

ELEMENT STEWARDSHIP ABSTRACT

for

Iris pseudacorus L.

Yellow flag iris, water flag

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Author of this Abstract: Mandy Tu, The Nature Conservancy's Wildland Invasive Species Team, Dept. of Vegetable Crops & Weed Sciences, University of California, Davis, CA 95616. Phone: (530) 754-8891.

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THE NATURE CONSERVANCY

4245 North Fairfax Drive, Arlington, Virginia 22203-1606 (703) 841-5300

SCIENTIFIC NAME

Iris pseudacorus L.

The genus name “*Iris*” is the Greek goddess of the rainbow and messenger to the gods. The species epithet “*pseudacorus*” means false *Acorus*, which is the name of a somewhat similar-looking genus in the Araceae or Arum family (Bailey 1949).

SYNONYMS

Synonyms for *Iris pseudacorus* L. include: *Iris acoriformis* Boreau, *I. bastardi* Boreau, *I. curtopetala* F. Delaroché ex Redouté, *I. lutea* Lam, and *I. paludosa* Pers. (TROPICOS 2003).

COMMON NAMES

Yellow flag, yellow iris, water flag, or pale yellow iris

DESCRIPTION AND DIAGNOSTIC CHARACTERISTICS

Iris pseudacorus is a robust, clumping perennial herb in the Iridaceae (Iris family). *Iris pseudacorus* is easy to identify in flower, since it is the only totally yellow-flowered *Iris* in wildlands in the United States (Ramey 2001). At maturity, *I. pseudacorus* grows to a height of 0.40-1.5 meters (1.3-4.9 ft) tall. Its thick fleshy rhizomes often form dense horizontal mats, with each rhizome measuring 1 to 4 cm in diameter with roots that may extend vertically 10-20 (30) cm deep. The stiff, sword-like leaves are glaucous, number approximately 10 per ramet, are about 50-100 cm long by 10-30 mm wide, have raised midribs, and are arranged with sheathing and overlapping leaf bases (Crawford 2000; Jepson 1993; Sutherland 1990; Hitchcock & Cronquist 1973; Bailey 1949).

Flowers of *I. pseudacorus* are borne on tall erect peduncles. Each inflorescence may have one to several large, showy flowers (Hitchcock & Cronquist 1973). The flowers measure 8-10 cm in diameter and vary from pale yellow to almost orange in color (Sutherland 1990; Bailey 1949). The flowers are bisexual. The perianth segments (3 sepals and 3 petals) are fused at the base, and form a flaring tube with the sepals spreading and reflexed. The 3 stamens are each individually fused by their filaments to the sepals, and the showy tongue-shaped sepals are often adorned with brown spots or purple veins, and are generally less than 6 cm long. The petals are erect and less conspicuous, and are narrower than the sepals. The 3 style branches are petal-like with two-lobed lips, are mostly < 25 mm long, and are opposite and curved over the sepals (Jepson 1993; Hitchcock & Cronquist 1973). *I. pseudacorus* has an inferior, 3-chambered ovary. Fruits are elongated capsules.

Seeds of *I. pseudacorus* are pitted, pale brown, disc-shaped (roughly circular and flattened), and measure approximately 2.0-5.0 mm in diameter and 0.5-3.0 mm tall (Crawford 2000; Jepson 1993; Bailey 1949). Seeds are arranged in three densely packed vertical rows within the seed pod or capsule (Sutherland 1990). These erect capsules at maturity are a glossy green

color and measure 4-8 cm in length, 5.0-8.0 mm in width, and are 3-angled and cylindrical (Jepson 1993; Hitchcock & Cronquist 1973).

STATUS

Iris pseudacorus is listed as a state noxious weed in Vermont, is listed as noxious in one county in Montana, and is also on the Washington State Noxious “C” List, indicating that it is widespread and its control can be enforced if locally desired. *Iris pseudacorus* is also present on several other lists of plant pests, but without regulatory or legal status. For instance, it is listed on the California Invasive Plant Council (CalIPC) “B” List, indicating a wildland pest plant of lesser invasiveness, and is also a Category 2 (moderately invasive) plant in USDA-Forest Service Region 9 (Eastern Region).

