Practical Guidebook for the Identification and Control of Invasive Aquatic and Wetland Plants in the San Francisco Bay-Delta Region

Brazilian waterweed

Cape ivy

Dense-flowered cordgrass

Eurasian watermilfoil

Giant reed

Giant salvinia

Himalayan blackberry

Hydrilla

Pampas grass

Perennial pepperweed

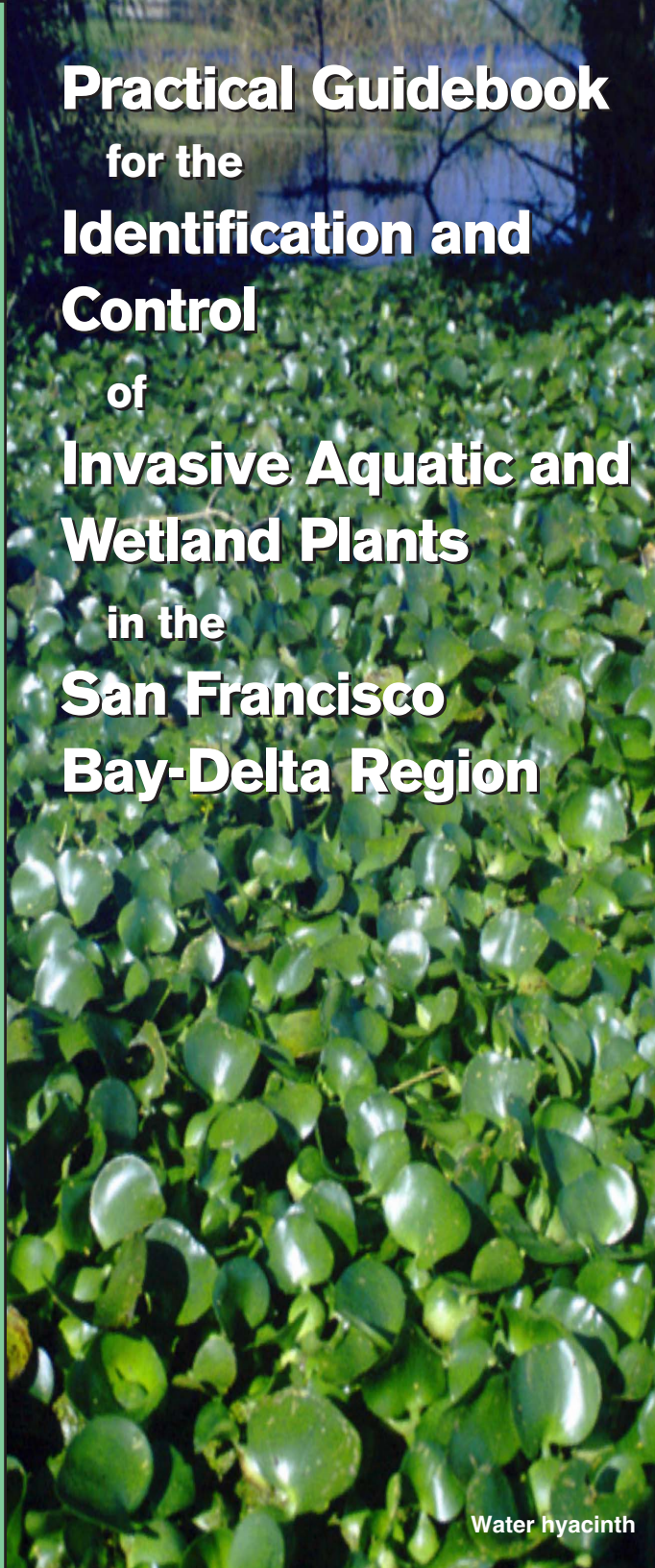
Periwinkle

Purple loosestrife

Salt cedar

Smooth cordgrass

Water hyacinth



Water hyacinth

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Also available on the web at:
http://www.sfei.org/nis/

Introduction

Why this guidebook?

Plants from around the world are invading our lakes, ponds, streams, sloughs, bays and wetlands. Some of these invasions cause serious economic and ecological problems: marinas get clogged with water hyacinth—stream sides get choked with ivy and tamarisk—native plants and animals become threatened or endangered. Local efforts can greatly help solve these problems. These guidelines are designed to help identify, prevent, and control the most serious plant invasions.

A recurrent theme in this guidebook is that prevention and early intervention is by far the best way to control invasive plants. Invasive plants often establish themselves and flourish while those people who could have identified the fledgling invasion and made a critical early intervention stand idle, because they lack familiarity with the plants, control techniques, and the trouble that lies ahead if the invasion is allowed to continue.

This guidebook's goal is to provide you with information to take action against non-native plant invasions. Early detection of invasions can save vast amounts of labor and money. Prudent land managers and their staff will be familiar with all of these species, make control plans for existing invasions, and actively look for new arrivals.

Who should read this book?

Anyone can use this book to identify serious plant invasions in aquatic and wetland habitats of the San Francisco Bay-Delta and watershed. Natural resource managers, ranchers and farmers, marina and resort operators, duck club owners and reservoir managers can use these guidelines to learn about methods for preventing and controlling the invasions, and to contact government agencies and support groups that can provide further assistance. The guidebook's minimal use of botanical terminology increases readability for all.

Why these plants?

These plants are considered by Bay-Delta invasive plant experts to represent some of the most significant threats to Bay and Delta waterways and wetlands.

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Plants in or on open water

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Brazilian waterweed (Brazilian elodea)

Egeria densa

Background

Identification

- Grows rooted in mud, submerged or floating, with stems up to fifteen feet long, 1/8 inch thick.
- Small smooth spear-shaped leaves 3/4 to 1-1/2 in. long, 1/16 to 1/8 in. wide, arranged in a whorls of 3 to 6 leaves, many whorls along stem.
- Prominent white flowers floating on water surface (or emerging just above surface), with thread-like attachment to stems.
- Compare to *Hydrilla,* p. 19.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Can reproduce from fragments of above- and below-ground stems.
- All plants in California are male (Hickman 1993).

Habitat and local distribution

- Streams, ponds, and sloughs (Hickman 1993).
- Native to South America, introduced to California more than 30 years ago and is now found in the Delta and other Bay Area freshwater. A popular plant in aquariums, it may have been introduced to Delta from an aquarium (CDBW 2003).

Impacts

- Displaces native plants and associated wildlife; shades submerged habitat.
- Dense growth impedes water flow, blocks irrigation pipes, and interferes with boating, swimming and other water recreation.

