to other riparian vegetation, nearby buildings, and people.
- Since very few insects or other animals can eat or use the cane, all forms of wildlife are reduced in numbers. Previously complex food webs containing many species of birds, amphibians, and mammals become simplified, leaving just a few species that can survive in Arundo stands. These include other pest species, such as Norway rats and the blue-green sharpshooter which can damage vineyards.
- Arundo canes grow vertically instead of arching over the stream. Therefore, Arundo doesn't provide as much shade to the stream as native riparian trees. Without shade, the stream water becomes warmer and less hospitable, even lethal, for native fish. Higher temperatures foster algae and non-native "trash fish" such as carp.

Problems for the Watershed

- Arundo's root masses are easily undercut by flowing streamwater. In a watershed with many Arundo colonies, vast quantities of stems and rhizomes can be uprooted and transported during high flows. The Arundo debris can accumulate at bridge crossings, culverts, pipes, ditches, and stream eddies. The pressure of water behind a large mat of uprooted Arundo can wash out bridges and other infrastructure, causing great expense, inconvenience, and danger to people. High winter flows routinely deposit miles of Arundo debris on beaches.
- Fire is a natural and beneficial process in many native plant communities, but not in riparian areas, where the vegetation is lush and green all year. Because Arundo is extremely flammable, once it becomes established it increases both the probability of wildfire and the intensity of fires once they occur. If Arundo becomes abundant it can change a riparian forest from a fire barrier to a fire carrier. Arundo rhizomes respond quickly after fire, sending up new shoots that quickly outgrow native species. Fire thus tends to shift riparian areas in the direction of pure stands of Arundo.
- Large, dense colonies of cane act as filters, collecting sediment carried in by the stream. The surface under the Arundo colony can rise enough to force water into new paths which may collide with streambanks across from, or downstream of, the Arundo infestation. The result is accelerated erosion of the streambanks, lost property, and expensive repairs, and sometimes ill will between neighbors.
- Natural riparian communities are the most diverse areas in the California landscape in terms of the numbers of plant and animal species they support. They are also one of the ecosystems most devastated by human development. Only a small fraction of California's former riparian forests and marshes remains. The remaining riparian zones offer refuge for many native species, including those at great risk of extinction. These struggling creatures include fish that require cool clean water, amphibians that need hiding places, birds that require a diverse structure of trees or shrubs plus native foods, and insects that feed and reproduce on native plants. The plight of these animals parallels the decline in riparian plant species, many of which require natural flooding patterns and the cool, humid environment provided by native trees. Arundo infestation adds riparian habitat degradation to riparian habitat loss, compounding the pressure on these rich, precious places.



C. You, The Landowner, are the Key to Eradicating the Arundo Menace

The eradication of Arundo depends on property owner participation. Eradication efforts can only succeed with landowners' help in locating and removing the plant or allowing access to your property so others can remove it. Arundo has become so widespread that government agencies and citizen groups cannot eliminate it alone. Even the basic task of finding it cannot be achieved without landowner cooperation. Many large colonies are known, but untold numbers of smaller clumps are not. Groups providing eradication assistance cannot be effective without the scouting eyes and helpful reports of property owners.

Informed property owners play a crucial role in preventing the spread of Arundo. A new invasion can go unnoticed at first. Once the infestation has grown, it can be difficult to control. Knowledge and vigilance are keys to successfully defending your property from these invaders. An uninformed landowner could unwittingly harbor a fugitive pest plant while it reproduces and spreads downstream onto a neighbor's property or, over a period of years, throughout a whole river system. In order to prevent new infestations, landowners need to know what the plant looks like and where to find it. You can learn this from agencies and groups addressing non-native pest plant issues (see Who to Contact).

Property owners with land in agricultural production can suffer real losses from pest plant invasions. Even landowners not involved in commercial production need to be concerned with pest plants. Non-native species like Arundo can reduce the value of property whether an owner's interest is commercial, recreational or ecological. Both human use and wildlife use are diminished when invasive plants take over. If we are to be good stewards of the land, we must take on the task of fending off these non-native invaders. The stakes are high; our riparian resources are too precious for us to allow them to be lost through inaction.



D. Eradication of Arundo From Waterways is the Goal

Arundo CAN be Eradicated in Northern and Central California

Central and northern California have relatively recent invasions of Arundo, compared to other regions such as Florida and southern California. Several large areas of solid or near-solid Arundo do exist, particularly in the Sacramento River delta, the north-western Sacramento Valley, parts of the coast ranges, and the San Francisco Bay Area. However, most watersheds in our region have infestations that can be completely removed once attention and resources are focused on them. Eradication of these smaller infestations is imperative if we are to avert ecological crisis. Removing small colonies is not difficult, and the resources to deal with large colonies are increasing as awareness grows.

