Flowering Rush

(Butomus umbellatus)

Best Management Practices in Ontario

ONTARIO INVASIVE PLANT COUNCIL

Foreword

These Best Management Practices (BMPs) provide guidance for managing invasive flowering rush (*Butomus umbellatus*) in Ontario. Funding and leadership for the production of this document was provided by Environment and Climate Change Canada, Canadian Wildlife Service – Ontario (CWS-ON). These BMPs were developed by the Ontario Invasive Plant Council (OIPC) and its partners to facilitate invasive plant control initiatives by individuals and organizations concerned with the protection of biodiversity, agricultural lands, infrastructure, crops and species at risk in Ontario.

The intent of this document is to relay specific information relating to aquatic invasive plant control practices that have been recommended by leading professionals across Ontario. This document contains the most up-to-date, effective, and environmentally safe control practices known from research and experience. It complies with current provincial and federal legislation regarding pesticide usage, habitat disturbance and species at risk protection. It is subject to change as legislation is updated or new research findings emerge. The information provided in this BMP is not to be considered legal advice. The timing windows suggested will differ throughout Ontario and by management activity and should be tailored to your region. Interested parties are advised to refer to the applicable legislation to address specific circumstances. Check the website of the OIPC (https://www.ontarioinvasiveplants.ca/) for updates.

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Inquiries regarding this document can be directed to the
Ontario Invasive Plant Council (OIPC)
380 Armour Rd, Unit 210
Peterborough, ON
K9H 7L7
Phone: (705) 741-5400
Email: info@oninvasives.ca

For more information on invasive plants in Ontario, please visit the following websites: www.ontarioinvasiveplants.ca, www.ontario.ca/page/invasive-species-ontario, www.invadingspecies.com, www.invasivespeciescentre.ca or www.ontario.ca/page/remove-invasive-aquatic-plants.

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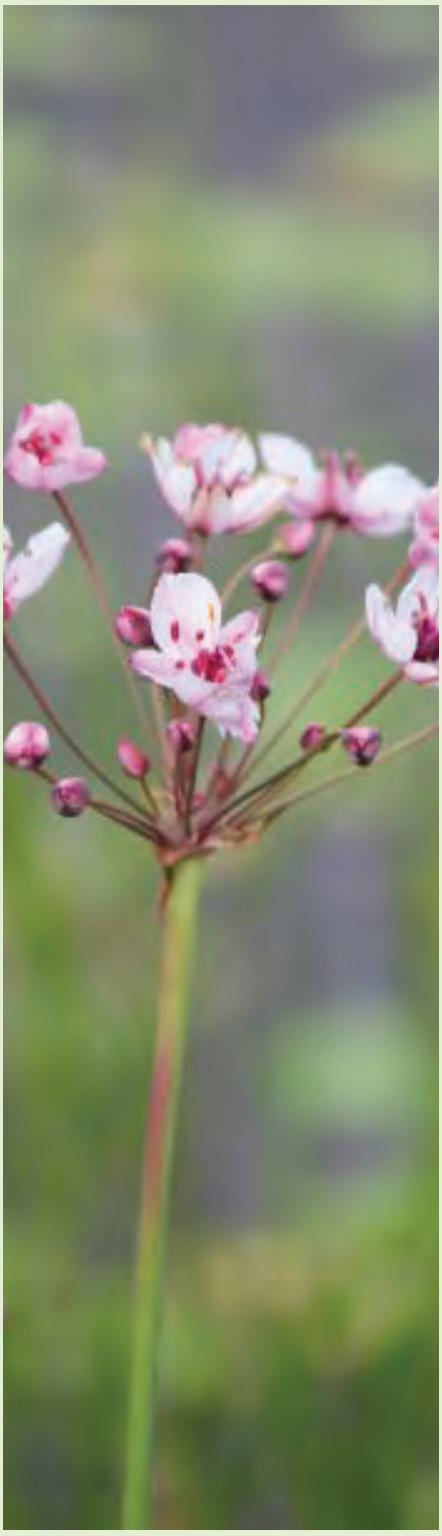


Flowering rush.

Photo courtesy of: Bill McIlveen, Dominion Seedhouse Garden, Georgetown Ontario.

Preface

Aquatic Invasive Plants

Native aquatic plant communities play an important role in sustaining healthy aquatic environments for both humans and wildlife. They provide food and shelter to a variety of animal species. Many invertebrates, fish, birds, and mammals use aquatic plant cover to escape from predators, and the shelter of aquatic plants provides nursery habitat for fish, frogs, and salamanders. Sturdy emergent plants provide nesting material for birds and mammals, and building supplies for humans who construct baskets, mats, boats and dwellings from cattail, rush and bulrush stems. They help to prevent shoreline erosion, assist in nutrient cycling, and provide calm areas for sediment to settle to the lake bottom, increasing water clarity.

A number of aquatic invasive plants threaten Ontario's waterways. These are non-native species, which were introduced to Ontario from outside their normal range by human activities and threaten the environment, economy, or society. Once established they can out-compete native plants, threaten species at risk, inhibit recreational uses of waterways (like boating, swimming or angling), disrupt storm drainage or hydro-electrical generation, increase flood probability, and in some cases, impact water quality. In recognition of the damage these aquatic invasive plants can cause, Ontario has developed an Aquatic Invasive Plant List which consists of 20 threatening aquatic invasive plants. Eight of these species threaten Ontario's wetlands, lakes and waterways making up the "Watch List", while 12 are already causing a significant impact to Ontario's aquatic ecosystems.

There are eight aquatic invasive plants that make up Ontario's Aquatic Invasive "Watch List":

- Brazilian elodea (*Egeria densa*) *
- Hydrilla or waterthyme (*Hydrilla verticillata*)*
- Parrot's feather (*Myriophyllum aquaticum*)*
- European lake sedge (*Carex acutiformis*)
- Rough mannagrass (*Glyceria maxima*)
- Common water hyacinth (*Eichhornia crassipes*)
- Water lettuce (*Pistia stratiotes*)
- Watermoss – Salvinia species (*Salvinia molesta, S. auriculata, S. minima, S. natans*)

Twelve aquatic invasive plants already found in the province are causing a significant impact on Ontario's wetlands, lakes and waterways. They include:

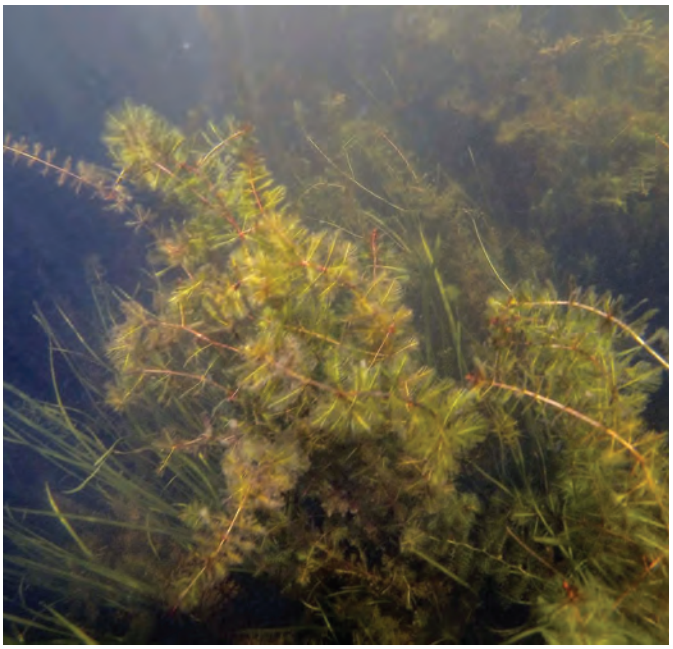
- European water chesnut (*Trapa natans*)*
- Water soldier (*Stratiotes aloides*) *
- Invasive *Phragmites* or Common reed (*Phragmites australis*)**
- European frog-bit (*Hydrocharis morsus-ranae*)***
- Carolina fanwort (*Cabomba caroliniana*)***
- Yellow floatingheart (*Nymphoides peltata*)***
- Curly-leaved pondweed (*Potamogeton crispus*)
- Eurasian water-milfoil (*Myriophyllum spicatum*)
- Flowering rush (*Butomus umbellatus*)
- Hybrid water-milfoil (*Myriophyllum spicatum x M. sibiricum*)
- Purple loosestrife (*Lythrum salicaria*)
- Yellow iris (*Iris pseudacorus*)

Aquatic invasive plant species regulated as prohibited (*) or restricted (**) under the Invasive Species Act (2015) *as of January 1st, 2018. In Ontario, it is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade these species. The prohibited (*) species are also listed in the Great Lakes and St. Lawrence Governors and Premiers "least wanted" aquatic invasive species list, as they pose an imminent threat to the Great Lakes – St. Lawrence River region.*

**** Aquatic invasive plant species under review for addition to the* Invasive Species Act (2015) *as of February 2020.*

Aquatic Plant Types

There are three types of aquatic plants: submerged, floating-leaved, and emergent. Submerged aquatic plants grow entirely underneath the water. Floating-leaved aquatic plants have leaves that float on the top of the water, and may be free-floating (the roots hang in the water and are not attached to substrate) or be rooted in the sediment at the bottom of the lake. Emergent aquatic plants usually grow in shallow water and the flowers or stems grow above the water. Control methods will differ for each plant and plant type.