Prevention and Control

Prevention

- Invasive plant awareness and regular monitoring is critical to identify and stop a new invasion before it takes off.

- Inform the public and any boat launch area staff of the need to remove all plant debris from boats and equipment at the ramp area after each use. The California Department of Boating and Waterways (CDBW) has developed educational resources for boaters (CDBW 2003a; CDBW 2003b).
- Inform the public of the importance of refraining from dumping aquarium contents into natural water bodies.

General control notes

- Control efforts are usually most successful in areas where there is minimal movement of water, e.g., ponds and lakes (Anderson and Hoshovsky 2000).

Manual or mechanical control

- Mechanical harvesting, cutting, and rotovation—expensive and may promote spread of plant due to the sprouting of plant fragments left behind (Anderson and Hoshovsky 2000; WAPMS 2003).

  Estimated costs: harvesting costs range from $500-800 per acre, with additional costs for mobilization and equipment ($35,000-110,000) (WSDE 2001); cutting costs range from $400-3,000 for portable boat-mounted equipment to $11,000 for mechanized underwater cutters (WSDE 2001); and rotovation costs range from $1,000-1,700 per acre, depending on the size of the treatment area, plant density, equipment needed, and scale of removal (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

- Manual removal—can be used for small infestations, but care must be taken to also remove fragments and roots, which can resprout (CDBW 2000).

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; if divers and dive tenders need to be contracted, costs may range from $500-2,400 per day (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

- Dredging—may be used to remove plant material; costly and intrusive, but may be appropriate for small, seasonally dry water bodies.

Biological control

- Sterile (triploid) grass carp—stocking permit for aquatic plant management required by California Department of Fish and Game (Anderson and Hoshovsky 2000); however, not permitted in many

San Francisco Bay-Delta waterways and not suitable for water bodies with inlets and outlets.

Estimated costs: costs per fish range from $7.50-15.00 (Gibbons et al. 1999); quantity dependent on plant species, density of plant, and water temperature (WSDE 2001).

Chemical control

➢ Application of herbicides—diquat, copper-based product, acrolein, and fluridone have been applied in California in the control of Brazilian elodea; special care must be taken when applying herbicides in aquatic systems (Anderson and Hoshovsky 2000).

Estimated costs: vary depending on size of treatment area, scale of treatment, and herbicide dosage; costs per acre for materials and application by a contractor may range from $900-1,400 for fluridone. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Plants in or on open water

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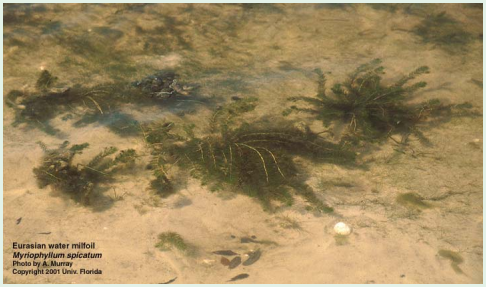

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Eurasian watermilfoil

Myriophyllum spicatum

Background

Identification

- Grows submerged, rooted in mud or sand, with branching stems 20 to 30 in. long that widen towards the root.
- Finely divided, feather-like leaves, 1/2 to 1–1/2 in. long, in groups of 4 around stem.
- Spike of flowers, 1–1/2 to 3 in. long, extends up from water surface, typically pink.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Grows rapidly, creating dense mats on the water surface.
- Can reproduce from stem fragments.

Habitat and local distribution

- Freshwater lakes, ponds, and slow-moving waters.
- Present but uncommon in Bay Area ditches and lake margins (Hickman 1993); also found in the Delta (BDOC 1994).

Impacts

- Dense mats at water surface can exclude native plants and related wildlife, shade aquatic habitat, and impede boating, swimming and other water recreation.
- Clogs irrigation pipes and canals.

Prevention and Control

Prevention

- Invasive plant awareness and regular monitoring is critical to identify and stop a new invasion before it takes off.
- Inform the public and any boat launch area staff of the need to remove all plant debris from boats and equipment at the ramp area after each use. The California Department of Boating and Waterways (CDBW) has developed educational resources for boaters (CDBW 2003).

Manual or mechanical control

- Mechanical harvesting—expensive; results in further spread of plant due to the sprouting of plant fragments left behind (Spencer, pers. comm.); not recommended unless infestation covers significant portion of the water body.

  Estimated costs: harvesting costs range from $500-800 per acre, with additional costs for mobilization and equipment ($35,000-110,000) (WSDE 2001); there may be additional fees for disposal of plant material.

- Manual removal—time-intensive but viable method for infestations of less than one acre; all fragments and roots must be removed to prevent resprouting (Bossard 2000).

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; if divers and dive tenders need to be contracted, costs may range from $500-2,400 per day (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

- Raising water levels—limits plants' access to light; may be used in conjunction with light-limiting dyes or shade barriers (Spencer, pers. comm.).

- Lowering water levels—dehydrates plants or freezes them in winter (Spencer, pers. comm.).

  Estimated costs: minimal costs if outlet structure in place, with additional potential costs due to loss in tourism or recreation (Gibbons et al. 1999).

- Suction dredging—removes underwater roots and plant material on water surface; expensive, but good for small infestations (Spencer, pers. comm.).

  Estimated costs: vary depending on plant density, equipment used, and transport fees for the removal of dredged material; costs for contract divers and dive tenders range from $1,200-2,400 per day, with additional fees for dredged material removal (Gibbons et al. 1999).

Biological control

- No insect biological control agents approved by USDA for this species in California (Bossard 2000).

- Sterile (triploid) grass carp—may work, although Eurasian watermilfoil is not a preferred food (WSDE 2001). Stocking permit for aquatic plant management is required by the California Department of Fish and Game; however, not permitted in many San

Francisco Bay-Delta waterways and not suitable for water bodies with inlets and outlets.

Estimated costs: costs per fish range from $7.50-15.00 (Gibbons et al. 1999); quantity dependent on plant species, density of plant, and water temperature (WSDE 2001).

Chemical control

➢ Application of herbicides—fluridone applied in low concentrations early in season to reduce impacts on native vegetation's active growing period (Anderson 1981).

Estimated costs: costs per acre for materials and application by a contractor may range from $900-1,400, depending on size of treatment area, scale of treatment, and dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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S. Robinson, Georgia Dept. of Nat. Res., www.invasive.org

Giant Salvinia completely covering a waterway.