Horror Stories From Elsewhere

We have vivid examples of the consequences of not taking action. In southern California, several rivers demonstrate the bleak result of unchecked Arundo expansion. According to Arundo expert Gary Bell, "By far the greatest threat to the dwindling riparian resources of coastal southern California is the alien grass species known as Arundo donax." Arundo has been the biggest problem for stewards in coastal river drainages of southern California, especially in the Santa Ana, Santa Margarita, Santa Clara, Tijuana and other major and minor watersheds where it sometimes occupies entire river channels from bank to bank, covering thousands of acres. Once a wholesale conversion to Arundo occurs, the ecological results are dire, and public safety concerns erupt over the extreme hazard of fire and flood. Eradication in these watersheds requires serious measures, including extensive spraying of herbicide from helicopters. The key to preventing situations like these is removing Arundo infestations while they are still small, before they take over the entire riparian zone.



E. "Yes, But..." Or, Typical Concerns for the Landowner

Q I have Arundo growing in my yard. Should I remove it?

A Not necessarily. Arundo can coexist with us and other plants when it is in the right place. Arundo only poses a threat to our environment when it is growing near waterways or is disposed of improperly. Arundo in your yard is fine if it is growing well away from any stream or drainage that leads to a stream. When pruning Arundo, do not dispose of cuttings where they could possibly wash into waterways and take root.

Q If this Arundo is such a threat, why haven't I heard about it?

A Biological invasions of non-native plants are subtle and tend to sneak up on us. Many non-native plants have become quite infamous, such as kudzu, yellow starthistle, and water hyacinth. New invasions of non-natives occur over time. Arundo is well-known in Southern California, and has only recently been recognized as a major threat to rivers and streams further north. Now, while the invasion is in its early stages, is the time to get control.

Q I found Arundo growing on my creek bank. Should get rid of it right away?

A The only time you need to act immediately to eliminate Arundo is if it is threatening the stability of your creekbank or about to wash away downstream. It is more important that you use the removal method most appropriate for your site. Improper control methods could damage property, cause erosion and even help spread the plant downstream (see Techniques for Eradication).

Q I think I might have Arundo on my property but I can't tell if it's bamboo. Who can help me identify it and eliminate this plant from my property?

A Local public agencies and non-profit groups have staff who can determine if Arundo is on your property and the best method to use to eradicate it (see Who to Contact). Bamboo leaves grow on small branches called petioles. Arundo's broad leaves have no petioles; instead, they extend all the way to the stem, where they have a broad base that wraps around the stem. Bamboo leaves are generally smaller than Arundo's and often shiny.

Q I don't think I have Arundo on my property, but I'd like to help. What can I do to help get rid of this plant in our area?

A Getting involved in citizen groups doing restoration work locally is the best way to actively participate in eradication efforts. Once you learn basic identification and eradication techniques, you can help lead your community in prevention and eradication of Arundo (see Who to Contact).

Q I'm concerned about having strangers working on my property. What if someone gets hurt or damages my property?

A A property owner can avoid liability for individual injury and property damage by doing the eradication work themselves and/or with labor covered by their own insurance. An owner can also hire an organization or company with its own liability insurance. Many non-profits have policies that cover volunteers. At a cost of several thousand dollars per acre to eradicate Arundo, you should seriously consider collaborating with local organizations and resolving liability concerns as they arise.

Q I'm concerned about losing my creek bank. How do I know that removing the Arundo along the creek won't cause erosion.

A Arundo is a poor choice for bank stabilization and will eventually fail. If the Arundo roots are left intact during eradication, very little soil loss will occur between the time the Arundo dies and the area is replanted with native species. The dead Arundo roots will help secure the bank until the new plantings establish deep, secure roots.

Q I feel uncomfortable with the use of herbicides by the creek. How do you kill the plants without harming the fish?

A The herbicides used to control Arundo near water have been approved for aquatic or riparian use by the US Environmental Protection Agency and the California Department of Pesticide Regulation. The approval process involves an extensive review of the herbicide's toxicological properties. If used properly, the herbicide poses no appreciable harm to wildlife, fish and other aquatic species (see boxes on herbicides in the section on Techniques for Eradication). It can be applied directly, without spraying, to prevent accidental exposure. If you are uncomfortable using herbicides, there are mechanical eradication techniques that require more vigilant follow-up.

Q Do I need a permit to remove the Arundo next to the creek?

A In most cases of non-native plant removal on your own property, a permit is not required. However, in some cases of herbicide application, an operator identification number may be required from the county Agricultural Commissioner's office. Always contact your local Commissioner to verify your requirements. (See Who to Contact and the box on Requirements for Herbicide Applicators.)

Q Do I need a permit to burn the pile of cut canes?

A A burn permit is required from your local fire department. Your regional Air Quality Management District must be contacted to confirm that your scheduled date is approved for burning. A burn can only take place during the burn season which is generally during the wet months (approximately November through the end of April). The Air Quality Management District requires that the green cuttings dry out for at least six weeks before burning. (See Who to Contact.)