Submerged aquatic plant.

Photo courtesy of: Robert Canning, Severn Sound Environmental Association.

Floating-leaved aquatic plant.

Photo courtesy of: Eric Snyder, Ministry of the Environment, Conservation and Parks.

Emergent aquatic plant.

Photo courtesy of: Alex Yakovlev, inaturalist.org/observations/37955352, licensed under CC-by-NC 4.0.

Photo courtesy of: Kyle Borrowman, Ducks Unlimited Canada.

Introduction

Flowering rush, also known as water gladiolus or grassy rush, is a moderately tall aquatic perennial that resembles a rush or a large sedge but is actually neither, being the sole member of the family Butomaceae. Native to Europe, Asia and Africa, it has become naturalized throughout the Great Lakes and other regions of Canada and the USA where it has been problematic due to its ability to displace native vegetation, alter nutrient cycling, negatively impact fish and wildlife habitat, and interfere with recreational activities and irrigation systems.

Flowering rush is believed to have been introduced to North America at two separate locations. It was first identified in North America in 1897 in the mudflats of the St. Lawrence River near Montréal, Québec, where it was thought to have been accidentally introduced in the soil ballast of ships (Columbia Basin Cooperative Weed Management Area, 2019). A second introduction, whether intentional or not, occurred along western Lake Erie and Lake St. Clair. It is likely that this species has also been intentionally re-introduced several times through the horticultural trade, because its showy flowers have made it an attractive ornamental plant for water gardens and ponds. Its popularity in water gardens has likely contributed to the spread and dispersal of this species over long distances. Once established, flowering rush mainly spreads vegetatively through rhizomes via fragmentation or rhizome bulblets. This can happen naturally through water and ice movement, or when wildlife such as muskrats, use parts of the plant as building material. It is also spread by human activities, such as gardeners or boaters who inadvertently transport rhizome bulblets and fragments on their equipment. Once established in naturalized areas, management and control of flowering rush can be very challenging.

Flowering rush is frequently found in shallow-water habitats, often occurring in wetlands alongside other native submergent or emergent species. It is a versatile plant with a number of reproductive and growth strategies which contribute to its success as an invader. It can grow both as an emergent plant with standing foliage in shallow water or a submerged plant suspended in the water column in depths up to 6 m in lakes and rivers. It can also grow as a sterile plant that flowers occasionally and produces sterile seed or as a fertile plant that flowers regularly and produces viable seed.

This document was developed to address the challenges of controlling flowering rush and to help guide the effective and consistent management of invasive flowering rush populations across Ontario.

Description

Height:

Flowering rush is a moderately tall perennial plant. When growing as an emergent plant in shallow waters, it can grow from 1.5 – 2 m in height and resemble a large sedge or rush.

Emergent

Flowering rush can grow as an emergent plant in shallow water. The leaves tend to flatten and twist spirally towards the leaf tips.

Photo courtesy of: Pavel Šinkyřík. Image has been released to Public Domain by P. Šinkyřík. Available: https://www.biolib.cz/en/image/id94639/.

Submergent

The leaves of flowering rush can grow up to 3 m when fully submersed in water. Leaves are lax and floating in deeper water.

Photo courtesy of: Mayorov Survey R, Lomonosov Moscow State University. Available: inaturalist.org/observations/19861485, licensed under CC-by-NC 4.0.

Leaves and Stems:

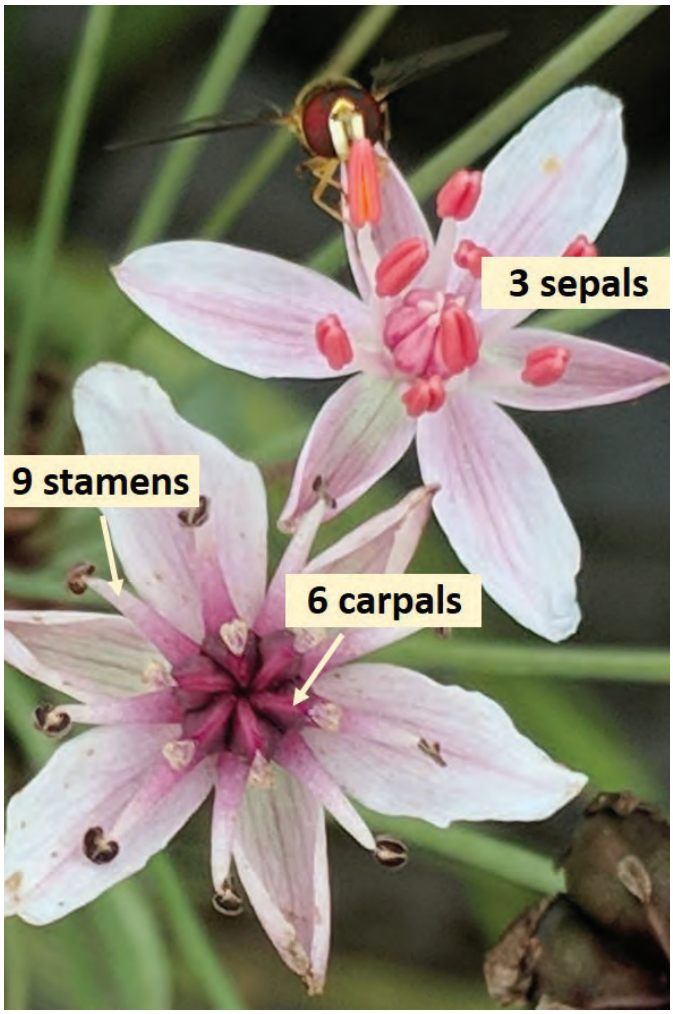
The leaves are triangular in cross-section particularly at the base and tend to flatten and twist spirally towards the leaf tips. They emerge directly from the rhizome, feel spongy and compressible, and are untoothed and parallel-veined. The leaves are long, typically 1 m when growing emerged along shorelines, but can grow up to 3 m long when fully submersed in water. The leaves can either be lax and floating when submerged in deep water or stiff and erect when found in shallow water.

Leaves are triangular in cross section.

Photo courtesy of: Derek Stone, Riverwood Conservancy.

Flowers:

It is easiest to identify flowering rush between June and September, when it is in flower. The flowers grow in umbrella shaped clusters of approximately 20 to 50 flowers. Each flower grows on a thin stalk and has three outer sepals which are smaller and may be slightly greenish, and three petals that are white to deep purple in colour. There are six carpels, each of which can produce about 200 seeds, and 9 stamens. Flowers produce abundant nectar from nectaries at the base of the carpels and are visited primarily by honeybees (*Apis mellifera*), flies (family Syrphidae), and wasps (*Vespa* spp.). Only plants in very shallow water or on dry sites (emergent plants) will produce flowers, and usually only the fertile variety will flower consistently.



Each flower has three smaller outer sepals and three petals. There are six carpels, and nine stamens. Flowers are visited by insects such as syrphids.

Photo courtesy of: Mike Tidwell. Available: inaturalist.org/observations/17424826, licensed under CC-by-NC 4.0.

Fruit:

The fruits are a dry crown-shaped seed capsule. Sterile plants produce little, if any, viable seed, while fertile plants produce an average of 8,800 seeds per inflorescence. Although these seeds can be viable, they tend not to germinate or be considered an important method of reproduction and spread.

Flowers grow in umbrella shaped clusters. The fruits are a dry crown-shaped seed capsule.

Photo courtesy of: Mike Tidwell. Available: inaturalist.org/observations/17424826, licensed under CC-by-NC 4.0.

Roots:

The roots are fleshy and rhizomatous. Similar to many invasive plants, the majority of biomass of flowering rush is in the rhizomes. Flowering rush has an extensive root system once established and rhizomes can form numerous side branches and lateral buds, which become brittle and break with age. Rhizome fragments can then break spontaneously or with even minor disturbances (i.e. wave action, animal foraging activity or boat traffic). Rhizome fragmentation (vegetative reproduction) remains the primary method of dispersal and spread for this species, in addition to breakage of rhizome buds called bulbils from the parent plant. A single plant is capable of producing 12 – 43 bulbils a year, each of which can produce a new plant. Bulbils can form both on the rhizome and on the flowers.

Rhizomes are fleshy and rhizomatous.

Photo courtesy of: Mike Tidwell. Available: inaturalist.org/observations/17424826, licensed under CC-by-NC 4.0.

Lookalikes

When flowering rush is in flower, the umbel-shaped cluster of pink – purple flowers in late summer is very distinct and unlike any other flowering marsh plant. However, when not in flower, flowering rush can be more difficult to identify as it resembles many other emergent or submergent shoreline species. For this reason, it is important to learn the distinguishing features of flowering rush and key features of other wetland plants before initiating any kind of control.

Flowering rush is a moderately tall (up to 1.5 m) plant, with leaf stems that are triangular in cross-section, parallel-veined and tend to twist towards the tip. The leaves are basal, emerging directly from a creeping rhizome, and the leaves are spongy and compressible, rebounding when squeezed.