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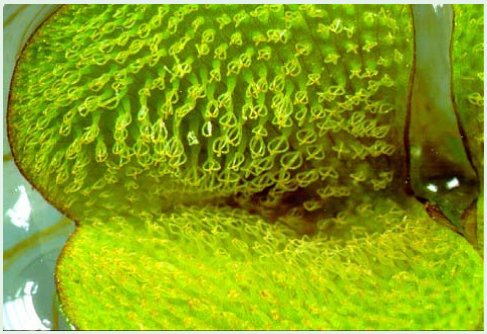
USDA APHIS – Oxford, N. Carolina Arch., www.invasive.org



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Detail of upper leaf surface.

Giant salvinia

Salvinia molesta

Anticipated Bay-Delta invader
Not yet reported in area

Background

Identification

- Free-floating aquatic fern, with no true roots.
- Leaves in sets of three, two floating, one submerged and root-like; oval floating or standing leaves are arranged in opposite pairs, each typically 3/4 in. long. In dense mats, leaves take a nested appearance, arranged on-edge in chains (see photo).
- Upper leaf surface covered with minute hair-like structures (see photo).
- Typically forms mats on water surface up to several feet thick (see photo).

Growth and spread

- Grows very rapidly, plant population can double in a week.

Habitat and local distribution

- Freshwater ditches, ponds, lakes, calm rivers.
- First seen in US in 1998; spreading through southern US, including the lower Colorado River on the CA/AZ border. Found and possibly eradicated in San Diego River (WAPMS 2003; USGS 2003).
- Potential invader of Bay Area freshwater sloughs.

Impacts

- Crowds out native plants.
- Thick mats shade shallow habitats.
- Depletes oxygen in water.
- Clogs irrigation and water supply structures.

Prevention and Control

Prevention

- Invasive plant awareness and regular monitoring is critical to identify and stop a new invasion before it takes off.
- Inform the public and any boat launch area staff of the need to remove all plant debris from boats and equipment at the ramp area

after each use. The California Department of Boating and Waterways (CDBW) has developed educational resources for boaters (CDBW 2003).

- ➢ Preventing new infestations is particularly important with *Salvinia* due to the plant's extremely rapid growth and reproduction.
- ➢ Local plant management agencies (e.g., CDFA, CDBW, and USFWS) should be contacted if *Salvinia* is discovered in the Bay-Delta watershed.

Manual or mechanical control

- ➢ Manual removal—CDFA uses this method in small ponds (Leavitt, pers. comm.); however, method not effective for larger areas.

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; if divers and dive tenders need to be contracted, costs may range from $500-2,400 per day (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

Biological control

- ➢ Sterile (triploid) grass carp—stocking permit for aquatic plant management required by CDFG (Leavitt, pers. comm.); however, not permitted in many San Francisco Bay-Delta waterways and not suitable for water bodies with inlets and outlets.

  Estimated costs: costs per fish range from $7.50-15.00 (Gibbons et al. 1999); quantity dependent on plant species, density of plant, and water temperature (WSDE 2001).

- ➢ Salvinia weevil (*Cyrtobagous salviniae*)—trials are currently underway in the lower Colorado River (Olsen 2003).

Chemical control

- ➢ Application of herbicides—CDFA applies fluridone at low rates in water bodies where there is little to no flow to maximize the herbicide's exposure time (Leavitt, pers. comm.).

  Estimated costs: costs per acre for materials and application by a contractor range may from $900-1,400, depending on size of treatment area, scale of treatment, and dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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USDA APHIS – Oxford, N. Carolina Arch., www.invasive.org

Hydrilla wrapped around a boat motor.

Hydrilla

Hydrilla verticillata

Background

Identification

Grows submerged, rooted in mud or sand.

- Small spear-shaped leaves 1/2 to 3/4 in. long, 1/16 wide, with toothed edge, arranged in a whorls of 4 to 8 leaves, many whorls along each stem.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Can reproduce from fragments of stems, rhizomes (underground stems), or roots.

Habitat and local distribution

- Canals, ponds, lakes (Hickman 1993).
- Native to Eurasia, Hydrilla infestations have been documented in Delta sloughs (USGS 2000).
- Currently not widespread in the Delta, though there is a risk of further infestations.

Impacts

- Can form huge masses throughout the water column that block water flow, shade habitat, deplete oxygen, and interfere with boating, swimming and other water recreation.

Prevention and Control

Prevention

- Invasive plant awareness and regular monitoring is critical to identify and stop a new invasion before it takes off.
- Inform the public and any boat launch area staff of the need to remove all plant debris from boats and equipment at the ramp area after each use. The California Department of Boating and Waterways (CDBW) has developed educational resources for boaters (CDBW 2003a; CDBW 2003b).

General control notes

- Essential to control is removing the vegetative and reproductive matter (Leavitt, pers. comm.).
- CDFA has a hydrilla eradication program statewide and should be contacted to discuss control efforts.

Manual or mechanical control

- Manual removal—effective for small infestations, but fragments must also be removed (Leavitt, pers. comm.).

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; if divers and dive tenders need to be contracted, costs may range from $500-2,400 per day (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

- Suction dredging—CDFA uses this method on a small scale, however fragments must also be removed to prevent resprouting (Leavitt, pers. comm.).

  Estimated costs: vary depending on plant density, equipment used, and transport fees for the removal of dredged material; costs for contract divers and dive tenders range from $1,200-2,400 per day, with additional fees for dredged material removal (Gibbons et al. 1999).

Biological control

- Sterile (triploid) grass carp—permit required by CDFG; currently authorized only in six counties in Southern California (Leavitt, pers. comm.); however, not permitted in many San Francisco Bay-Delta waterways and not suitable for water bodies with inlets and outlets.

  Estimated costs: costs per fish range from $7.50-15.00 (Gibbons et al. 1999); quantity dependent on plant species, density of plant, and water temperature (WSDE 2001).

Chemical control

- Application of herbicides—CDFA applies copper-based products which provide rapid control, and fluridone which provides slower control of the above ground vegetation in the water column (Leavitt, pers. comm.).

  Estimated costs: costs for materials and application by a contractor may range from $900-1,400 per acre for fluridone, depending on size of treatment area, scale of treatment, and dosage. It is

recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Plants in or on open water

Ben Greenfield, SFEI

Dormant hyacinth completely covering a Delta slough

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©1999, Vic Ramey, Univ. of Florida

A floating mat of flowering hyacinth.

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Water hyacinth

Eichhornia crassipes

Background

Identification

- Free-floating on surface of water, bushy, fibrous roots, often in large mats measuring tens or hundreds of feet in diameter. Can appear to be rooted in mud.
- Round or oval shiny green leaves, 3 to 8 in. across; buoyant bulbs at base of leaf stalk.
- Pale blue, purple to whitish flower with 6 petals.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Multiplies and spreads rapidly; in ideal conditions grows faster than any other known plant. New individuals can sprout from pieces of runners, and in as little as a week the number of individuals can double. Also reproduces by seed. Seeds typically sink into sediment and can remain viable for 15 to 20 years.
- Obtains nutrients directly from the water.
- Stout leaves act as sails, aiding rapid spread.