The deleterious effects of Arundo infestation are becoming widely known. US Fish and Wildlife Service, California State Parks, California Department of Fish and Game, flood control districts, CalTrans, the California Department of Forestry, and the US Navy are some of the public agencies that recognize the negative effects of Arundo and have implemented eradication programs. Several private organizations, including the Nature Conservancy, the California Native Plant Society, California Exotic Pest Plant Council, Team Arundo (in southern California), and Team Arundo del Norte are also involved in Arundo eradication.

Q If I remove the Arundo along my property, I'll lose my privacy screen. I'd like to help but how do I maintain my privacy?

A Arundo can be replaced with plants that make an excellent screen and pose no threat to our waterways (see Revegetation). A temporary fence can be erected during eradication while new plants are getting established.

F. Do as Much or as Little of the Eradication Work Yourself as You Want

Ridding your property of Arundo is not necessarily complicated (see Techniques for Eradication). However, eradication requires good timing, thoroughness, and vigilant follow-up to eliminate stubborn re-growth. You can do the work yourself with your neighbors and friends. The work can be a fun way to get some exercise and help the creek. If you are unable to do the work yourself, or if the infestation is too large or if access is too difficult, help is available to eradicate Arundo (see Who to Contact).

G. Who to Contact for Information, Permits, Funding, or Eradication Work

General Information

See the summary table on the next page for contacts. The best place to find local sources of information is in the phone book under Government Listings and in the Yellow Pages under Landscaping and Environmental Services. Ask questions until you find someone knowledgeable.

Public agencies and non-profit organizations are valuable resources. Please use them. Their trained staff can provide a wealth of knowledge and save you a lot of time and effort in the long run. From these sources, you can learn how to identify Arundo, plan eradication projects, obtain the necessary permits and mitigate adverse effects on the environment. At times it may seem like a bureaucratic maze to negotiate, but the benefits far exceed the cost in effort. The information agencies provide can help you avoid mistakes and unnecessary costs. It can also prevent environmental loss and neighboring property damage. The benefit gained by going through these channels is worth the wait.

Permits

In general, a permit or other similar approval is not required to use herbicides to remove Arundo. (See box on Requirements for Herbicide Applicators.) However, this may depend on the herbicide that will be used, the size of the project area, and whether the applicator is the landowner. If you plan to use herbicides to control Arundo, you should contact your county Agricultural Commissioner's office for more information.

Who to Contact

Listings in the last column refer to the local telephone directory unless otherwise noted.

Agency or Group Name	Assistance Available					How to Contact
	Information	Permits	Eradication	Restoration	Funding	
Agricultural Commissioner	Regulates herbicide use	Operator Identification Number may be required				County listing
Air Pollution Control District	Advises days when burning can occur					County listing
County or Local Water Districts		Some counties may require a permit	Varies			County listing
California Conservation Corps (CCC)	Eradication Consulting		Eradication	Restoration, native plants		State listing
California Department of Fish and Game (DFG)	Endangered Species impacts, biology, restoration, permits	Streambed Alteration permit		Various		State listing
California Exotic Pest Plant Council (Cal EPPC)	Biology, eradication techniques, permit, revegetation					Not a state agency. Website is www.caleppc.org
Fire Department (or District)	Safety, burn permit	Burn permit (for burning canes only)				City or County listing
Local Non-Profits	Varies by group		Varies	Varies		See Yellow Pages: Environmental Organizations, Landscaping and Environ. Services
Natural Resource Conservation Service (NRCS)/Resource Conservation District (RCD)	Erosion control, restoration		On-Site Consulting	On-Site Consulting	Various	County listing
Flood Control District or Agency	Varies by county	Some counties may require a permit	Varies		Varies	County listing
Private Companies	Estimates for eradication, restoration		Varies	Varies		See Yellow Pages: Landscaping and Environ. Services
Team Arundo del Norte (TAdN)	Eradication techniques, biology, grant information, regional eradication coordination					Web Site: www.ceres.ca.gov/tadn
United States Army Corps of Engineers (USACE)		Section 404 permit (for earthmoving or fill in stream)				United States listing
United States Fish and Wildlife Service (USFWS)	Endangered Species impacts, biology				Partners for Wildlife	United States listing
Regional Water Quality Control Board	Water quality issues	401 Water Quality Certification (for earthmoving or fill in stream)				State listing
United States Bureau of Land Management (BLM)					War on Weeds	United States listing

This information was current as of 1999. Periodic updates are available through the TAdN website at www.ceres.ca.gov/tadn

A permit is required to burn the cut canes. (See summary table on page 9 for other possible permit requirements.)

Eradication

Many local and regional environmental or watershed groups have ongoing volunteer programs to eradicate Arundo and restore riparian areas. If such a program doesn't exist in your area, it is not difficult to start one. "Arundo-bashing" small to medium infestations is perfect for weekend work-parties. Community-based eradication projects build awareness about invasive plant species and also encourage communities to work together to solve problems. If you want assistance organizing a community-based eradication project, see "Controlling Arundo in Your Watershed: a Guide for Organizations," available through the same sources as this Landowner Handbook. Or, contact Team Arundo del Norte at www.ceres.ca.gov/tadn.