STEWARDSHIP SUMMARY

Iris pseudacorus is a hardy, herbaceous perennial wetland plant that has been widely planted around the world as a showy garden or pond ornamental plant (Ramey 2001). It was first documented as escaped in North America in Newfoundland by Fernald in 1911 (Cody 1961), and is now widely established in low-elevation wetlands, ditches and marshes throughout much of North America, except in the Rocky Mountain region (Raven & Thomas 1970). It is speculated that *I. pseudacorus*' initial escape from cultivation may have been from rhizomes washing away from low-lying gardens during flood events (Thomas 1980; Cody 1961). Its subsequent spread is likely from the break-up of rhizomes or from its abundantly produced seeds (Crawford 2000). It has also been extensively planted for erosion control or to remove metals in sewage treatment plants, as it is effective at removing nutrients and trapping sediments (Gedebo & Froud-Williams 1998). Once established, *I. pseudacorus* can colonize in large numbers and form dense single-species stands, outcompeting native wetland plants and excluding native animals. *I. pseudacorus* is still widely available and sold as a garden ornamental, and continues to escape into new wildland areas.

Small patches of *I. pseudacorus* can be controlled by the physical removal of the entire rhizome system. Larger patches can be controlled either by the application of a foliar-applied herbicide alone, or by a combination of cutting followed by herbicide application to those cut leaves and stems. Glyphosate herbicides have been shown to be effective at controlling *I. pseudacorus*. Since *I. pseudacorus* frequently grows in or adjacent to water, be sure to use an aquatic-labeled herbicide and an application method that minimizes off-target effects.

HABITAT & RANGE

Iris pseudacorus is native to Europe and the British Isles, Western Asia, North Africa, and the Mediterranean region (Ramey 2001; IPANE 2001; Crawford 2000; Cody 1961). In its native range, *I. pseudacorus* is common to a variety of fertile, low-lying wetland habitats. It grows readily on sediments and litter around the margins of standing or sluggish, mesotrophic and eutrophic waters. It is also common in wet meadows, fens, swamps and reed bed, saltmarshes, and in permanently wet sand dunes (Sutherland 1990). When used as a landscaping plant along bodies of water, it commonly spreads along river- and stream-banks, lake or pond edges,

or into marshlands. *Iris pseudacorus* can also invade into floodplain forests and along rocky coastal shores (IPANE 2001; Crawford 2000).

Iris pseudacorus has been widely used in ornamental plantings, erosion control, and sewage treatment in North America since the early 1800s. It escaped cultivation, and is now documented as established in Canada from British Columbia, Saskatchewan, Alberta, Manitoba, Ontario, Quebec, Newfoundland, New Brunswick and Nova Scotia (Canadian Botanical Conservation Network; IPANE 2003). In the United States, *I. pseudacorus* is documented from Alabama, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia and Wisconsin (USDA, NRCS 2002). *Iris pseudacorus* is also documented as a wildland invader in New Zealand (Sutherland 1990).

IMPACTS AND THREATS POSED BY *IRIS PSEUDACORUS*

Iris pseudacorus is widely distributed in North America and can form dense colonies in low elevation freshwater or brackish wetlands, lake and pond shorelines, and in floodplain riparian areas (Raven & Thomas 1970). In natural areas, these colonies can invade and dominate a variety of vegetation types, displacing native plant and animal diversity, and altering successional trajectories (IPANE 2001; Crawford 2000).

Once established, its thick tuberous rhizomes can tolerate both prolonged anoxic and/or drought conditions, and its rhizomes and seeds can be transported downstream for further spread (Sutherland 1990; Jacono 2001). The rhizome mat can prevent the germination and seedling growth of other plant species. The mat also creates improved habitat for *I. pseudacorus* by compacting soil and elevating the topography, therefore creating a habitat that is drier and with increased rates of siltation and sedimentation.