Habitat

- Native to Central/South America; released into the St. Johns River, Florida about 1885.
- Local distribution includes freshwater and brackish ponds and sloughs of the Delta and North Bay. Mats of hyacinth are seen floating downstream at certain times of year.

Impacts

- Dense contiguous mats create navigation and safety concerns in waterways, harbors, and marinas.
- Interferes with irrigation and power generation by clogging pumps and siphons.
- Can completely exclude native floating and submerged vegetation, shade habitat, change water temperature.
- Can deplete dissolved oxygen.

Prevention and Control

Prevention

- Invasive plant awareness and regular monitoring is critical to identify and stop a new invasion before it takes off.
- Inform the public and any boat launch area staff of the need to remove all plant debris from boats and equipment at the ramp area after each use. The California Department of Boating and Waterways (CDBW) has developed educational resources for boaters (CDBW 2003b).
- Inform the public to never dump aquarium contents into a natural water body; legislation to ban the sale of hyacinth as an aquarium or pond plant may reduce its spread.

Manual or mechanical control

(Huff 2000)

- Mechanical removal—may be successful for small, isolated areas, such as ponds and lakes; to eliminate the risk of resprouts, all plant fragments must be removed.

  Estimated costs: harvesting costs range from $500-800 per acre, with additional costs for mobilization and equipment ($35,000-110,000) (WSDE 2001); there may be additional fees for disposal of plant material.
- Floating barriers—used to contain plant within an area.
- Suction Dredging—efforts have included drying and burning of removed plant material.

  Estimated costs: vary depending on plant density, equipment used, and transport fees for the removal of dredged material; costs for contract divers and dive tenders range from $1,200-2,400 per day, with additional fees for dredged material removal (Gibbons et al. 1999).
- Manual removal—may be useful for small areas, but is time and labor intensive.

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; if divers and dive tenders need to be contracted, costs may range from $500-2,400 per day (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

Biological control

- CDFA tested water hyacinth-eating weevils (*Neochetina* spp.) and a moth (*Sameodes albiguttalis*) at selected sites in the Delta, but

results were less successful than expected, in part due to colder winter temperatures (CDBW 2003a; Huff 2000; WAPMS 2003).

Chemical control

➢ Application of herbicides—CDBW applies glyphosate (Rodeo®) and 2,4-D in the Sacramento-San Joaquin Delta and tributaries (Godfrey 2000).

Estimated costs: vary depending on size of treatment area, scale of treatment, and herbicide dosage; costs per acre for materials and application by a contractor are approximately $250 for glyphosate and may range from $700-1,000 for 2,4-D. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

Integrated control

➢ For control of larger infestations, mechanical removal prior to growth period, followed by herbicide application is effective (Huff 2000).

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Plants in or near the marsh

Michael May, SFEI

Cape ivy climbing Eucalyptus

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Cape ivy (German ivy)

Delairea odorata (synonym *Senecio mikanioides*)

Background

Identification

- Climbing vine with small inconspicuous yellow flowers (see photo).
- Leaves and stems are smooth, shiny, hairless, plentiful, bright green. Leaves are 1 to 4 in. long, evenly spaced on stem, with 5 to 9 lobes each.
- Easily confused with native wild cucumber *Marah fabaceus*. *Marah* leaves are not as shiny, *Marah* stems are ribbed (not smooth), *Marah* produces many spiraling tendrils and *Marah* produces distinctive round 1 in. fruit covered in spines.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Sends out runners which root and create new plants.
- Can resprout from fragments of runners or roots.

Habitat

- Native to South Africa.
- Grows well in shady and damp places, disturbed ground.

Impacts

- Highly invasive, spreads quickly, capable of blanketing native vegetation including trees (see photo).

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

General control notes

- Follow-up monitoring and treatment required to remove resprouts (Bossard 2000).

Manual or mechanical control

(Bossard 2000)

- Manual removal—use of pointed or pronged rake to remove stems and roots; plant material should be removed from site; should not be ground or dumped unbagged due to sprouting of plant fragments; supplemental vegetation should be considered to prevent erosion and invasion by other invasive plants; potential disturbance to non-target plant species since tends to grow in mats close to ground.➢
- Prescribed burning—not extensively studied since foliage has high moisture content.

Biological control

- Biological control agents— currently none are available for release in California (Bossard 2000). However, the US Department of Agriculture, Agricultural Research Service (USDA-ARS) is conducting host specificity tests on the Cape ivy gall fly (*Parafreutreta regalis*) and stem-boring moth (*Digitivalva delaireae*) (Balciunas 2003).

Chemical control

- Application of herbicides—mixture of 0.5% glyphosate, 0.5% triclopyr, and 0.1% silicone surfactant applied as a foliar spray proved effective in removal project in San Francisco; optimal time to apply is in late spring past flowering stage (Bossard and Benefield 1995); use cautiously along pond and stream banks and where water table is close to the surface (Bossard 2000).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Michael May, SFEI

Plants in or near the marsh

San Francisco Estuary Invasive Spartina Project, www.spartina.org

San Francisco Estuary Invasive Spartina Project, www.spartina.org

San Francisco Estuary Invasive Spartina Project, www.spartina.org

Dense-flowered cordgrass

Spartina densiflora

Background

Identification

- Erect grey-green stems, 1 to 5 feet tall.
- Spike-like collection of small flowers, 2–1/2 to 12 in.
- *S. densiflora* foliage is more grey and grows in compact bunches, compared to native *S. foliosa*. *S. densiflora* also blooms up to a month earlier.
- See also the entry for smooth cordgrass, *Spartina alterniflora*.

Identification key (with photos) at: San Francisco Estuary Invasive Spartina Project web site (http://www.spartina.org).

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Can spread from fragments of root or underground stem, often transported with tides. Seeds can float and may also be transported with tides (Faber 2000).
- Once established, plants spread laterally by vegetative shoots (Faber 2000).

Habitat and local distribution

- Middle to high tidal zone of salt marshes.
- Native to Chile, first established in California in Humbolt county, later introduced to Marin County in a wetlands restoration project.
- Currently *S. densiflora* is found along Corte Madera Creek, and across the Bay at Point Pinole.

For maps of distribution, refer to http://www.spartina.org.