Most sedge species, particularly in the genus *Carex* have three-sided stems ("sedges have edges") like flowering rush, but are much smaller, and none have leaves that spiral towards the tips, or are spongy/compressible when squeezed. Other look-alike species include cattails (*Typha* spp.), bur-reeds (*Sparganium* spp.), and arrowheads (*Sagittaria* spp.), however none of these have leaves that spiral towards the tip or are three-sided. Cattails have flat leaves and are parallel-veined, while bur-reed leaves show cross-venation. Sweet flag (*Acorus calamus*) superficially resembles cattail, but the leaves are four-sided (diamond-shaped in cross-section) with off-centre mid-veins, narrow flower clusters that arise from the side rather than the tip of the stem, and the rhizomes contain strong volatile oils, giving it a distinct spicy aroma. Flowering rush can also resemble the emergent stiff leaves of the invasive water soldier (*Statiotes aloides*), but water soldier has serrated leaf edges. Arrowheads, eelgrass and water soldier all arise from sterile basal rosettes of narrow linear leaves, but all of these species have cross-venation on the leaves. Tape or American eelgrass (*Vallisneria americana*), can resemble the submerged form of flowering rush but has a band of lacunae (air spaces) along the leaf midrib.

Table 1. Flowering rush and its Look-alikes.

	Flowering rush Family (Butomaceae)	**Grass Family** (Poaceae)	**Sedge Family** (Cyperaceae)
	 Photo courtesy of: Wasyl Bakowsky.	 Photo courtesy of: John F Foster.	 Photo courtesy of: John F Foster.
Plant Type	Emergent or submergent	Emergent	Emergent
Stem	• Flowering stems are round in cross-section	• Round in cross-section • **Internodes hollow** • Nodes jointed, swollen	• Usually three-sided in cross-section (except *Scirpus* spp) • **Internodes are solid** • Nodes not jointed
Leaves	• **Spiraling of emergent leaves** • **Parallel-veined** • **Triangular; spongy and compressible** • Arise basally from a stout, creeping rhizome	• Leaves do not spiral • Parallel-veined • Flat; not spongy or compressible • Two vertical rows (on opposite sides of the stem) • Sheath open	• Leaves do not spiral • Parallel-veined • Flat or v-shaped; not spongy or compressible • Three vertical rows (in three columns when viewed from the side of the stem) • Sheath closed in front
Flowers	• Perfect; umbrella shaped clusters of approximately 20-50 white, pink to deep purple flowers on an erect, leafless flowering stalk • 3 petals and 3 sepals per flower • 9 stamens, 6 pistils per flower	• Usually perfect • Each floret wrapped in 2 bracts/scales (called the lemma and palea)	• Perfect • Each floret subtended by a single bract/scale
Fruit	• Dry crown-shaped seed capsule	• Grain (caryopsis) • One seed for each flower	• Achene; lens-shaped or 3-sided, may have bristles or hairs around the base. One seed (achene) for each flower

**Key identifying characteristics have been bolded.*

	Sedge Family (Juncaceae)	**Cattail Family - Broad-fruited burreed** *(Sparganium eurycarpum)*	**Cattail Family - Common cattail** *(Typha latifolia)*
	 Photo courtesy of: John F Foster.	 Photo courtesy of: Reuven Martin, inaturalist.org/observations/29892965, licensed under CC-by-NC 4.0.	 Photo courtesy of: John F Foster.
Plant Type	Emergent	Emergent; many leaves partially submerged	Emergent
Stem	• Round in cross-section • **Internodes are solid** • Nodes not jointed	• Up to 1.2 m tall • Forms a **zigzag pattern** where flowers are positioned at each node	• Stems over 1 m tall
Leaves	• Leaves do not spiral • Parallel-veined • Flat or round; not spongy or compressible • Three vertical rows • Arise basally • Sheath open in front, often auricled	• V-shaped, 6-19 mm wide • Spongy at base, flexible, ribbon-like • Cross-veined	• Flat, 10-25 mm wide • Spongy but very strong • Parallel veined
Flowers	• Perfect • Two series of three, petal-like structures, which are actually the sepals and petals that surround the pistil	• Tiny, round and green • Male flowers 1-2 cm wide and **bur-like**, female flowers 3-4 cm wide	• Tiny, in dense spikes • **Male spike at stem tip 10-20 cm long, female spike immediately below** • Female spikes green in early summer, brown with age
Fruit	• Three-part capsule with many small, black seeds	• **Nut-like achenes** • Flat at tip, beak-like **2-pronged, persistent style**	• Minute achenes, with many brown hairs, which gives mature spikes their brown colour.

**Key identifying characteristics have been bolded.*

Reproduction and spread can occur through breakage of rhizome fragments.

Photo courtesy of: Peter Rice, University of Montana.

Biology and Life Cycle

Ploidy: number of sets of chromosomes in a plant cell.

North America has been colonized by two reproductive types of flowering rush: a diploid and a triploid type. The diploid type has two sets of chromosomes and is sexually fertile, being capable of three methods of reproduction. These include developing flowers and viable seed in the summer months, producing vegetative bulbils on the rhizomes or the flowers, and by breakage of rhizome fragments and branches. Triploid plants have three sets of chromosomes and are sexually sterile. They produce sterile flowers that rarely bloom, rarely produce any viable seed, and rarely produce vegetative bulbils, although they tend to produce more highly branched rhizomes than the diploid plants, allowing their rhizomes to fragment and break off more easily. There may be ecological trade-offs between the two types. For example although the sterile triploid type has a more limited capacity for spread as it can only reproduce one way (i.e. via rhizome fragmentation), it can also survive a broader range of environmental conditions than the fertile diploid type and as such, are geographically spread more broadly and thinly across North America than diploid types. Fertile diploid types, in contrast, may be able to spread more quickly within a local area but have a lower tolerance to high nutrient levels and environmental change and are more restricted in their range (Lui *et al.*, 2005). These reproductive differences also have important implications for the management of this species, as will be described in further detail, below.

Flowering rush will initiate growth in early spring typically in late February to mid-April, which is sooner than native aquatic vegetation. Leaf growth is rapid and peaks during mid-summer, then senesces in the fall. Flowering rush is very cold tolerant, but during the fall frost the leaves will die back and collapse to the ground instead of remaining upright like cattails.

Flowering rush along the shoreline of Ramsay Creek, Ontario.

Photo courtesy of: Rosario Castanon Escobar, Rideau Valley Conservation Authority.

Habitat

Flowering rush can grow in a variety of aquatic environments. It tends to prefer shallow areas with fluctuating water levels such as along shorelines, wetlands, lakes and irrigation canals, although it is also versatile and can be found in flowing water and in various substrate types (i.e. muddy or rocky). It is less likely to establish in areas with stable water levels, as periods of low water levels support growth of new plants. It can grow as an emergent plant along shorelines and as a submerged plant, going out to water depths of up to 6 m (deeper than native cattail which reaches depths of 2 m), although they are most abundant in water depths of less than 1.3 m (Madsen *et al.*, 2016). The different reproductive types also vary in the habitat in which they are found, with fertile diploid types more commonly occurring in shallow, emergent habitats and sterile triploid plants more commonly in deeper submerged habitats (Lui *et al.*, 2016). It is intolerant of salt or brackish waters.

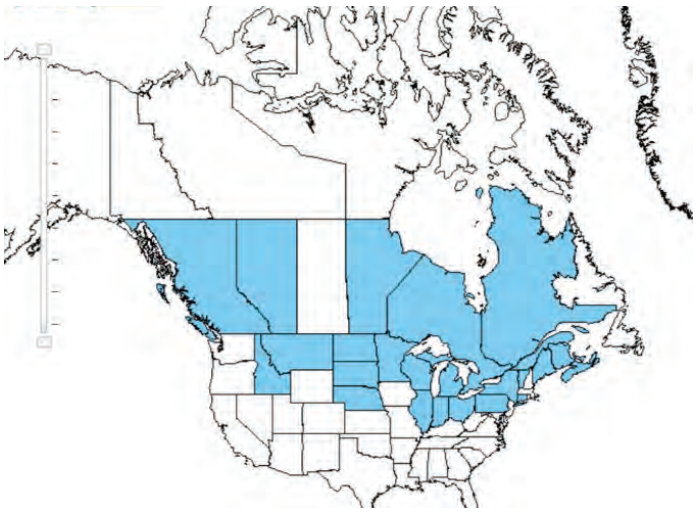
Pathways of Spread and Distribution in Ontario

Flowering rush was discovered in North America by 1900 in two separate locations, indicating two separate introductions: in eastern Lake Ontario/St. Lawrence River, and in western Lake Erie and Lake St. Clair. It is thought to have been both accidentally introduced, through soil ballast and packing material, and intentionally introduced, through the horticultural trade. In Ontario, populations are still most concentrated in the two areas of initial introduction, and more thinly scattered throughout the Great Lakes region, and in regions as far north as Thunder Bay.