Companies that offer eradication and restoration services vary by region. Consult your phone book.

Funding

Funding for individual eradication projects can come from grants. These are usually for community-based projects sponsored by public agencies and non-profit foundations or organizations. Some come from specific public agency projects, and some can assist landowners directly. If eradication of Arundo on your property is beyond the means of individual or volunteer efforts, contact these agencies to inquire about funding for your project. If a potential sponsor is not yet interested in funding Arundo eradication, another organization may be willing to convince them of the project's validity.

H. Techniques for Eradication

Different methods may be needed to control Arundo, depending on the size of the infestation, the amount of cane debris that must be dealt with, the terrain, the season, and whether the canes are mixed with desirable native plants. This section explains different methods of Arundo removal. Some are less practical than others and are rarely used. We've included most of the techniques employed in the past and present to show the breadth of experimentation and to illustrate the advantages and disadvantages of each method. Getting rid of Arundo is usually a multi-year effort. Five or more years of monitoring and re-treatment of the site may be necessary, depending on size and age of the infestation and other variables. Likewise, costs are highly variable depending on the slope of the site, the ease of access, who is doing the work, and the disposal method.

Consider the effects of your work in the riparian zone on fish migration and bird nesting. This issue is critical, especially when rare, threatened, or endangered species may be present. Bird nesting is from about March to around July. Anadromous fish migrate from the ocean back to their home streams at various times throughout California. Consult the US Fish and Wildlife Service, the CA Department of Fish and Game, or the National

Marine Fisheries Service to find out if protected species, especially salmon, steelhead, or other anadromous fish, may be present at your site. If they are, work carefully according to any guidance the agencies provide.

Cut Only

The technique: This method requires cutting the canes off at the base of the plant and hauling the cuttings out of the streambed for disposal.

Equipment needs: Cutting can be done with loppers, chainsaw, or a power brush-cutter. Chainsaws work well for some, but the fibrous stems can clog or derail the chain. A tight, sharp chain is crucial. Loppers are safest.



Personnel requirements: A single person or a group can use this method. Size of infestation will determine the size of the work crew needed. Using power tools requires more space and therefore limits the number of workers in a given area.

Timing: Cutting Arundo can be done at any time of the year. Rain and high water may limit access in the wet season. The best time to cut Arundo is during the growing season.

Side-effects: There are very few side effects with the Cut Only method. Soil disturbance and erosion can be a problem when working on steep slopes or on unstable soils. Because no herbicides are used, there is no time or resources spent on training and herbicide regulatory requirements. Further, there is no risk of herbicide spillage or accidental misuse.

Cost: The financial cost is minimal if performing the work yourself. Hiring outside labor to do the work can be costly, especially since this method will require constant follow-up. The physical and emotional cost is great because the canes grow back so fast and strong, discouraging all but the hardest volunteers.

Success rate: The Cut Only method has poor results in controlling Arundo. Removing the stalks from the banks can eliminate some spread of the plant downstream. However, the plant will readily regrow from the roots. Without herbicide treatment, cutting is usually a waste of time and labor.

Appropriate use: The Cut Only method is useful on small infestations where there is great concern for herbicide use. It can also be used to prevent further spread of Arundo when there is an immediate concern for a clump collapsing into a stream or to remove

Work carefully! Wear gloves. Arundo stems and leaves are sharp and can cut skin. The surfaces are abrasive. Avoid cutting canes at sharp angles. The cut edges can cause injury if someone falls on them. Watch the ends of the canes you are handling, so as not to hit or cut someone.

Remember:
No Sharp, Pointy Stumps!



canes that have fallen over into the water. (Also, one should not hesitate at any time to harvest the cane when building materials are needed or if your clarinet is in need of a fresh reed!)

Root Removal

The technique: This method involves digging up the roots and hauling roots and canes out of the creekbed for disposal.

Equipment needs: Shovels and picks for small infestations. If hand digging, the work is easier if you first cut and remove the canes, then address the roots. A backhoe or excavator and grapple can be used for large colonies. In this case, the stems do not have to be cut off first. In fact, the stems can help pull up the rhizome mass intact. Excavating in the streambed is generally not recommended and may require a Streambed Alteration Agreement from the California Department of Fish and Game or a permit from the U.S. Army Corps of Engineers (see *Who to Contact*).

Personnel requirements: A single person or a group can use this method, depending on the size of the infestation.

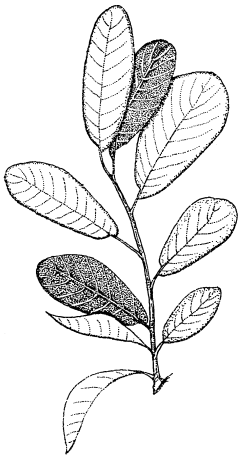
Timing: Digging Arundo can be done at any time of the year. Rain and high water may limit access and reduce bank stability in the wet season.