Impacts

- Grows higher in tidal range than native plant, potentially replacing natives such as alkali heath, *Jaumea*, and western marsh rosemary, and pickleweed (Faber 2000; Grossinger et al. 1998).

Prevention and Control

Prevention

- Plant *S. foliosa* in disturbed tidal marsh areas.
- Search threatened areas regularly (at least annually) to look for newly arrived plants.

General control notes

- A large-scale invasive *Spartina* control project for San Francisco Bay and Delta was in process as this guide was published. In upcoming years this effort should produce the best control information for the region. Check the Invasive Spartina Project web site (address below) regularly.
- There is little information on control methods for dense-flowered cordgrass (Faber 2000). Control methods for smooth cordgrass should be applicable and are detailed below.

Manual or mechanical control

(Daehler 2000)

- Hand pulling—effective for small infestations and in soft substrates; underground stems (rhizomes) must also be removed.

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density (Gibbons et al. 1999). There may be additional fees for disposal of plant material.
- Solarization—mow stems and cover with geotextile fabric or heavy-duty black plastic; covering must be well secured; most effective if covered for one or more years.

Biological control

- Biological control agents—none have been approved by USDA; probably not a viable method due to potential risk to native California cordgrass (Daehler 2000).

Chemical control

- Application of herbicides—2 to 5% glyphosate (Rodeo®) along with a surfactant recommended by hand spraying; apply at low tide for maximum exposure; more than one application may be necessary; only Rodeo® registered for use in estuarine wetlands (Daehler 2000).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size

of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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San Francisco Estuary Invasive Spartina Project web site (http://www.spartina.org). Contents of site includes species ID sheets, invasion impacts, distribution maps, control program information, project documents, and related web sites.

Plants in or near the marsh

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Giant reed

Arundo donax

Background

Identification

- Huge erect stems up to 30 feet tall, 1–1/2 in. thick, typically growing in clumps.
- Smooth, arching, draping leaves, up to 3 feet long, 1/2 to 2 in. wide.
- Plume-like collection of flowers at top of plant, cream to purplish.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Does not appear to produce viable seed; spreads with underground stems or by sprouting of plant fragments.
- Can form extensive colonies.

Habitat and local distribution

- Moist places, seeps, ditchbanks, freshwater to brackish.
- Native to Europe or India, found on many Delta islands and adjacent mainland, downstream to Suisun Bay, some South Bay sloughs (Grossinger et al. 1998).

Impacts

- Displaces native plants and associated habitat through shading and groundwater reduction (Dudley 2000).
- Large colonies are fire hazards.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

General control notes

- Follow-up monitoring and treatment required to remove resprouts (Dudley 2000).

Manual or mechanical control

(Dudley 2000)

- Manual removal—combination of cutting stems and digging up roots with shovel or pickax.
- Mechanical harvesting—reduces biomass but problematic since underground stems and roots must also be removed.

  Estimated costs: harvesting costs range from $500-800 per acre, with additional costs for mobilization and equipment ($35,000-110,000) (WSDE 2001); there may be additional fees for disposal of plant material.
- Prescribed burning—does not remove underground stems and roots and may cause damage to native species.

Biological control

- Biological control agents—none have been approved by USDA for species (Dudley 2000).
- Grazing (cattle, sheep, goats)—partial success in reducing biomass of plant but does not eliminate underground stems and roots (Daar 1983).

Chemical control

- Application of herbicides—glyphosate applied by foliar spray (most effective when applied after flowering and prior to dormancy period) or concentrated solution applied directly to freshly cut stems (TNC 1996).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Team Arundo Del Norte (web site) http://ceres.ca.gov/tadn. Contains a wealth of information on *Arundo* control.

James H. Miller, USDA Forest Service, www.invasive.org

Plants in or near the marsh

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Himalayan blackberry

Rubus discolor

Background

Identification

- Arching stems, green to reddish purple, 1/4 to 3/4 in. thick, deeply angled (not round in cross-section).
- Flowers white to pinkish, 1 in.
- Spines are subtly curved, thick, most with wide bases, unlike native blackberry *(Rubus ursinus)* whose spines are straight and thin.
- Leaf generally with 5 separated leaflets, sharply toothed edges, whitish on underside; native blackberry leaf always has 3 leaflets.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Seeds are well dispersed by wildlife feeding on the ample fruit.
- Arching stems that contact ground root and create daughter plants.
- Root and stems pieces often resprout.

Habitat and local distribution

- Disturbed moist areas, roadsides.
- Needs lots of sun.
- Native to Eurasia, very common throughout Bay Area.

Impacts

- Creates dense thickets, impenetrable due to sharp spines; crowds out native plants.
- Favored by rats for food and shelter (Hickman 1993).

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

Manual or mechanical control

(Hoshovsky 2000)

- ➢ Mechanical cutting of canes—not viable method alone since roots will resprout.
- ➢ Hand digging and removal of roots—time-intensive but effective, especially for small infestations; however, all root fragments must be removed to prevent rapid resprouting.
- ➢ Mowing or hand trimming—requires several trimmings to deplete food supply; optimal time is at beginning of flowering period; roots may resprout.

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; equipment costs range may from $100 to over $1,000 (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

Biological control

- ➢ Biological control agents—none have been approved by USDA due to the potential risk to the commercial species (Hoshovsky 2000).
- ➢ Grazing—goats have been used in California to control spread of species (Daar 1983).

Chemical control

- ➢ Application of herbicides—glyphosate (as Roundup®) effective when leaves are young and actively growing, not when plants have been recently cut; apply evenly to leaf surface until wet, however dripping herbicide will harm other grasses and shrubs; triclopyr works better in lawn areas since it is not as harmful to most grasses (DNRP 2000).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Michael May, SFEI

Sprouting from buried root fragment.

Plants in or near the marsh

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Pampas grass adjacent to wetland pond in Alameda.

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Pampas grass seeding in foreground. This is the time for physical removal.

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Pampas grass

Cortaderia jubata, Cortaderia selloana

Background

Identification

- Multiple plume-like collections of white flowers, each on stout stalk, often over 6 feet high (see photo).
- Bunched mass of thin leaves, 1/2 in. wide and up to several feet long, with sharp finely serrated edges; haystack-like appearance.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Spreads from wind-blown seed. Viable seeds, genetically identical to the parent, are produced without pollination.
- Tiller fragments can sprout when soil is moist (Bossard 2000).

Habitat and local distribution

- Native to South America, now found all over Bay and Delta region in disturbed sites and a broad variety of habitats. Has been used to control erosion in serpentine soils (Danielsen et al. 2003).