In its introduced range, there are differences in geographical distribution between sterile triploids and fertile diploids. Diploid populations, which are capable of spreading both by seed and rhizome/ bulbils, are mainly found in the two locations where the species was first introduced (eastern Lake Ontario/St. Lawrence River, and western Lake Erie and Lake St. Clair), while sterile triploids are more thinly scattered to the north, far-east and far-west of the introduced range. Sterile triploids predominate in the western and eastern Canadian provinces, as well as the Columbia Basin, Indiana, Minnesota, North Dakota, Maine and Montana (CBCWMA, 2019). The more widespread range of triploids may be because they can tolerate a broader range of environmental conditions than diploids; however, the most likely cause is that triploids are the main plant type sold by the horticultural industry due to their larger, showier flowers (Lui *et al.,* 2005). Flowering rush can spread over large distances through ornamental garden planting, which remains one of the most important vectors for dispersal. It can also disperse to new areas when pieces of rhizome or bulbil fragment break from the parent plant due to some disturbance, such as wave action caused by boating, or wildlife foraging.

In North America, flowering rush is widely naturalized in wetlands, lakes, ditches, and slow-moving rivers in 21 U.S. states and 9 provinces. In Canada it has been found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. In the United States, it is abundant in the Great Lakes states, and in the northern states closest to the Canadian border and is becoming an increasing problem in the far western U.S., including the Columbia River Basin. It has a very wide range of hardiness (zones 3-10) which makes it capable of being widely invasive in the United States and Canada

For up-to-date distribution maps, please visit www.EDDMapS.org/ontario or www.inaturalist.ca.



Flowering rush distribution in Canada and the United States.

Map courtesy of: United States Department of Agriculture, Natural Resource Conservation Science.

Flowering rush infestation.
Photo courtesy of: Ben Legler.

Impacts

Ecological:
Flowering rush has a moderate level of impact in Great Lake aquatic ecosystems. Although it can be found in sparse patches amongst native vegetation, it also has the potential to dominate wetland sites once established, forming dense monocultures that displace native vegetation and reduce biological diversity. At high densities, flowering rush may form a mat of plants which can separate and float on the surface and accumulate sediment, filling in shallow margins (littoral zones) of lakes or wetlands. For this reason, flowering rush has been called an 'ecosystem engineer'.

In addition to accumulating sediment, flowering rush can increase water temperature, alter nutrient flows, and significantly alter fish habitat by covering open water normally used by native fish for spawning. These dense stands provide ideal shelter for predatory fish such as northern pike (*Esox lucius*), which is a non-native and invasive species west of the continental divide in North America and which preys on native species like salmonids (McPhail and Lindsey, 1970; CBCWMA, 2019). For example, in the Flathead River of the Columbia River Basin, juvenile northern pike are associated exclusively with flowering rush infestations, which provides rearing habitat for the larval and early juvenile stages of northern pike.

Flowering rush can threaten other shallow water native emergent species, such as wild rice (*Zizania aquatica*), which provides habitat for species at risk in Ontario, such as Least Bittern (*Ixobrychus exilis*) and Black Tern (*Chlidonias niger*). Changes in water levels may promote the spread of flowering rush, helping populations to expand when water levels are low and the soil surface is exposed. However, flowering rush does not tend to be as aggressive as some other aquatic invaders in Ontario. In a sampling study along the St. Lawrence River in Quebec, native species diversity was still higher in areas dominated by flowering rush compared to sites dominated by *Phragmites australis* or reed canary grass (*Phalaris arundinacea*). It also has a smaller rate of long-distance spread compared to other species like purple loosestrife (*Lythrum salicaria*), as it spreads more locally by rhizome fragmentation than long distance by seed (Lavoie *et al.,* 2003). It is important to note that flowering rush can establish and succeed in pristine sites inhabited by native plants and is frequently found growing alongside other native plants (Madsen *et al.,* 2016).

Flowering rush can grow extensively in reservoirs and ditches.

Photo courtesy of: Janet Mason, Ottawa Stewardship Council.

Economic:

Flowering rush can grow extensively in reservoirs and ditches, impacting irrigation and power dam management, as well as interfering with recreational activities such as boating, fishing and swimming. Since irrigation canals and dam reservoirs fluctuate seasonally in water depth, they create ideal conditions for the establishment and spread of flowering rush, as exposed soils in late winter to early spring are moist with little competition from native vegetation. For example, a canal in the Aberdeen-Springfield system in Idaho requires management action for flowering rush every two or three years (CBCWMA, 2019). It also impacts swimming by providing ideal habitat for the great pond snail (Lymnaea stagnalis), an intermediate host for the parasite that causes swimmer's itch (CBCWMA, 2019).

Table 2.

Species listed under the federal *Species at Risk Act* for which flowering rush is identified as a threat in Ontario.

Species at Risk	Status	Habitat/Details	Primary Threat from Flowering Rush
Least Bittern (*Ixobrychus exilis*)	Threatened	• Smallest member of the heron family • Able to breed and nest in a variety of emergent plants including stands of invasive species but has a strong preference for cattail marshes with a mix of open pools and channels • Builds its nest above the marsh water in stands of dense vegetation, hidden among the cattails. Nests are almost always built near open water, which is needed for foraging • Typically found south of the Canadian Shield, especially the central and eastern parts of the province, with small numbers breeding occasionally in northwest Ontario. It has disappeared from much of its former range, especially in southwestern Ontario due to loss of wetlands	• Threat assessment: Invasive species like flowering rush are a medium level of concern* • Can displace native emergent plants like cattail and degrade marsh habitat • Changes the conditions for nest building (i.e. alters vegetation composition)
King Rail (*Rallus elegans*)	Endangered	• Ontario's largest rail; secretive • Prefers shallow, densely vegetated freshwater marshes • Northern limit of breeding range is in southern Ontario with only ~30 pairs left (MNRF SAR website). Thinly spread, preferring larger coastal wetlands along Lake St. Clair, Lake Erie, Lake Simcoe and Kingston, as well as inland marshes in the Bruce Peninsula • Nests are dinner-plate sized platforms made of plant material just above the water in shrubs or clumps of marsh plant	• Threat assessment: Invasive species, like flowering rush are a high level of concern* • Changes the conditions for nest building (i.e. alters vegetation composition)
Swamp rose-mallow (*Hibiscus moscheutos*)	Special Concern	• Perennial wetland plant of the Malvaceae family • Most commonly found in deep-water cattail marshes and meadow marshes. • Restricted to shoreline marshes in Ontario, in the Carolinian and Great Lakes – St. Lawrence forest region, Lake Erie, Ontario or St. Clair	• Requires early successional habitat and can be outcompeted by invasive exotic plants like flowering rush • Flowering rush is known to occur with swamp mallow populations • Threat assessment: Invasive exotic plants are a high level of concern*

***Level of Concern:** Criteria indicating whether managing the threat is a high, medium, or low concern for the recovery of the species, consistent with population and distribution objectives.*

Applicable Legislation

Requirements, such as permits, that could apply to aquatic invasive plant control activities will depend on the location of removal in Ontario, as well as the timing and type of activity (e.g. mechanical/manual or chemical) being undertaken. This document does not provide an exhaustive list of permits or rules that may apply to every situation where control is being undertaken. It summarizes some of the agencies that may need to be contacted prior to aquatic vegetation removal, depending on the species, location, and activity. It is the responsibility of the individual undertaking the control activities to comply with any applicable legislation. In the event that there is a discrepancy between the information provided and the legislation, the legislation shall prevail.

Aquatic Invasive Plant Removal in Provincial Crown Land and Shorelands (Mechanical/Manual Control)

In Ontario, the beds of most waterbodies are provincial Crown land. The Ministry of Natural Resources and Forestry (MNRF) manages these lands under the *Public Lands Act*. The *Public Lands Act* applies to the use of provincial Crown land and shore lands. The Act does not apply to federal lands and water bodies, for example protected heritage areas managed by Parks Canada (National Parks, National Marine Conservation Areas and National Historic Sites including the Rideau Canal and Trent-Severn Waterway) or by Environment and Climate Change Canada (e.g. National Wildlife Areas) and certain isolated waterbodies on private lands.

According to the Regulations prescribed in O. Reg. 239/13 under the *Public Lands Act*, a person may remove invasive aquatic plants such as Flowering rush by mechanical means or by hand without a permit if they follow all of the rules for removing aquatic invasive plants (https://www.ontario.ca/page/remove-invasive-aquatic-plants). These rules include following the In-Water Work Timing Window Guidelines (https://www.ontario.ca/document/water-work-timing-window-guidelines) established to protect fish from impacts during spawning, migration and other critical life stages.

If you cannot meet all of the prescribed rules or want to conduct control or removal activities outside of the timing window guidelines, you will need a work permit to remove flowering rush. Information on how and when you need a work permit for projects on Crown land and shore lands as well as permit applications can be obtained online or by contacting your local MNRF office (see Table 3).