Along the eastern seaboard, *I. pseudacorus* often invades open marsh areas, where it can form dense stands. Cox (1999) reports that in Connecticut, *I. pseudacorus* was able to exclude the native arrow-wood (*Peltandra virginica*), a plant whose fruits are an important food of wood ducks during the nesting season. Along the lower Potomac River near Washington, D.C., *I. pseudacorus* contributed to the conversion of riparian marshes into mesic forest dominated by *Fraxinus* species. It formed a thick rhizome mat which elevated the seed bed further above the water table, and created a drier habitat type that is favored by ashes (*Fraxinus* spp.) rather than willows (*Salix* spp.), a historic component of these marshes (Crawford 2000; Thomas 1980).

Iris pseudacorus is well established along the Frio River, a free-flowing spring-fed river in south central Texas (Jacono 2001). It also covers over 2100 km (1,300 miles) of irrigation canals and laterals near Flathead Lake and in Ninepipes National Waterfowl Refuge in Montana (Preece 1964; Rubtsoff 1950), and has been documented as growing in complete exclusion of most other native marsh vegetation along the Merced River in California (Raven & Thomas 1970). In Oregon, *I. pseudacorus* is common in coastal brackish marshes and is

able to displace native *Carex lyngbyei* marshes, as well as *Scirpus acutus*, *Carex* spp. and *Equisetum fluviatile* marshes (D. Pickering, in Randall & Rice 2003).

BIOLOGY AND ECOLOGY

Soils, Flooding and Drought Tolerance

Iris pseudacorus occurs only in temperate climates, is usually located growing in or near water, and can survive a range of environmental conditions. It occurs from sea level to 300 meters in elevation, is typically associated with sites that have continuously high soil-water content, does well in both freshwater and salt or brackish marshes, and can grow as an emergent in water up to 25 cm deep (Ramey 2001; Sutherland 1990). It is often associated with groundwater seepages or springs, and does not survive in continually drained or dry areas, although rhizomes are tolerant of droughts lasting as long as three months (Sutherland 1990). *Iris pseudacorus* may grow either with its rhizomes completely submerged and leaves emergent, or with its rhizomes contributing to mats of vegetation and litter that float in water. When under complete submersion, Hetherington *et al.* (1983) observed no growth of *I. pseudacorus*, but reported that rhizomes could survive over 8 weeks of continuous inundation. Schleuter and Crawford (2001) found that *I. pseudacorus* survived at least 28 days of total anoxia in the dark during the growing season, or up to 60 days during winter. They also found prolonged anoxia significantly reduced rates of respiration and photosynthesis, but upon return to oxidated conditions, plants recovered to full photosynthetic capacity within 3 to 10 days.

Iris pseudacorus occurs on a variety of soil types ranging from thin shingle layers of organic matter on gravel or sand, to thick mucky gleys. It often occupies habitats that are characterized by poor oxygen availability, such as lakeside muds, since it can tolerate extensive period of anoxic conditions (no free oxygen and reducing conditions), but *I. pseudacorus* can also grow in dry sandy soils (Sutherland 1990) or in peat soils (Thomas 1980).

Iris pseudacorus can survive in both high and low (relative to water level) salt marsh communities. In high salt marshes, individual rhizome clones (genets) are generally long-lived and have high rates of growth, but seedling establishment is rare (Sutherland & Walton 1990). Sutherland (1990) speculates that most seedlings die due to desiccation within their first 2 months. Conversely in low salt marsh sites, seedling establishment is common, but the persistence of *I. pseudacorus* stands depend on the continual dispersal of seeds from nearby sites, since most seedlings do not survive (Sutherland & Walton 1990). *Iris pseudacorus* can tolerate saline conditions, and populations can persist in water with a salinity level of 24⁰/₀₀ (seawater at 20 °C is 35⁰/₀₀) (Thomas 1980).