Impacts

- Can form dense stands that exclude other plants.
- Sharp leaves cut skin and can limit recreational use of area.
- Dense colonies can be fire hazards.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

Manual or mechanical control

(DiTomaso 2000)

- Hand removal of seedlings and established clumps—pickax or shovel effective tools; must remove entire crown and top-section of roots to prevent resprouting.

- Prescribed burning—not an effective long-term control method due to resprouting.

Biological control

- No known biological control agents (DiTomaso 2000).
- Grazing by cattle successful in New Zealand (Harradine 1991; Gadgil et al. 1984).

Chemical control

- Application of herbicides—spot treatment with post-emergence application of glyphosate; most effective when leaves sprayed to wet but not dripping (DiTomaso 2000).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

Integrated control

- Remove top foliage by cutting or burning; treat regrowth with post-emergence herbicide (Harradine 1991).

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Kenneth M. Gale, www.invasive.org

Plants in or near the marsh

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Perennial pepperweed growing among pickleweed in the South Bay.

Perennial pepperweed

Lepidium latifolium

Background

Identification

- Smooth, green-grayish leaves.
- Up to over 6 feet high, typically 3 to 4 feet.
- Dense aggregations of tiny white flowers (< 1/4 in.).
- Has horizontal underground stem (rhizome), which can be viewed by uprooting a plant.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Can reproduce from pieces of underground stems, or by seed.

Habitat and local distribution

- Can establish dense colonies in a wide variety of environments, including marshes, meadows, saline soils, riparian areas, beaches, and disturbed areas such as roadsides, agricultural fields and irrigation channels.
- Native of Eurasia. Arrived at the East Coast of the US about 1924. In 1941 the plant was present in Solano county, and in subsequent years has spread to all 9 Bay Area counties. Present in large quantities in the South Bay and Delta, and in limited amounts in the Central Bay (May 1995).

Impacts

- Can grow in dense linear patches along sloughs and levees to the exclusion of all other vegetation; able to displace native pickleweed and other native species.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

Manual or mechanical control

- Mechanical methods such as disking do not provide control alone since plants can rapidly resprout from fragments left in soil (Young et al. 1995).
- Prescribed burning—not effective method of control alone; typical infestations may not be able to maintain burning (Howald 2000).
- Flooding—may be successful if area is flooded for a prolonged period of time; plant abundance reduced at West Navy Marsh (Contra Costa County) when tidal action returned to diked marsh (May 1995).

Biological control

- Biological control agents—testing of biological agents not a likely control method due to the risk posed to commercial crop plants in the mustard family (Brassicaceae) and native *Lepidium* species (Young et al. 1995).

Chemical control

- Application of herbicides—chlorsulfuron, triclopyr (as Garlon3A® and Garlon4®), and glyphosate (as Rodeo® and Roundup®) have shown to be effective in controlling perennial pepperweed in studies at Grizzly Island Wildlife Area in Suisun Marsh (Howald 2000).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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Michael May, SFEI

Perennial pepperweed growing in pickleweed, South Bay.

Michael May, SFEI

Perennial pepperweed growing in tules, North Bay.

Plants in or near the marsh

James H. Miller, USDA Forest Service, www.forestryimages.org

James H. Miller, USDA Forest Service, www.forestryimages.org

James H. Miller, USDA Forest Service, www.forestryimages.org

Periwinkle

Vinca major

Background

Identification

- Sprawling ground cover, arching stems that root at the tips.
- Leaves oval with pointed tip, 2 1/2 in., arraigned in opposite pairs on stem.
- Solitary flowers purple to bluish, 1 to 2 in.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Does not reproduce by seed in the wild in California.
- Spreads rapidly by runners in ideal conditions.

Habitat and local distribution

- Native to Europe. Grows in shaded damp woodland areas, often along streams, and disturbed areas (Hickman 1993; Danielsen et al. 2003).

Impacts

- Sprawling growth encroaches on native plants.
- Dense root masses exclude native herbs and other plants.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

Manual or mechanical control

(Wright 1996)

- Pulling by hand.
- Solarization—cutting plants and covering with plastic.

Biological control

- Biological control agents—None known at this time (Bean and Russo 2003).

Chemical control

➢ Application of herbicides—foliar application of 2 % glyphosate (as Roundup®) during the spring was used with success in a removal study conducted by the Golden Gate National Park Conservancy (Wright 1996).

Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

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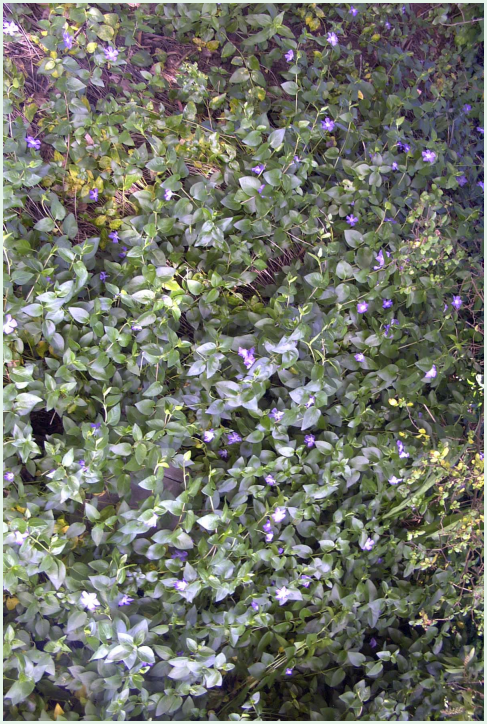
Michael May, SFEI



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Periwinkle

Plants in or near the marsh

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Purple loosestrife

Lythrum salicaria

Background

Identification

- Multiple stems rise typically less than 5 feet tall, occasionally up to 9 feet tall, leaves spear-shaped 2 to 6 in. long with smooth edges.
- Flowering stems end in a 4 to 14 in. spike of purple flowers, each with a small yellow center.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Reproduces primarily from seed, occasionally from stem fragments.

Habitat and local distribution

- Native to Europe, introduced in US by early 1880s (Grossinger et al. 1998).
- Common in disturbed wetland habitats, such as stream and river banks, edges of ponds, lakes, and reservoirs, flooded areas, ditches and roadsides, but can colonize fairly pristine wetland areas, including marshes, wet prairies, meadows, pastures, and bogs (Benefield 2000).
- Found in several places in the freshwater marshes of Bay-Delta area, generally at a low density.

Impacts

- Competes with cattails and other native marsh plants.
- Degrades habitat for waterfowl and other wildlife.
- Obstructs boating and other waterway recreation.
- Clogs irrigation systems.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.