Aquatic Invasive Plant Removal in Federal Lands and Waters

Parks Canada:
Rideau Canal or Trent-Severn Waterway

For federal waters under the authority of Parks Canada, authorization is required from the Parks Canada Agency for any plant removal activity in these waters. If there is critical aquatic species at risk habitat on Parks Canada land, Fisheries and Oceans Canada (DFO) might also be involved. Within the Ontario Waterways (Rideau Canal and Trent Severn Waterway), permit applications and guidelines for aquatic plant removal can be obtained online (see Table 3 for contact information). Depending on the scope of the project, a permit for control work might involve one of two pathways. For residential or smaller projects, please see policies for In-water and Shoreline Works and Related Activities. https://www.pc.gc.ca/en/docs/r/poli/page01, or for larger projects please see policies under the Research and Collection Permit http://www.pc.gc.ca/apps/rps/page1_e.asp.

Federal waters that are not regulated by Parks Canada are generally under the authority of DFO, and information about requirements related to

projects near water can be obtained online. The requirements under Ontario's *Invasive Species Act* would still apply to any designated plants transported off federal lands (i.e. for disposal).

Other Federal Lands & Waters

Other federal lands and waters include national wildlife areas, national marine conservation areas, some migratory bird sanctuaries, First Nations reserve lands, federal ports, harbours, anchorages, aquatic sites under the Federal Contaminated Sites Program, and other waters within federally-owned land.

Aquatic Species:

Federal waters that are not regulated by Parks Canada are generally under the authority of DFO when it comes to aquatic invasive species. Activities such as the removal of aquatic plants, may require authorization(s) from DFO if fish or fish habitat and/or aquatic species at risk may be impacted. DFO is responsible for administering the *Fisheries Act*, federal legislation that provides protection of all fish and fish habitat. Under the *Fisheries Act*, no one may carry out work which would lead to the death of fish, or to the harmful alteration, disruption or destruction of fish habitat without a permit. If a removal project might impact an aquatic species at risk, then authorization from DFO is required prior to undertaking any projects. A Request for Review form outlining the project and the potential impact on fish and fish habitat would need to be submitted to fisheriesprotection@dfo-mpo.gc.ca. A biologist would then review the project to determine if a *Fisheries Act* Authorization or Species at Risk permit is required. For more information, visit: http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html.

Terrestrial Species:

Environment and Climate Change Canada is responsible for issuing permits involving terrestrial species at risk for federal lands and waters not regulated by Parks Canada. The *Species At Risk Act* (SARA) contains prohibitions against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals of threatened, endangered, and extirpated species listed in Schedule 1 of the Act. The Act also contains a prohibition against the damage or destruction of their residences (i.e. nest or den).

Photo courtesy of: Suzanne Labbe, https://www.inaturalist.org/observations/38390022, licensed under CC-by-NC 4.0.

These prohibitions apply to individuals of such SARA-listed species that are:

- found on federal lands in a Province, or on lands in a Territory under the authority of the Minister of the Environment and Climate Change or Parks Canada;
- migratory birds protected by the *Migratory Birds Convention Act*, 1994 (MBCA), anywhere they occur, including private lands, lands in a province, in a territory, or federal lands; and,
- aquatic species anywhere they occur, including private lands, lands in a Province and lands in a Territory.

For further information on *Species at Risk Act* permitting and when a SAR permit is required, visit: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/permits-agreements-exceptions/general-questions-answers.html.

Any further questions can be directed to the appropriate Environment and Climate Change Canada regional office: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/permits-agreements-exceptions/contact-coordinator-regional-offices.html#Ontario.

Small Craft Harbours

If your property is located in a small craft harbour (https://www.dfo-mpo.gc.ca/sch-ppb/index-eng.html), you must contact DFO before controlling aquatic plants such as flowering rush (http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html).

Aquatic Invasive Plant Removal Using Herbicides

Under the federal Aquatic Invasive Species Regulations, the use of herbicides may be authorized by Fisheries and Oceans Canada, Parks Canada or the Ontario Ministry of Natural Resources and Forestry to prevent the introduction or spread of, or to control or eradicate non-native aquatic plants. You can apply for an authorization here: https://www.dfo-mpo.gc.ca/species-especes/ais-eae/applyappliquer/page01-eng.html. In addition, if you plan to use herbicides to control aquatic invasive plants anywhere in Ontario, approval is also required from the Ontario Ministry of the Environment, Conservation and Parks (MECP). Information on requirements for aquatic herbicide applications can be obtained by contacting a MECP regional office to discuss plans and what pesticide permits may be required: https://www.ontario.ca/page/ministry-environment-conservation-parks.

You must not undertake any in-water work during fish spawning season or during the time of other critical fish life stages. The following link contains information on when in-water work is restricted within Ontario: https://www.ontario.ca/document/water-work-timing-window-guidelines.

Table 3. Contact Information (Summary)

	Location	Activity	First Contact	Contact Information
Federal	Rideau Canal or Trent-Severn Waterway	Manual/Mechanical	Parks Canada	**TSW:** 705-750-4900 or Ont.Trentsevern@pc.gc.ca **Rideau:** 613-283-5170 or RideauCanal-info@pc.gc.ca
Federal	Federal waters other than the Rideau Canal or Trent-Severn Waterway	Manual/Mechanical	Environment and Climate Change Canada, Canadian Wildlife Service	905-336-4464 or https://www.canada.ca/en/environmentclimate-change/services/species-riskpublic-registry/permitsagreements-exceptions/contact-coordinatorregional-offices.html#Ontario
Federal	Federal waters other than the Rideau Canal or Trent-Severn Waterway	Manual/Mechanical	Fisheries and Oceans Canada, Fish and Fish Habitat Protection Program	1-855-852-8320 or http://www.dfo-mpo.gc.ca/pnw-ppe/contact-eng.html 905-336-4464 or https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/permits-agreements-exceptions/contact-coordinator-regional-offices.html#Ontario
Federal	Small Craft Harbour	Manual/Mechanical	Fisheries and Oceans Canada, Small Craft Harbours Division, Regional Director	204-983-5721 or https://www.dfo-mpo.gc.ca/contact/sch-ppb-eng.html
Provincial	Crown Land (in Ontario the beds of most water bodies are Crown land)	Manual/Mechanical	Ontario Ministry of Natural Resources and Forestry	1-800-667-1940 or www.mnr.gov.on.ca/en/contactus
Both	All locations in Ontario	Chemical	Ministry of the Environment, Conservation and Parks	1-800-565-4923 or https://www.ontario.ca/page/ministry-environment-conservation-parks

Other Information

Table 4. Summary of legislation involving aquatic plant removal

Legislation & Regulating Body	Summary of Purpose	Application to Management	For More Information
Constitution Act/ British North America Act (Ontario and Canada share responsibility for protecting fish) Ministry of Natural Resources and Forestry (Ontario) Fisheries and Oceans Canada (Canada)	Protection of Fish	**In-Water Work Timing Window Guidelines:** In-water work is restricted during fish spawning season of other critical fish life stages. A work permit is required for the removal of any aquatic invasive plants within a timing window.	In-Water Work Restrictions: https://www.ontario.ca/document/water-work-timing window-guidelines
Federal			
Department of Transport Act Historic Canals Regulations		If located within **Rideau Canal** or **Trent-Severn Waterway**, a permit from Parks Canada will be required for any aquatic invasive plant removal.	Rideau Canal: http://www.rideau-info.com/local/local_legislation.html
Fisheries Act Fisheries and Oceans Canada	Protection of Fish and Fish Habitat	No one can carry out work which would lead to the death of fish, or the harmful alteration, disruption or destruction of fish habitat. If there is risk of harm to fish or their habitat, authorization from DFO is required prior to undertaking any projects.	Fisheries and Oceans Canada Regional Offices: http://www.dfo-mpo.gc.ca/regions/contact/index-eng.htm To remain in compliance with the *Fisheries Act* and the SARA consult the guidance found at the following websites: projects near water http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html and permitting https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/permits-agreements-exceptions/general-questions-answers.html
Fisheries Act – Aquatic Invasive Species Regulations Fisheries and Oceans Canada	Protection of Fish and Fish Habitat	The use of herbicides may be authorized to prevent the introduction or spread of, or to control aquatic invasive plants that may cause harm to fish, fish habitat or use of fish.	Apply to prevent, control or eradicate an aquatic invasive species https://www.dfo-mpo.gc.ca/species-especes/ais-eae/apply-appliquer/index-eng.html