Iris pseudacorus has high nitrogen requirements (Ellenberg 1979 in Sutherland 1990), and can tolerate a considerable range of soil acidity, although it prefers acid soils (pH 3.6-7.7; average pH 6.0). It can survive freezing temperatures, but seedlings do not survive winter temperatures below -10 °C (Sutherland 1990). Marshes and swamp-marsh transitional areas typically have high light levels and *I. pseudacorus* growth generally does not seem to be light limited. However, light may be a limiting factor for *Iris* seedling establishment (Thomas 1980).

Pollination & Seed Production

Iris pseudacorus is pollinated by bumble bees (*Bombus* spp.) and long-tongued flies (Ramey 2001). Coops & Van Der Velde (1995) found that each plant produces an average of 5.6 seed-yielding pods, which produce 32-47 viable seeds each.

Seed Dispersal

Water is the primary dispersal agent for both seeds and rhizome fragments of *I. pseudacorus* (IPANE 2001). *Iris pseudacorus* seeds are buoyant (because of a hard seed coat and an internal gas space) and can remain so for at least 7 months, indicating that they can be dispersed long distances by water (hydrochory) (Coops & Van Der Velde 1995; Ridley 1930). Seeds are likely to be deposited at the high water mark, and if deposited onto exposed moist soil, seeds have high rates of germination (Coops & Van Der Velde 1995).

Seed Germination

Iris pseudacorus seeds germinate well on moist, drained soil, but do not germinate in completely inundated conditions (Gebedo & Froud-Williams 1998; Coops & Van Der Velde 1995; Thomas 1980). Even under optimal conditions, they have relatively low rates of germination (48% from freshly collected seed in Britain), and seedlings in the field are rare in most habitats (Sutherland 1990). In laboratory conditions, 85% of overwintered seeds germinated, but in field conditions, only 20% germinated the following spring, with another 20% germinating the second spring (Dymes 1920 in Sutherland 1990). Scarification of seeds, such as by a late summer fire, can increase germination success (Ellis 1965 in Sutherland 1990).

Jesson (1955 in Sutherland 1990) speculated that *I. pseudacorus* seed germination is not light dependent, but is probably more dependent on temperature. He reported that the optimal temperature for seed germination is 20 to 30°C and that seeds did not germinate below 15°C. He also noted that seeds can still germinate after being kept in seawater for 31 days.

ECONOMIC USES

Iris pseudacorus has been used primarily as an ornamental plant in water gardens, but has also been widely planted for erosion control and in sewage treatment ponds (Sutherland 1990). Many *I. pseudacorus* cultivars have been developed, with features such as variegated leaves, double flowers, or novel flower colors such as pale yellow, cream or white. *I. pseudacorus* has been used in sewage treatment plants to collect sediments and to remove heavy metals such as copper and iron from wastewater (Piccardi & Clauser 1983).

Iris pseudacorus does not provide food for native animals and contains large amounts of glycosides that are poisonous to grazing animals (IPANE 2001). All parts of the plant are poisonous, especially the rhizomes. Symptoms of *I. pseudacorus* poisoning include moderate to severe bouts of abdominal pain, gastroenteritis, nausea, vomiting, diarrhea, spasms, staggering, and paralysis (Forsyth 1976 in Sutherland 1990; Jacono 2001). Birds do not consume any part of *I. pseudacorus*, nor are they known to disperse of *I. pseudacorus* seeds (IPANE 2001; Thomas 1980).

MANAGEMENT

Potential for Restoration of Invaded Sites

As with all prolific invaders, the key to successful and cost-effective control of *I. pseudacorus* is to prevent new infestations or to begin control efforts while populations are still small and manageable. *Iris pseudacorus* has a high degree of reproductive vigor, a wide range of adaptability, and few pests and predators. It can reproduce both vegetatively and sexually, and is difficult to manage once firmly established. If controlled during the early stages of invasion, however, the potential for successful management is high.