- ➢ Search threatened areas regularly (at least annually) to look for newly arrived plants.

General control notes

- ➢ Follow-up monitoring of treated areas suggested for three years to ensure reinfestation does not occur (Benefield 2000).

Manual or mechanical control

(Monheit, pers. comm.)

- ➢ Hand digging and cutting—CDFA hand removes plant's root ball, and prior to blooming, cut and bag the flower head to prevent dispersal of seeds.
- ➢ Mowing—tests conducted in other states have shown this method to further spread rather than control purple loosestrife since plant fragments left behind can root.

Biological control

- ➢ Biological control agents—two leaf-eating beetles (*Galerucella* spp.), a root-mining weevil (*Hylobuius transversovittatus*), and a seed-eating beetle (*Nanophyes marmoratus*) are permitted for release in California; however, low density of purple loosestrife in the San Francisco Bay-Delta may not be able to maintain insect population (Monheit, pers. comm.).

Chemical control

- ➢ Application of herbicide—CDFA applies glyphosate (Rodeo®) with a R11 surfactant from a hand-held sprayer to minimize drift of herbicide (Monheit, pers. comm.).

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

References and more information

Benefield, C. 2000. *Lythrum salicaria*. In Invasive Plants of California Wildlands. Carla C. Bossard, John M. Randall, Marc C. Hoshovsky, Editors. University of California Press. Available at http://groups.ucanr.org/ceppc/Invasive_Plants_of_California's_Wildlands.

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USDA APHIS—Oxford, North Carolina Arch., www.invasive.org

Plants in or near the marsh

Jil Swearingen, USDI Nat. Park Service, www.invasive.org

Jil Swearingen, USDI Nat. Park Service, www.invasive.org

William Ciesla, Forest Health Mgt. Int., www.invasive.org

Salt cedar (Tamarisk)

Tamarix spp.

Background

Identification

- Shrub or small tree, 5 to 20 feet tall.
- Pale green leaves are small and scale-like, on thin stems with many branches.
- Flowers pink to white in color, appearing from spring to late summer.

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Habitat and local distribution

- Well-adapted to alkaline soils, wind, and a wide range of temperatures; typically found along waterways.

Impacts

- Excludes other plants from growing underneath, due to salt deposited from leaves.
- Aggressive root system depletes ground water needed by native species.

Prevention and Control

Prevention

- Plant natives or spread native seed in disturbed areas.
- Search threatened areas regularly (at least annually) to look for newly arrived plants.

General control notes

- Difficult to eradicate since species spreads rapidly and usually resprouts after treatment. Follow-up monitoring to treat resprouts essential (Lovich 2000).

Manual or mechanical control

(Lovich 2000)

- Root plowing and cutting—useful for initial removal of heavy infestations; follow-up application of herbicides suggested to treat resprouting.

  Estimated costs: vary depending on if volunteers conduct removal and on the plant density; equipment costs range may from $100 to over $1,000 (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

- Pulling by hand—uprooting of seedlings and small plants.
- Prescribed burning—useful for reducing biomass prior to herbicide application.
- Flooding— effective when thickets can be flooded for one to two years.

Biological control

- Biological control agents—USDA currently testing several insect species from other countries for release in United States (DeLoach 1997).
- Grazing—cattle grazing can reduce amounts of sprout regrowth (Gary 1960).

Chemical control

(Lovich 2000)

- Apply triclopyr (as Pathfinder II®) to bark of smaller stems (< 4-inch diameter); wet bark at base of stem prior to herbicide application.
- Treatment of resprouts by glyphosate (Rodeo® or RoundupPro®) or imazapyr (Arsenal®) during growing season; only Rodeo® is registered for aquatic habitats.

  Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

Integrated control

- Cut larger shrubs and apply triclopyr (as Garlon 4® or Garlon 3A®); use of Garlon 3A® most effective when applied during growing season (Lovich 2000).

References and more information

DeLoach, C.J. 1997. Biological control of weeds in the United States and Canada . In: Luken, J.O and J.W. Thieret (eds.). Assessment and Management of Plant Invasions. Springer-Verlag , New York , NY.

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Michael May, SFEI

Spartina alterniflora
(non-native)

Spartina foliosa
(native)

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Michael May, SFEI

Dormant Spartina alterniflora *along a channel bank in Oakland.*

Smooth cordgrass

Spartina alterniflora

Background

Identification

- Erect green stems, 1–1/2 to 7 feet tall, typically 2 to 4 feet.
- Spike-like collection of small flowers.
- Differences between non-native *Spartina* and native *Spartina foliosa* are subtle, and the two species hybridize.
- In adjacent patches, *S. alterniflora* typically appears taller and more robust than *S. foliosa.*
- Base of *S. alterniflora* stem typically reddish, while the stem of native *S. foliosa* appears green or white (see photos). Hybrid stems may or may not appear red. Any red coloration is indicative of *S. alterniflora* or hybrid.

Identification key (with photos) at: San Francisco Estuary Invasive Spartina Project web site (http://www.spartina.org).

Identification key in: Hickman, J. ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press.

Growth and spread

- Can spread from fragments of root or underground stem, often transported with tides. Seeds can float and may also be transported with tides (Daehler 2000).
- Once established, plants spread laterally by vegetative shoots (Daehler 2000).

Habitat and local distribution

- Lower elevation zone of salt marshes.
- Native to east coast of US, present in San Francisco Bay from Point Pinole (San Pablo Bay) south to the sloughs of the South Bay.

For maps of distribution, refer to http://www.spartina.org.

Impacts

- Grows lower in tidal range than native plant, reducing open mudflat habitat for shorebirds and other wildlife (Grossinger et al. 1998; Daehler 2000).

➢ Clogs flood control channels and tidal marsh channels (Collins 2002).

Prevention and Control

Prevention

➢ Plant *S. foliosa* in disturbed low-elevation tidal marsh areas.

➢ Search threatened areas regularly (at least annually) to look for newly arrived plants.

General control notes

➢ A large-scale invasive *Spartina* control project for San Francisco Bay and Delta was in process as this guide was published. In upcoming years this effort should produce the best control information for the region. Check the Invasive Spartina Project web site (address below) regularly.

Manual or mechanical control

(Daehler 2000)

➢ Hand pulling—effective for small infestations and in soft substrates; underground stems (rhizomes) must also be removed.

Estimated costs: vary depending on if volunteers conduct removal and on the plant density (Gibbons et al. 1999). There may be additional fees for disposal of plant material.

➢ Solarization—mow stems and cover with geotextile fabric or heavy-duty black plastic; covering must be well secured; most effective if covered for one or more years.