Legislation & Regulating Body	Summary of Purpose	Application to Management	For More Information
Species at Risk Act (SARA) Environment and Climate Change Canada	Protection and Recovery of Species at Risk and their Habitats	Permits are required by those persons conducting activities such as aquatic invasive plant management that may affect species at risk or damage habitat. For activities that may affect species listed on Schedule 1 of SARA and for activities which contravene SARA's general or critical habitat prohibitions, permits may be required. The SARA applies to terrestrial lands including federal lands, parks, national marine areas for aquatic critical habitat.	For more information on species at risk, critical habitat, or obtaining a permit, consult: https://wildlife-species.canada.ca/species-risk-registry/sar/permit/permits_e.cfm
Migratory Birds Convention Act (MBCA) & Regulations Environment and Climate Change Canada	Protection of Migratory Birds, and their Nests and Eggs	No person or vessel shall deposit a substance that is harmful to migratory birds, or permit such a substance to be deposited, in waters or an area frequented by migratory birds or in a place from which the substance may enter such waters. Permits are not issued for waterbodies where migratory birds may be present.	Learn more about the MBCA Act: https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legalprotection/convention-act-regulations.html
Provincial			
Lakes and Rivers Improvement Act (LRIA)		The *Lakes and Rivers Improvement Act* (LRIA) regulates the design, construction, operation, maintenance and safety of dams in Ontario. LRIA approval may be required when constructing a new, or altering an existing, dam, water crossing, channelization, enclosure, and/or pipeline or cable. Proponents should be aware of the LRIA during the approval and permitting process for works that may need to be reviewed against this legislation.	LRIA administrative guide: https://www.ontario.ca/page/lakes-and-rivers-improvementact-administrative-guide
Conservation Authorities Act		Under the *Conservation Authorities Act*, conservation authorities regulate activities in and around areas affected by water-related natural hazards, such as flooding and erosion. These areas include watercourses, wetlands and shorelines. A permit may be required from your local CA for activities in these areas, including aquatic invasive plant removal. Contact your local CA to find out if your project requires a permit.	Find your local CA: http://www.conservation-ontario.on.ca/

Invasive Management Planning

Management Considerations

Preventing the establishment and spread of aquatic invasive plants like flowering rush is more cost-effective than eradicating or managing populations once established in a water body. Early detection and rapid response is key to preventing negative impacts on biodiversity, the economy, and society. For tips on prevention, see "Preventing the Spread" on page 37.

Once flowering rush has been confirmed at a location, a control plan should be developed based on infestation size, site accessibility, potential for spread and the risk of environmental, economic or social impacts. Site-specific conditions such as native plant richness and diversity, wildlife usage and water table fluctuations should also be considered when developing control plans. A detailed inventory of each site is strongly recommended before starting control efforts to help ensure proper methods and timing are used to minimize negative impacts to wildlife and native plant species. In addition it is important to use a control plan that incorporates integrated pest management (IPM) principles. IPM is a decision-making process that helps control invasive species effectively, economically, and in an environmentally sound manner. Knowledge of the pest species (i.e. biology of the plant and its life cycle) and its surrounding environment are used to inform a variety of control methods to ensure the most effective prevention and management techniques are used.

Learn how to recognize flowering rush on your property.

Photo courtesy of: John F Foster.

Mapping – For Landowners

As a landowner it is important to be aware of invasive plants that can threaten your property. One of the first steps is to learn how to recognize aquatic invasive species like flowering rush that might be present in bodies of water on your property. While land managers such as Conservation Authorities or municipalities might hire or recruit contractors to conduct an ecological survey, private landowners with smaller properties may be able to conduct their own survey. If you know you have flowering rush in one area of your property, ensure you map the rest of the property to identify other infestations and to document its current and potential future distribution. For detailed information on mapping techniques consult the Landowners Guide for Managing and Controlling Invasive Plants in Ontario here: http://www.ontarioinvasiveplants.ca/resources/technical-documents.

To see what might already be in your area, visit EDDMapS Ontario: http://www.eddmaps.org/ontario/.

To report an invasive species, see "Tracking the Spread" on page 38.

Landscape Level Management – For Land Managers:

The establishment and spread of an invasive aquatic species can be curtailed by following a management plan that applies a coordinated, integrative approach across a landscape rather than at the scale of a single waterbody or individual landowner. Vander Zanden and Olden (2008) have suggested a "smart" prevention approach to management that integrates landscape-level thinking with a science-based prioritization scheme. This involves assessing the vulnerability of sites across a landscape to aquatic invasive species invasions, by integrating knowledge about the primary pathways of introduction, ecological conditions that promote establishment, and the impacts an invader will have once established. This knowledge can then be used to target management and prevention efforts towards areas most vulnerable to invasion, such as areas of high boat traffic. A strategic and integrated landscape approach to management also serves to bring partners, landowners, and land managers together to work towards a common goal.

Once established, effective management and control of flowering rush will require ongoing treatments and a combination of control measures. It's not always realistic, especially for large infestations, to try and eliminate the infestation all at once. Determine the desired plant community and the land use objective, and then develop an appropriate IPM strategy.

Rhizome fragments are buoyant, allowing for long-distance dispersal.

Photo courtesy of: Peter Rice, University of Montana.

Setting Priorities

Establishing your highest priority locations for control prior to management will help to determine your best course of action. Therefore, when developing a management strategy, it's important to take into account the following considerations to help inform control decisions:

1. If you have limited resources, try to remove the outlying populations (isolated plants or satellite populations) first, to prevent further spread.
2. If you have more resources, working into larger "core" populations of European frog-bit can reduce dispersal and spread into uninfested areas. In many cases, resource limitations may prohibit immediate removal of entire core populations. Under these circumstances, core areas should be prioritized and addressed strategically.
3. Concentrate on preventive strategies in high-priority areas such as boat launches or where European frog-bit is most likely to establish and cause the greatest impact, such as sensitive wetland ecosystems or areas of fluctuating water levels such as irrigation canals.
4. Protect federally, provincially and regionally rare species and communities by removing invasive plants and ensuring rare species are not negatively impacted by control efforts.
5. Review the different control options and costs with considerations to surrounding water, habitat, time of year and type of land use i.e. high-traffic recreational areas, agriculture.
6. Ensure all landowners have been identified and consulted before control takes place.
7. Consider dedicating a certain time each year to control efforts and make it a joint effort with neighbouring landowners/land managers.
8. Follow-up monitoring is crucial to remove new plants that may emerge after initial control efforts.

Prioritizing within a Control Area

(This section is modified from The Landowners Guide to Managing and Controlling Invasive Plants, published by Credit Valley Conservation).

1. Focus on large blocks of un-invaded areas and keep them free of invaders.
2. Control small, younger, outlier (satellite) populations first.
3. Reverse the invasion, expand the cleared area outward and ensure that un-invaded areas are kept free of invasive plants (with regular monitoring).

This flow chart can help land managers choose where to first focus their control efforts, if the decision has been made to control only satellite populations due to limited resources:

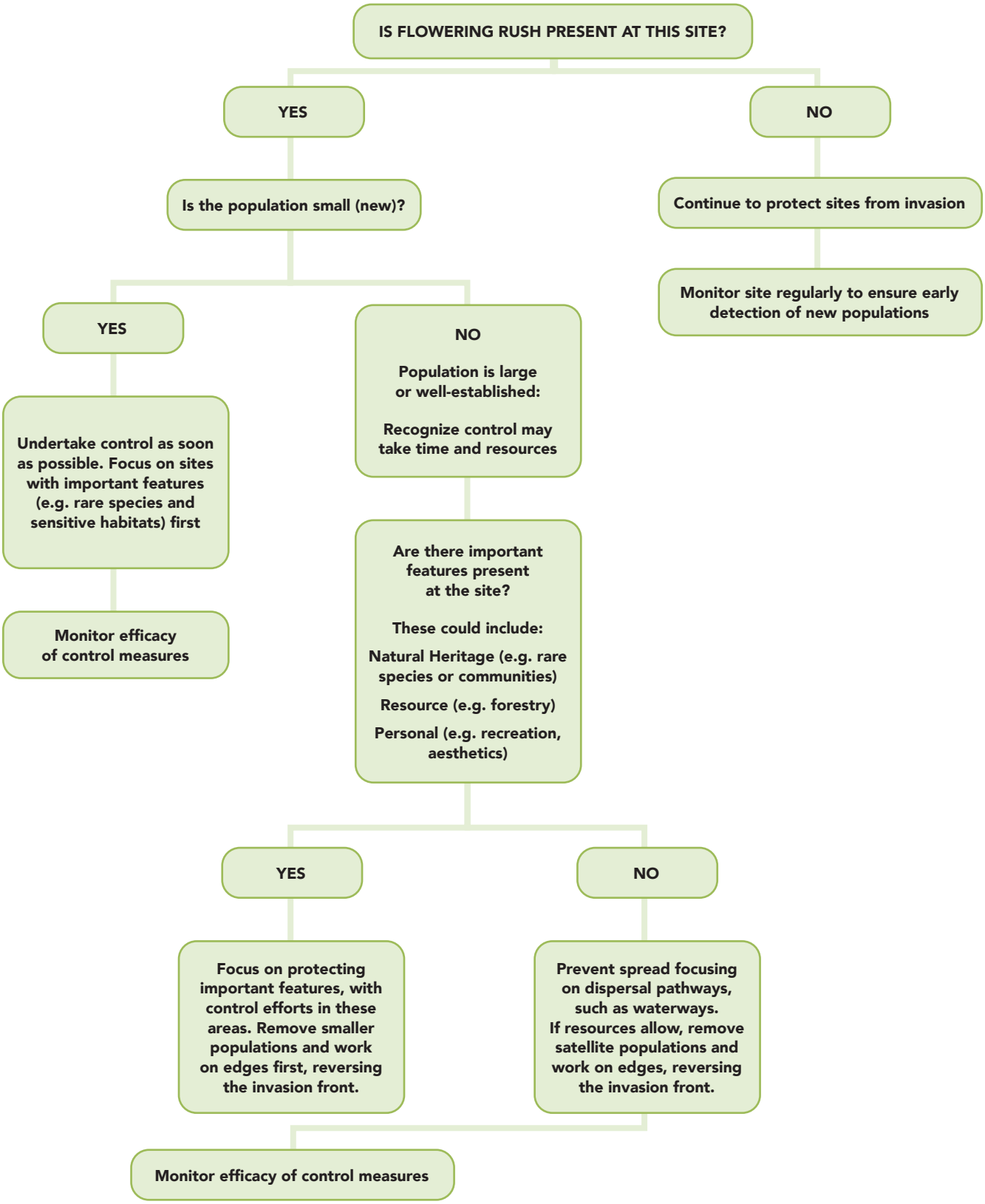


Figure 1: How to prioritize flowering rush sites for effective control.