The best control of *I. pseudacorus* will likely occur with the use of an integrated management approach, where certain control methods are combined (such as mowing followed by herbicide), and closely monitored to assess the effectiveness of that treatment. Monitoring is also useful to identify any regrowth from seeds or resprouts or any new populations, so that follow-up treatments can occur. Lastly, depending on the remnant propagule bank and/or distance to seed sources, many weed management projects must be followed by active restoration efforts to obtain desired results.

Manual and Mechanical Control

Manual or mechanical methods that remove the entire *I. pseudacorus* rhizome mass can successfully control small, isolated patches. These methods, however, are very time and labor-intensive, since even small rhizome fragments can resprout. Additionally, digging disturbs the soil, may fragment rhizomes, and promote germination of *I. pseudacorus* and other undesirable species from the soil seed bank (Jacono 2001).

Pulling or cutting *I. pseudacorus* plants may provide adequate control, but only if it is repeated every year for several years to weaken and eventually kill the plant. Dead-heading (removing the flowers and/or fruits) from plants every year can prevent seed development and seed dispersal, but will not kill those plants (Crawford 2000). Care should be taken when pulling, cutting, or digging *I. pseudacorus*, since resinous substances in the leaves and rhizomes can cause skin irritation (Cooper & Johnson 1984 in Jacono 2001).

Cutting the foliage, followed by a herbicide application (see below for details), can provide good control with minimal off-target effects (Jacono 2001).

Grazing

Grazing *I. pseudacorus* is not an option because all parts of the plant are poisonous (IPANE, 2001; Jacono 2001).

Prescribed Fire

Fire is not recommended for the control of *I. pseudacorus*, since many native wetland plants are not adapted to fire, and fire does not carry well in most wetland areas. Because of their underground rhizomes, *I. pseudacorus* can survive cool burns (Clark et al. 1998 in Jacono 2001). Sutherland (1990) reported that late summer burns did not suppress seed germination the following year. In fact, fire may encourage seeds of *I. pseudacorus* to germinate in post-fire wetlands because of the disturbance and increased light levels.

Chemical

Iris pseudacorus can be effectively controlled by herbicides. Since it usually grows in or adjacent to water, an aquatic-labeled herbicide and adjuvant must be used. Glyphosate (for example, tradenames Rodeo[®], Aquamaster[®] or Glypro[®]) applied in a 25% solution (13% a.i.) using a dripless wick/wiper applicator, or applied in a 5 to 8% solution if sprayed, when used with the appropriate non-ionic surfactant adjuvant, can effectively kill *I. pseudacorus* (R. McClain, pers. comm.).

The timing and choice of application technique will determine control efficacy and should work to minimize off-target effects. *Iris pseudacorus* can be controlled by either directly applying the herbicide to foliage, or by immediately applying herbicide to freshly cut leaf and stem surfaces. Herbicides can be directly applied to *I. pseudacorus* foliage or cut stems by a dripless wick system or using a backpack sprayer. Be sure to always take appropriate precautions and wear suitable clothing and equipment, and follow all instructions on the herbicide label. Use a dye in the herbicide mix so you can watch for accidental contact or spill of the herbicide.

Iris pseudacorus is resistant to terbutryne (Thomas 1982).

Biological Control

There are currently no biological control agents available for *I. pseudacorus* control, although it is fed upon by several invertebrates and fungi. Invertebrates known to feed upon *I. pseudacorus* include: the beetles *Mononychus punctumalbum* and *Aphthona nonstriata*, the flies *Atrichopogon pollinivorus*, *Cerodontha ireos*, *C. iridis*, and *Eumerus strigatus*, the true bugs *Pachybrachium fracticollis*, *Cymus glandicolor*, and *Adelphocorus ticinensis*, the aphid *Aphis newtoni*, and Lepidoptera *Amphipoea crinanensis*, *Archanara algae*, *A. sparganii*, *Xylena vetusta*, *Celaena leucostigma*, *Diacrisia metelkana*, *Dydraecia micaceae*, *Orthotailia sparganella*, *Plusia festucae*, *Sparganothis pilleriana*, *Spilosoma urticae*, and *Clepsis spectrana*. Additionally, the following fungi are known to feed upon *Iris*: *Ascochyta pseydacori*, *Belonium nigromaculatum*, *Belonopsis iridis*, *Botryotinia convulata*, *Ectostroma iridis*, *Mycosphaerella iridis*, *M. macrospora*, *Nectriella dacrymycella*, and *Phoma pseudacori*. The plant disease *Pseudomonas iridis* (iris root rot) has also been found on *I. pseudacorus* and can cause premature yellowing of the leaves and rot the rhizomes. However, none of the abovementioned pests or pathogens has been investigated for their potential as biocontrol agents against *I. pseudacorus* (Sutherland 1990).