Biological control

➢ Biological control agents—none have been approved by USDA; probably not a viable method due to potential risk to native California cordgrass (Daehler 2000).

Chemical control

➢ Application of herbicides—2 to 5% glyphosate (Rodeo®) along with a surfactant recommended by hand spraying; apply at low tide for maximum exposure; more than one application may be necessary; only Rodeo® registered for use in estuarine wetlands (Daehler 2000).

Estimated costs: costs for materials and application by a contractor are approximately $250 per acre for glyphosate, depending on size of treatment area, scale of treatment, and

herbicide dosage. It is recommended to contract a licensed professional for herbicide applications (Gibbons et al. 1999).

References and more information

Collins, J. 2002. Invasion of San Francisco Bay By Smooth Cordgrass, *Spartina alterniflora*: A Forecast of Geomorphic Effects On the Intertidal Zone. Report Prepared for US EPA Region 9. May 2002.

Daehler, C. 2000. *Spartina alterniflora*. In Invasive Plants of California Wildlands. Carla C. Bossard, John M. Randall, Marc C. Hoshovsky, Editors. University of California Press. Available at http://groups.ucanr.org/ceppc/Invasive_Plants_of_California's_Wildlands.

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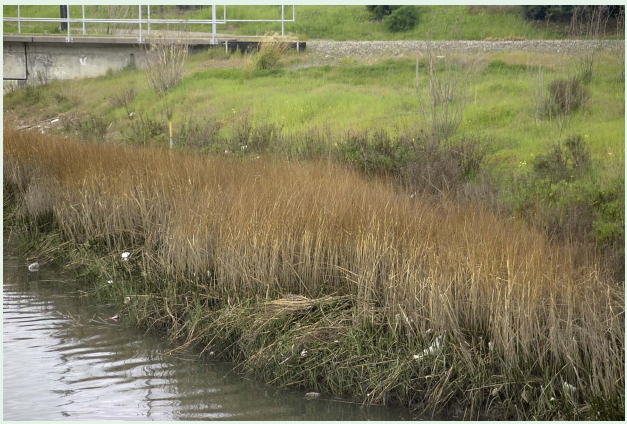
Grossinger, R., J. Alexander, A. Cohen, and J. Collins. 1998. Introduced Tidal Marsh Plants in the San Francisco Estuary: Regional Distribution and Priorities for Control. San Francisco Estuary Institute, Oakland California.

San Francisco Estuary Invasive Spartina Project web site (http://www.spartina.org). Contents of site includes species ID sheets, invasion impacts, distribution maps, control program information, project documents, and related web sites.



Michael May, SFEI

Additional resources

Publications

Clean Boating Habits. California Department of Boating and Waterways.

This booklet, which can be viewed on-line at http://dbw.ca.gov/Pubs/CleanBoatingHabits/index.htm or requested from the CDBW Public Information Office at (916) 263-0784, discusses ways boaters can prevent the introduction and spread of non-native species between water bodies.

Guide for Developing Integrated Aquatic Vegetation Management Plans in Oregon. Maribeth V. Gibbons, Mark G. Rosenkranz, Harry L. Gibbons, Jr., and Mark D. Sytsma. 1999. Center for Lakes and Reservoirs, Portland State University. Portland, OR.

This manual discusses the steps for developing an aquatic plant management plan. Useful technical references are also provided, including illustrated non-native aquatic plant fact sheets and information on various control methods.

Final Supplemental Environmental Impact Statement (EIS) For Freshwater Aquatic Plant Management. Washington State Department of Ecology, The Water Quality Program. 2001. Publication Number 00-10-040.

This EIS contains thorough descriptions of the various manual, mechanical, biological, and chemical control methods and their potential impacts. Copies can be ordered from the Washington State Department of Printing at (360) 753-6820 or at http://waprt.bizland.com/store/index.html.

Invasive Plants of California Wildlands. Carla C. Bossard, John M. Randall, Marc C. Hoshovsky, Editors. 2000. University of California Press.

This excellent book is also available on the web at http://groups.ucanr.org/ceppc/Publications/Invasive_Plants_of_California_Wildlands

Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. Mandy Tu, Callie Hurd, & John M. Randall. 2001. The Nature Conservancy.

Web sites/Organizations

California Department of Food and Agriculture—EncycloWeedia

http://www.cdfa.ca.gov/phpps/ipc/encycloweedia/encycloweedia_hp.htm

Notes on identification, biology, and management of plants defined as noxious weeds by California law.

California Exotic Pest Plant Council (CalEPPC)

http://www.caleppc.org

CalEPPC is devoted to invasive plant control in California. Informative documents such as *Invasive Plants of California Wildlands*, CalEPPC Symposium Proceedings, and quarterly newsletters can be viewed on-line.

Invasivespecies.gov—Species Profiles

http://www.invasivespecies.gov/profiles/main.shtml

This is the web site for the National Invasive Species Council, which coordinates Federal invasive species activities and programs. Provides a list of links to information available on the Web for several aquatic and wetlands plants.

King County, Washington. Department of Natural Resources and Parks, Water and Land Resources Division—Noxious Weed Identification

http://dnr.metrokc.gov/wlr/LANDS/Weeds/weedid.htm

Provides photographs and brief descriptions for identifying the species on King County's Noxious Weed List.

San Francisco Estuary Invasive Spartina Project

http://www.spartina.org

Contents of site includes species ID sheets, invasion impacts, distribution maps, control program information, project documents, and related web sites.

The Nature Conservancy, Wildland Invasive Species Team

http://tncweeds.ucdavis.edu

Provides well-researched abstracts on species management and control methods, a photography archive, and a Weed Control Methods Handbook that can be viewed on-line.

University of Florida, Center for Aquatic and Invasive Plants

http://aquat1.ifas.ufl.edu/

Provides plant information and images of native and non-native species found in Florida (including *Arundo donax*, *Egeria densa*, Eurasian watermilfoil, hydrilla, water hyacinth, *Spartina alterniflora*, *Salvinia molesta*).

United States Geological Survey, Nonindigenous Aquatic Species

http://nas.er.usgs.gov/

Provides nationwide distribution maps and sightings database for several invasive aquatic plant species.

Washington State Department of Ecology—Water Quality Program, Aquatic Plant Management

http://www.ecy.wa.gov/programs/wq/links/plants.html

Provides detailed information on control methods, including descriptions, advantages, disadvantages, and costs, and general and technical information non-native, invasive aquatic plants in Washington (including *Egeria densa*, Eurasian watermilfoil, hydrilla, water hyacinth, purple loosestrife, and salt cedar).