Long-term Management and Monitoring

Because of the persistent and aggressive nature of flowering rush and its ability to spread vegetatively through rhizome fragmentation and bulbils, a long-term management and monitoring plan should be created prior to the implementation of control efforts. Monitoring will enable assessment of the initial control measures, including their effectiveness, as well as the types of follow-up treatments that are necessary. Ongoing management is critical to the success of a project; after removal, a site remains at risk of reinvasion by nearby populations or another invasive species.

Monitoring could be as simple as taking photos or performing a visual inspection, or it could be more complex and include extensive surveys. In general, annual treatment is imperative and should focus on selectively removing isolated populations as they appear. Follow-up spot treatment will help to ensure the invasive population remains under control and allows for the regeneration of native plant species. For more information on monitoring see the Landowners Guide for Managing and Controlling Invasive Plants in Ontario here: http://ontarioinvasiveplants.ca/resources/technical-documents.

After Management: Assessing Regeneration vs. Restoration

Consider the following factors:

1) **Level of disturbance at the site:**
    a. Was this a heavily invaded site (i.e. was much disturbance caused during control measures)?
    b. Will it continue to be disturbed (e.g. through beach use or trail use/management)?
2) **Biology of the invasive species removed:**
    a. Is there a seed bank to consider?
    b. Are there seedbanks from other invasive plants in the area?
3) **Re-invasion risk:**
    a. Are there invasive species nearby which could re-invade the site from nearby trails, watercourses or other pathways of introduction?
4) **Existing native vegetation:**
    a. Will any native vegetation that still exists on the site regenerate quickly?
    b. Does it need help? Species with specific habitat requirements or reproductive strategies resulting in low fecundity, including species at risk, may require re-introduction. The majority of plant species should be able to recover naturally, especially if healthy populations exist adjacent to the controlled area.

If you answered **Yes** to most of the questions under 1 to 3, it is most likely that (a) the site will be re-invaded before it has a chance to regenerate on its own, or (b) that flowering rush will continue to invade and be present among the native species so that annual control of flowering rush may be required. Restoration will be needed to reduce the risk of re-invasion.

Control Measures

Control of flowering rush can be challenging. As this species mainly spreads vegetatively via rhizome fragments, bulbils on the rhizomes and seed heads, the target of effective control must be to remove or destroy all rhizome and bulbil pieces. No single method is effective at removing all rhizome fragments. The most successful control programs have focused on taking an Early Detection and Rapid Response (EDRR) approach, identifying new populations through field surveys and then promptly removing individual plants to prevent further spread, and then continuing to control populations consistently over multiple seasons, often five years or more. An integrated approach, combining multiple methods (i.e. cutting and benthic barriers) is also more effective than doing one technique in isolation. Great care must be taken to remove all reproductive parts of the plant when implementing any physical control method. Dispose of removed plants properly, and thoroughly dry to prevent plants from sending new shoots. Although restoring a treated area with native vegetation could be beneficial, research indicates that flowering rush plants quickly reclaim sites that have been planted by native species.

Manual

Cutting Below the Water Line:	
Infestation Size:	Small to medium size infestations.
Goal:	Control spread and decrease abundance. Repeated cutting will strain resources put towards rhizome growth, limiting its spread during the growing season.
Timing:	Start around early July, when plants are beginning to reach maturity, and continue throughout the summer months.
Treatment Frequency:	To be effective, must do multiple cuts throughout the summer over many years.
Best Practice:	Cut plants below the water line. Best for emergent plants in shallower areas (at water depth less than 1.3 m).
Regulatory Considerations:	*Constitution Act/British North America Act, Fisheries Act, Department of Transport Act, Conservation Authorities Act.*
Advantages:	Inexpensive. Effective at reducing spread with multiple cuttings over multiple years.
Disadvantages:	Plants exhibit rapid growth throughout the season and will quickly grow back if not cut regularly. Repeated cuttings over multiple years may be time consuming and impractical. More effective in dryer, shallower areas, very challenging in greater water depths (greater than 1.3 m). Will only control spread, not eradicate.

Cutting Seed Heads:

Cutting mature seed heads can help prevent spread in fertile diploid populations that produce viable seed. However, this method does not address the main method of spread (vegetative reproduction via spread of rhizomes and bulbils). Seed spread is not a critical method of spread for either diploid or triploid types. Sterile

triploids which are more widely spread in Ontario rarely flower and produce sterile seed, while fertile diploid types show limited seeds in the seed bank, lack of seed production and failure of many seeds to germinate.

This method does not address the main method of spread as vegetative reproduction (via spread of rhizomes and bulblets).

Manual removal event at Brewer Park Pond, Ottawa, Ontario.

Photo courtesy of: Rosario Castanon Escobar, Rideau Valley Conservation Authority. Great Lakes, and Energy (EGLE).

Manual removal at Fletcher Wildlife Garden, Ottawa, Ontario. Plant material can be placed onto an inflatable raft, then floated to the shore and emptied.

Photo courtesy of: David Hobden, Fletcher Wildlife Garden.

Hand Removal:

Infestation Size:	Individual plants or small populations.
Goal:	Prevent isolated plants (satellite populations) from becoming established and spreading further. Eradication if all rhizome pieces effectively removed.
Timing:	Spring – Summer.
Treatment Frequency:	Each year during the growing season (summer) for several years. More frequent removals will give the most consistent control (Turnage *et al.*, 2019).
Best Practice:	Best used in combination with an EDRR program, monitoring for new populations, then using simple hand tools and buckets to remove the entire isolated plant. A pitchfork can gently lift the plant from the mud, then an individual can use their hands to get underneath the plant and lift it out without breaking the root system. The pitchfork should be plunged into the surrounding soil 8-12 inches from the plant at a 45-degree angle, going around the plant in a circle. Extreme care must be taken to remove all root fragments and bulbils, preventing them from escaping and spreading to new areas. Note that rhizome fragments as small as 1 cm have been observed to germinate. After removing the plant, search the area for any fragments and try to dislodge any bulbils that may float to the water's surface and dispose of properly. Control should be done when water levels are low enough to ensure that the entire plant is removed. Digging should not be done in high water due to the risk of spreading rhizome fragments and contributing to the growth of the population.
Regulatory Considerations:	*Constitution Act/British North America Act, Fisheries Act, Endangered Species Act, Department of Transport Act, Public Lands Act, Conservation Authorities Act.*
Advantages:	Simple, effective and selective. Potential to remove entire plant and to prevent further spread via satellite populations.
Disadvantages:	Not always effective as it is very difficult to remove all plant material. Time consuming and labor-intensive, only practical for isolated patches. This method has not been shown to decrease stem densities and can encourage spread if not carefully performed.

Raking:

Not recommended.
Raking to remove plant material can disturb the shallow rhizomes and likely increase spread.

Benthic Barriers:

Not recommended.
Benthic barriers, bottom screens, or benthic mats are covers laid on the bottom sediment of a water body to block sunlight, preventing plants from photosynthesizing and suppressing their growth. These barriers target the rhizome, the main method of spread, and can restrict growth in small, localized areas. They are best used in locations such as boating docks and marinas, where they can be effective with proper placement and maintenance. Barriers should be made of a material such as geotextile that is permeable to prevent gas bubbles from forming. This will reduce the likelihood of the barrier floating to the water surface. The best material is biodegradable and does not require removal. When left in the water, these mats will accumulate sediments, allowing new plants to root on top which essentially buries the flowering rush and it eventually decomposes. However, this method is considered low efficacy as it is expensive, difficult to install, laborious and requires routine monitoring and maintenance throughout the growing season. Further, barriers are a non-selective control measure, potentially negatively affecting the growth of native aquatic plants and impacting fish spawning and nursery habitats. Since plants can continue to grow and spread once covered, the barrier should extend well beyond the edge of a flowering rush patch and be adequately weighted to prevent growth. It is not clear how long a mat should remain in place to kill all rhizome material; however, in a trial in Idaho plants were still viable after 5 years of cover, and in other trials plants still grew around the edges three years after cover (CBCWMA, 2019). This method is more effective if used in an integrated approach with other methods (i.e. cutting plants below the water line in combination with benthic barriers). Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent Severn Waterway or Rideau Canal. For projects on Provincial Crown Land, placement of these materials requires MNRF approval under the Public Lands Act; they do not fall under the provincial rules for removing invasive or native aquatic vegetation in Ontario.