Side-effects: Digging the roots up disturbs the soil and causes erosion. The soils in the creekbed become vulnerable to being washed away. Roots that were missed or cut during digging are more likely to be uprooted during a high water event and deposited downstream, spreading the infestation. On the other hand, since no herbicide is used, there is no possibility of soil or water contamination and no accidental damage to desirable plants nearby.

Cost: The financial cost is minimal if performing the work yourself. The physical effort of digging it out by hand is great. Hiring a heavy equipment operator to do this work can be costly, especially since this method is slow and access can be difficult. Also, regrading and replanting the disturbed area can add to the cost significantly (See *Revegetation*).

Success rate: Reports are mixed. Canes will resprout from rhizomes that were missed, or were buried more deeply than the digging. The cost, soil disturbance, and equipment access problems make it an unpopular choice.

Appropriate use: When roots are exposed from erosion and vulnerable to washing downstream, it is appropriate to remove them. It is also acceptable to dig out Arundo roots when the clump is small, on the upper bank and on stable ground.



Spray Only (Foliar Herbicide Application)

The technique: This method requires spraying the leaves and stems of Arundo with a systemic herbicide such as glyphosate (Roundup® or its aquatic equivalent Rodeo®). See box for more information about herbicide. Tall Arundo stands can be accessed with ladders. Trails can be cut into larger stands to allow access into the colony. Stems should be left intact for the first year to prevent resprouting. Stems can be left indefinitely unless they pose a flood or fire hazard.

Equipment needs: (See Herbicide Usage and Handling for spraying equipment.) You may need a tall folding ladder for spraying the tops of clumps, and an umbrella for an assistant.

Personnel requirements: An operator trained in the use and handling of herbicides (see Requirements for Herbicide Applicators). An assistant to hold ladder.

Timing: The optimal time for foliar application, or spraying the canopy of Arundo clumps, is after flowering or in late summer to early fall, when the plant is entering dormancy. This is when the rate of translocation of herbicide from leaves or stems down to the roots is greatest. Foliar spray can still be effective throughout Arundo's growing season. (See Herbicide Usage for more information on spraying.) Apply herbicide on dry days and early mornings before winds pick up.

Side-effects: The greatest risk when spraying Arundo is the potential for spraying desirable vegetation. Arundo grows up to 30 feet tall and is difficult to spray without hitting surrounding vegetation and water, particularly if there is any wind. Herbicide overspray can be reduced by using ladders for tall Arundo stands. You can shield desirable plants with tarps or cut off branches of willows—and other species that can resprout—that may be accidentally sprayed. There is little risk of soil disturbance and erosion when spraying Arundo.

Cost: Glyphosate is expensive, but relatively cheap compared to the costs of hired labor. Trying to spray tall stands of Arundo can waste herbicide. However, the foliar spray is highly diluted and therefore less is used compared to the Cut Stump method.

Success rate: Reported effectiveness ranges from 50% to 95% in the first year. Expect complete eradication to take up to 3 to 5 years. Effectiveness depends on the herbicide mixture, weather conditions, the time of year, and the amount of coverage. Rain and wind reduce effectiveness.

Appropriate use: The Spray Only method is best suited to small stands of pure Arundo that have not reached full height.

Cut, Reprout and Spray (Foliar Herbicide Application)

The technique: This method requires removal of the canes, allowing the roots to resprout, and following up with foliar sprays.

Equipment needs: (See Cut Only, above, for cutting equipment.) Cutting the canes can be done by hand or power tools depending on the size of infestation. Very large stands of

Using Herbicide

Herbicide Use Issues. Arundo grows so aggressively that effective eradication efforts usually rely on a systemic herbicide such as glyphosate (the active ingredient in Roundup® and its aquatic equivalent, Rodeo®). Unlike contact-type herbicides that only kill the above-ground portion of plants, a systemic herbicide is absorbed by plant leaves and stems and is then transported to the plant's root system where it kills the entire plant, roots and all.

When used properly, herbicides used to control Arundo will not result in appreciable residues in soil or water. In the case of glyphosate herbicides, minute residues of the chemical can be measured in soil and water for a short time after the application, but are considered environmentally insignificant. Glyphosate residues are rapidly adsorbed onto organic matter in soil and water and become biologically inactive. Before adsorption onto organic matter, glyphosate, even in concentrations much higher than would be used to control Arundo, poses no significant toxicological hazard to wildlife, fish and other aquatic animals. Proper herbicide use, however, is key, to ensure the greatest success in controlling Arundo, minimize herbicide use and costs, and maximize protection for the surrounding environment.

Although glyphosate is the most common herbicide for treating Arundo, this is not a specific recommendation. There are at least four different formulations of glyphosate on the market and each has its different specifications for use. There are also other herbicides approved for use on Arundo. For a written recommendation, contact your County Agricultural Commissioner for the name of a licensed Pest Control Advisor. Read and follow directions for all herbicides.