Sutherland (1990) reports that vertebrates rarely feed upon *I. pseudacorus*, since it contains large amounts of glycosides.

EXAMPLES OF MANAGEMENT PROGRAMS FOR IRIS PSEUDACORUS

In West Virginia, Russ McClain (TNC) reports good control results (98% kill) using applications of 13% a.i. glyphosate (he uses Rodeo[®] in a 25% solution) plus a non-ionic surfactant and marking dye. He has applied this herbicide mixture to *I. pseudacorus* by using a dripless wick applicator to apply herbicide to either freshly cut stems or to intact foliage.

McClain recommends carrying out these treatments during the growing season, so that the herbicide can be effectively transported into the rhizome system. He reports the best results by applying herbicide early in the season (i.e. just post-bloom, mid-June in West Virginia infestations), but is still investigating the timing of applications. McClain speculates that the enhanced effectiveness of herbicide applications early in the growing season may be due, in part, to the thinner waxy cuticle on young, fresh foliage.

CONTACTS

Russ McClain, Conservation Ecologist
TNC-West Virginia Chapter
rmcclain@tnc.org

MONITORING

Monitoring is a vital component in any weed management program, and the goals and objectives for monitoring should be determined prior to any weed management activities. Monitoring can encompass several purposes, such as to determine whether changes that have occurred are due to management actions, or to survey for new weed populations or regrowth from treated plants.

To determine the effectiveness of control treatments, monitoring should optimally occur both before and after control efforts. Monitoring of this type does not necessarily need to occur every year (depending on the species and the treatment applied), but should be continued for several years following treatments to determine whether the impacts are lasting. Data collected should assess changes in abundance (percent cover or density) of both *I. pseudacorus* and of desirable native species over time. Monitoring the status of other conservation targets, such as the growth and survival of restoration plantings, the regeneration of native plant species, invertebrates, and mammals, or other community attributes, may be important indicators of ecosystem health. In general, the objectives of monitoring should track those of management. While usually considered a research technique, measuring change in both “control” (unmanaged) as well as the treated areas can be an effective way of assuring that any changes detected in treated areas are actually the result of management actions and not due to other factors. In communities that are in early successional stages or which have been recently disturbed, declines in abundance of invasive species may occur over time without management.

Monitoring can also be used to identify new infestations as well as regrowth (from buried rhizomes or from the seedbank) of the weed, and should be paired with follow-up management treatments. For instance, many invasive species have the ability to resprout after treatment, so monitoring is essential to identify those places that need to be retreated to prevent re-invasion.

Research Needs

Although much is known regarding *I. pseudacorus* biology and growth, little is known regarding how to control it. The following research topics need attention:

- 1) What are the mechanisms of *I. pseudacorus* invasion and spread in different community types?

- 2) How does competition and shading affect the growth, survival, and reproduction of *I. pseudacorus*
- 3) Which, if any, insects or pathogens control *I. pseudacorus* abundance in its native range?

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AUTHORED BY: Mandy Tu, The Nature Conservancy's Wildland Invasive Species Team.

EDITED BY: John M. Randall and Barry Rice, The Nature Conservancy's Wildland Invasive Species Team, Dept. of Vegetable Crops & Weed Sciences, University of California, Davis, CA 95616, phone: (530) 754-8891.

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