Herbicide Use and Handling. Pesticide safety training is advised for all applicators. Always read and follow specific label directions and safety precautions. Be extremely careful with open containers of herbicide. Application should be done on dry days to avoid spreading the chemical where it's not wanted. If you use glyphosate, you must use Rodeo®, not Roundup®, if there is any chance of herbicide reaching the stream, by overspray or drift.

Requirements for Herbicide Applicators. The use of herbicides to remove Arundo on your own property generally does not require permits or other approvals. However, this may depend on the herbicide that will be used, the size of the project area and whether the applicator is the landowner. If you plan to use herbicides to control Arundo, you should contact your county Agricultural Commissioner's office for more information. If a volunteer group or an individual other than the property owner or a licensed applicator applies herbicide, that person or a representative of the group must have pesticide safety training, obtain a pesticide operator identification number, get a pest control recommendation, obtain a letter of authorization from the landowner, and file a monthly use report with the county Agricultural Commissioner's office.

Retreatment. If it rains within 24 hours of herbicide application, retreatment is necessary.

pure Arundo can be removed by experienced contractors with heavy machinery such as flail mowers. (See Herbicide Usage and Handling for spraying equipment.)

Personnel requirements: A single person or a group can use this method, depending on the size of infestation. Use of power tools requires more space and therefore limits the number of workers in a given area. One person trained in the use and handling of herbicides is needed to spray (see Requirements for Herbicide Applicators).

Timing: The best time to cut Arundo to force resprouting is during the spring and summer. The cutting should occur early in the growing season to allow time for resprouting in the same year. Follow-up spray should be scheduled when regrowth is still small and easy to reach, approximately two months after cutting. Foliar spray can be effective throughout Arundo's growing season, but fall is optimal.

Side-effects: The greatest risk when spraying standing Arundo is the potential for spraying desirable vegetation, particularly if there is wind. To reduce over-spray, tarps can be used to cover desirable vegetation, or willows and other plants that can resprout can be trimmed back. Large equipment can substantially disrupt the soil and damage desirable species and habitat.

Cost: For very large infestations, experienced crews using flail mowers can be cost-effective. For smaller infestations, Cut, Resprout, and Spray using hand tools may also use the least amount of materials. However, the labor for multiple follow-up sprays increases the costs.

Success rate: Foliar application has been found to be 50% effective the first year and 75% effective the second year and may take 3 to 5 years for complete eradication. Effectiveness depends on the herbicide mixture used, weather conditions, the time of year, and the amount of leaf coverage.

Appropriate use: This method can be used in most situations where Arundo is not mixed with desirable vegetation. Waiting for resprouts after cutting can be impractical when working in remote areas.

Cut Stump Herbicide Application

The technique: This method entails cutting the stalks off and applying undiluted glyphosate or other appropriate herbicide directly to the stump. Sometimes, the canes are first removed by cutting the stalks off 1 to 2 feet from the ground. With the area cleared of canes, access is safer and easier. The stumps are then re-cut to within 2" or 3" from the ground and treated with herbicide. It is important to only re-cut what can be treated within a couple of minutes. The longer the wait, the less likely the cut plant will draw the herbicide down into its roots. Cut the canes off squarely to make herbicide application easier and to avoid dangerous spikes jutting out of the ground. Professional applicators often use pressurized sprayers to treat the cut stumps of large infestations. This is not recommended for homeowners because spraying undiluted herbicide can be wasteful, expensive, and result in unacceptable herbicide runoff. A pressurized sprayer requires experience to operate accurately. It must be cleaned and the rinse-water disposed of properly. A small hand pump sprayer or a sponge dauber is much more efficient for a small-scale project.

Equipment needs: Loppers, chainsaws, or brushcutters can be used to cut the canes. A paint brush, sponge dauber, or small hand pump sprayer can be used to apply herbicide (see Herbicide Usage and Handling). Use marking dye such as Markit, available at hardware stores, mixed with the herbicide to differentiate treated stems from untreated. A brush or spray-bottle are easily obtained. On larger jobs, a dauber may prevent back pain, since the applicator can stand upright while using it instead of bending over.

A dauber can be made by adapting a standard watering wand: Remove the metal screen at the watering end, and replace it with a circular piece of sponge. Use fixtures available at a hardware store to make a tight cap for the handle end. Fill the wand with herbicide. A rubber squeeze-bulb, attached with hose-clamps on the handle end, will give better control of the flow of herbicide.

Forestry Suppliers (1-800-647-5368) has a dauber-type device for sale called the Swiper.

Personnel requirements: A large group can do the initial cutting and removal of canes. At least two or three people are needed to re-cut stems and apply the herbicide efficiently. Power tools require more space and therefore limit the number of workers in a given area. One person trained in the use and handling of herbicides is needed to supervise (see Requirements for Herbicide Applicators).

Timing: Cut Stump application can be done throughout the growing season, although effectiveness may be best when herbicide is applied in late summer or early fall before the plants enter dormancy. Application after recutting should be done within 2 minutes, though some eradicators have had acceptable results applying herbicide up to 20 minutes after recutting.

Side-effects: There is a risk of spillage when using undiluted herbicide. Exercise caution when handling open containers; avoid carrying them onto the site. Using a sponge dauber poses very little risk to surrounding vegetation. Capped sponge applicator wands are the least likely to spill and more efficient than brushing. There is a slight risk of soil disturbance and erosion when removing the canes by hand.

Cost: Very little herbicide is wasted with this precise application method. Non-target losses are avoided and follow-up is minimal. Property owners can save significantly by doing the work themselves.

Success rate: This method's effectiveness ranges from 50% to 95% in the first year. Expect complete eradication to take up to 3 to 5 years. The highly variable success rates are due to factors including the herbicide used, weather conditions, the time of year, and the thoroughness of coverage.

Appropriate use: This method can be used in most cases. It is the best method when working in mixed vegetation and near water sources. This method is also ideal in remote or hard to reach areas. Return trips are minimized and it is not necessary to pack in heavy tools. It is appropriate for supervised volunteer groups because it is simple and is safe to work in close proximity.

A Comparison of Techniques for Eradication:

Method	Best Use	Timing	Tools	Permits	Advantages	Disadvantages
Cut Only	On small patches when immediate action is needed and/or when there is great concern about herbicide use.	Anytime. Best in late summer/early fall when plant energy is transferred to roots.	Loppers or power brush cutter (steel-blade weed whacker).	Fire permit if burning cane debris.	Less disturbance of soil and surrounding vegetation. No herbicide used. Can use volunteers and simple tools.	Least effective. Cane resprouts from roots and requires maintenance.
Root Removal	For exposed or overhanging root wads, small infestations.	Dry season, to avoid soil loss.	Loppers, pick and shovel. Backhoe for very deep roots.	Fire permit if burning debris. Permit(s) to work in channel with backhoe.	No herbicide used. Can use volunteers. Low disturbance of other vegetation.	Moderate to significant soil disturbance.
Spray Only	Small stands of pure Arundo, before canes are full height, located away from water.	When plant is green. Best in late summer/early fall when plant energy is transferred to roots.	Glyphosate-based herbicide appropriate for foliar application. Sprayer with directional nozzle.	County Ag Commission permit for pesticide application by non-landowner.	Low soil disturbance. Short duration of labor each season.	Takes 3-5 years of annual herbicide applications. Risk from drift to non-target plants.
Cut, Resprout and Spray	Pure stands. Large infestations	Cut in spring to summer. Spray regrowth in late summer/early fall when plant energy is transferred to roots.	Loppers or power brush cutter (steel-blade weed whacker). Glyphosate-based herbicide appropriate for foliar application. Sprayer with directional nozzle.	County Ag Commission permit for pesticide application by non-landowner.	Low soil disturbance. Less risk of non-target herbicide drift than when spraying full-grown canes. Can use volunteers for cutting cane.	Takes 3-5 years of annual herbicide applications. Risk from drift to non-target plants.
Cut Stump	Appropriate for most situations including Arundo mixed with native vegetation.	Anytime during growing season. Best in late summer/early fall when plant energy is transferred to roots.	Loppers. Full-strength glyphosate-based herbicide. Wand or paintbrush applicator.	Fire permit if burning debris. County Ag Commission permit for pesticide application by non-landowner.	Low soil disturbance. Highest success rate. Low risk of non-target herbicide drift. Can use volunteers for cutting cane. Volunteers can work near applicator. Less use of herbicide, therefore lower cost.	Requires handling full-strength application of glyphosate-based herbicide.

Note: Various methods may be combined to optimized benefits at a given site. For example, a higher mechanical cut may be used first, followed by cut stump treatment to maximize herbicide uptake. This method could be followed by a regrowth period and spraying the regrowth.

Removal and Disposal of Arundo Debris

How Dead is Dead? Arundo rhizomes can dry out for over six months and still start growing vigorously whenever they come in contact with moisture. Cut Arundo stems will usually not sprout unless in contact with water or moist soil. Canes that have been cut and stacked for over one month are generally dead. Stem sections require two nodes to reproduce because leaves and roots will not both grow from the same node. (Nodes are the joint-like rings around the stem.) Therefore, small pieces of stem with no nodes or only one node pose no risk of spreading Arundo.

Removing Arundo canes from the immediate work-site is a chore in itself on some sites. A choke chain or rope can be used to tie a bundle of canes before they are cut to prevent them from falling in the creek and to facilitate removal. A winch or a vehicle can be used to pull large bundles up steep slopes. Rope or twine can be used to bundle cut canes to ease hand removal. A tarp can be used to gather up smaller pieces and drag them to a disposal area.

Composting: If you have the space and don't mind the sight of a mound of Arundo canes, just let them sit and rot in place. The canes decompose very slowly. This method is ideal for remote areas. Make sure the pile is stacked above the high water line and out of temptation's way. A passerby may discover that the canes make great spears and throw them back into the creek.

Chipping: The canes can be chipped on site, out of the creek, with a brush or tree chipper. It can then be hauled and dumped or mulched on site. Arundo is fibrous and can get caught in the cutting blades of lightweight chippers. It will chip better when dry and brittle. A chipper may not be practical in areas that are difficult to access.

Burning: The cut canes can be burned in a pile, but there are several restrictions. A burn permit must be secured from the fire department during the fire season and may be difficult to obtain. The burn area must be containable and far from brush and overhanging trees. The Air Quality Management District requires that any material to be burned must dry out for 60 days prior to igniting. The District must be contacted to confirm a burn day. Burning can be an ideal way of disposing of the canes if you have time to wait for the material to dry and for an appropriate burn day.

Dumping: Hauling and dumping large volumes of Arundo cuttings is time-consuming and can be expensive. Many cities and some counties have programs for pick-up of yard waste. Some disposal companies and dumps do not accept Arundo because it can be difficult to chip. Dumping is appropriate when other options are unavailable or when a dumpster is donated for a general creek cleanup event and the Arundo gets "cleaned up" too.

Revegetation After Arundo Removal

Areas that are stripped of Arundo may look devastated. The surest and cheapest way to restore native riparian vegetation is to let natural succession and flooding bring in appropriate plant material. Leave the site alone for one or two rainy seasons to see how well "passive" restoration will work. In riparian sites, the stream's high flows will generally carry fresh sediment and new native plants to the lower streambanks naturally. Nearby native vegetation will often fill available spaces. This process is periodic and may take several years to complete. Often, natural processes will revegetate the lower part of the bank, but "active" methods are sometimes necessary to revegetate the higher, drier areas with native species such as oak trees, upland shrubs, and native perennial grasses. Keep in mind several considerations when considering whether to do "active" revegetation.

- You may want to postpone revegetation until you have achieved complete *Arundo* eradication, since it may be difficult to avoid harming desirable plants during follow-up herbicide treatments.
- If you are downstream of *Arundo* infestations, or near other invasive riparian plant species such as Himalayan blackberry, tree of heaven, vinca (periwinkle), or ivy, prompt revegetation with natives may be necessary to prevent re-invasion of your site.

Revegetation costs are extremely variable, depending on the needs of the site, the intensity of planting, size of the area planted, and the labor source.

If you've decided to actively restore the site, plan your project carefully. Restoration of native plant communities is an art and science unto itself, which cannot be adequately communicated in this Handbook. It is best to err on the side of caution and remember that your site affects everything downstream. Seek advice from experienced people before you act.

Develop a list of desired plant species. Choose fast-growing native species that can flourish on your site. For example, for a privacy screen at the water's edge, use willow (*Salix* species) pole plantings. These are easy to establish in moist soils and grow rapidly. For the same effect on a high bank, try coyote brush (*Baccharis pilularis*). Don't plant expensive or labor-intensive species near the waterline, since they may be washed out in their first winter. Use only native species! We already have too much non-native vegetation along our waterways. Emphasize your preference for locally native plants to any experts you consult with.

Beware that earth-moving or placing any material in the stream may require permit(s). (See *Who to Contact*.) Obtaining a permit may require you to communicate your plans in explicit detail and then wait up to several months before proceeding. You may want to avoid activities that require permits.

To maximize fish and wildlife habitat, your long-term objectives should be to eventually shade the stream, stabilize the ground surface with native plants (not annual grasses), and provide a multi-leveled structure of greenery, from small shrubs to tall trees.

To avoid wasted time, energy, and money, research the proper timing and techniques for propagating plant material. Plant most species in fall.

These sources may provide information or implementation:

- Local chapter or state office of the California Native Plant Society.
- Nurseries specializing in locally native species.
- Look for ecological restoration services in the yellow pages listings for Environmental, Conservation and Ecological Organizations, or Environmental and Ecological Services.
- Society for Ecological Restoration, California Chapter (SERCAL), at www.sercal.org or SERCAL, 915 L Street, #C-104, Sacramento, CA 95814, (805) 634-9228.



Arundo Control in the Future

Biocontrol is the use of insects or disease organisms to control harmful pests. Research has begun to investigate the feasibility of biocontrol for Arundo. If the USDA Agricultural Research Service finds suitable biocontrol agents that attack Arundo, it will still be several more years of testing before any organisms would be released.

I. Credits

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Also available by the same group: "Arundo: Streamside Invader" (a brochure); "Controlling Arundo in Your Watershed: a Guide for Organizations;" and "Arundo: Streamside Invader" (a video). For copies of these materials, call Joel Trumbo of the California Department of Fish and Game at (916) 358-2952. Or, see the Team Arundo del Norte website at www.ceres.ca.gov/tadn or email team_arundo@ceres.ca.gov.

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Illustrations

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