Mechanical

Mowing/Rototilling:

Not recommended.
Mowing, rototilling or using machines like back hoes is not recommended as this can increase the rate of spread through rhizome fragmentation. However, in areas where flowering rush is dense, mowing repeatedly over many years (at least 5-10 years) may reduce the plant's rhizome energy reserves and reduce rhizome abundance. In southeast Idaho, a specially designed bucket attached to a backhoe has proven successful at reducing biomass and improving water delivery in irrigation canals (CBCWMA, 2019).

Rhizome and leaf-mining weevil *(Bagous nodulosus)*.

Photo courtesy of: Tim Haye, CABI.

Biological

Biological control is the use of an herbivore, predator, disease or other natural enemy to reduce established populations of invasive species. Most invasive species have no natural enemies in their new habitats. Biological control aims to re-establish an ecological balance between the invasive species and its natural enemies by selecting highly host-specific natural enemies from the country of origin and moving them to the country where the invasive species is a problem. This is only done after extensive host-range testing in the country of origin or under quarantine, to ensure that the potential biocontrol agent is host-specific to the targeted invasive species. This method has been used successfully for aquatic invasive plants in North America, including purple loosestrife (*Lythrum salicaria*), water lettuce (*Pistia stratiotes*), and common water hyacinth (*Eichhornia crassipes*).

There are currently no approved biocontrol agents for flowering rush, however recent research has identified several promising agents. This species is an excellent candidate for biocontrol, as it is the only species within the Butomaceae family, and the lack of a closely related species increases the likelihood of finding a host-specific insect or pathogen. The Flowering Rush Biocontrol Consortium (FRBC) was formed and a research and development program initiated in 2013. This group consists of state and provincial funders that have assisted in funding the Centre for Agriculture and Bioscience International (CABI) Switzerland and United Kingdom to conduct field surveys, host-specificity tests, and impact studies on potential biocontrol agents (Andreas *et al.*, 2019).

The rhizome and leaf-mining weevil (*Bagous nodulosus*) appears to be highly host-specific. Sequential no-choice oviposition (adult egg-laying) tests were performed in 2014-2018 on 45 test plants to ensure non-target species were not at risk. The weevil was found to be host-specific, with only one incident of an egg being laid on a European species *Baldellia ranunculoides*. Following further testing in 2018-2019, limited larval feeding was only observed on two non-native species, Amazon frog-bit (*Limnobium laevigatum*) and European frog-bit (*Hydrocharis morsus-ranae*). A petition for field release is expected to be submitted by the end of 2020 or early 2021.

Host specificity tests and impact studies for the stem and leaf-mining fly (*Phytoliriomyza ornata*) began in 2019. Initial tests indicate that this fly is highly host-specific and very damaging to flowering rush, although testing is expected to continue over the next several years to confirm.

The white smut fungal pathogen (*Doassansia niesslii*) was discovered in northern Germany in 2016 and appears to be highly host specific and damaging to flowering rush. However, this strain also appears to be highly specific to genotype – the fungus attacked the flowering rush genotype invading British Columbia but did not affect the genotype most common to the rest of western North America. Ongoing research will continue, including finding a strain that will attack the most common genotype.

Flowering rush, Carnachan Bay, Greater Napanee, Ontario.
Photo courtesy of: Tim Haye, CABI.

Chemical

The management of pesticides is a joint responsibility of the federal and provincial governments. Before a pesticide can be sold or used in Ontario, it must be registered under the federal *Pest Control Products Act* by Health Canada's Pest Management Regulatory Agency (PMRA) and be classified under the provincial *Pesticides Act* by the Ministry of the Environment, Conservation and Parks (MECP).

It is important that herbicides be applied in accordance with all label directions. The label is a legal document and prescribes how the herbicide may be legally used. Ensure you have the most current label and are aware of any re-evaluation decisions.

For an up-to-date list of herbicides labelled for aquatic invasive plant control, visit the Pest Management Regulatory Agency's web site product label search at http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php.

For more information about pesticide use in Ontario, visit: http://www.omafra.gov.on.ca/english/crops/resource/using-pesticides.htm#regulation and https://www.ontario.ca/page/pesticides.

In addition, unless an exemption is granted, any person applying herbicides in water must first obtain a permit issued by the MECP, in accordance with the *Pesticides Act* and Ontario Regulation 63/09. In most cases, an applicator (exterminator) appropriately licensed by the MECP is required to perform the treatment. Permits are reviewed and approved by the MECP with terms and conditions imposed on the use of the herbicide, such as restrictions on timing, location, size of application area, quantity of product used and set back distances from sensitive areas.

Only herbicides specifically labelled for aquatic use may be used to treat plants in water. In Canada, the only herbicide registered for control of aquatic plants that are growing in water is Reward Aquatic Herbicide (diquat, registration number 26271 *Pest Control Products Act*). Another potential aquatic herbicide, Habitat, a formulation for use over water (with the active ingredient imazapyr) is currently under review for registration by the PMRA.

Herbicides and Flowering Rush:

Control of flowering rush using herbicides is difficult as it is easy for chemicals to miss or fall off of the narrow, slightly twisted leaves of flowering rush. There is currently no herbicide that specifically targets flowering rush, although various broad-spectrum herbicides (i.e. diquat, imazapyr, glyphosate, 2,4-D) have been tried in the United States to control flowering rush populations (CBCWMA, 2019).

Diquat:	
Growth Form:	Applied to **submerged** growth form.
Goal:	Eradication.
Timing (season):	After fish spawning season (July 1st).
Treatment Frequency:	One treatment of diquat is permitted annually.
Best Practice:	Flowering rush is listed under the pesticide label for diquat. Diquat has been shown to be effective in reducing flowering rush biomass and frequency, although it does not impact root biomass. May require repeat applications and may be more effective in combination with other herbicides, such as systemic herbicides (Madsen *et al.*, 2016; CBCWMA, 2019). Diquat is a broad-spectrum contact herbicide that is available in Canada as a restricted herbicide and can only be applied by an exterminator licensed by the MECP. It is applied to the submerged form via the water column and can be greatly affected by water exchange processes that may dilute concentrations. For this reason, it works best when the water is cool and still; little or no wind is desirable. High levels of suspended sediment in water can reduce effectiveness. Other environmental factors can influence application and efficacy including water exchange, water temperature, pH, turbidity, conductivity. Undertow, current and other factors need to be considered when applying diquat. There should be no recreational use (boating, fishing) for 24 hours following application and no consumption of the water for five days. In many cases repeated applications in subsequent years can be done as a spot treatment.
Disadvantages:	Can harm many non-target species. Negative public perception.

Imazapyr:	
Growth Form:	Applied to **emergent** growth form.
Goal:	Eradication.
Timing (season):	After fish spawning season (July 1st).
Treatment Frequency:	Multiple treatments is ideal.
Best Practice:	Imazapyr is a non-selective herbicide that is applied as a foliar application to emergent plant growth. It is most effective when water levels are low and during calm weather. The effectiveness of a foliar application of imazapyr has had mixed results in fields trials. One study indicated that one treatment of imazapyr was not enough to reduce biomass of emergent flowering rush, particularly belowground biomass (CBCWMA, 2019). Others found effective control of above ground biomass with 2 and 3 qt/acre application rate (Rice *et al.*, 2009). In Flathead Lake spraying during drawdown after 12 – 17 cm of leaves had emerged was most effective at suppressing flowering rush for one season, but the rhizomes were not affected (Jacobs *et al.*, 2011).
Disadvantages:	Imazapyr is not yet approved for aquatic use in Canada.

RVCA Baxter Flowering Rush Removal Group.

Photo courtesy of: Rosario Castanon Escobar, Rideau Valley Conservation Authority.

Disposal

Flowering rush should be disposed of on dry land, above the high-water mark, to prevent material from re-entering the water. Depending on the amount of plant material removed, disposal methods can vary. Small amounts of biomass can be put on land to dry and then be mulched, buried, composted or left to decompose. Disposal sites should be at least 30 m from the nearest waterbody, preferably in a flat, vegetated area, preventing fragments from inadvertently entering the water through runoff or other means. Gardens or farm fields are excellent disposal sites. Alternatively, plant material can be sealed in a black plastic bag and left in direct sunlight for about one week. These can then be discarded in household garbage. For large amounts you should contact your local municipality to determine if plant material may be disposed of in the landfill.

Photo courtesy of: Bill McIlveen.

Restoration

After Control

In some invaded systems, planting a reclaimed area with native vegetation can help prevent the re-establishment of the invasive species. However, research indicates that this method is not very effective for flowering rush, as it can quickly reclaim sites that have been planted with native rhizomatous species; flowering rush is found alongside native plants in undisturbed ecosystems, suggesting that restoration likely would not prevent re-invasion.

Preventing the Spread

Early detection is the most effective tool for controlling the spread of aquatic invasive plants such as flowering rush and everyone can help by following these tips:

☑ Report it.

If you think you see flowering rush or another invasive aquatic plant, take a picture, record the location, and contact the Invading Species Hotline at **1-800-563-7711** or report online at www.eddmaps.org/Ontario or www.iNaturalist.ca. For more information, call the Invading Species Hotline at **1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

☑ Watch for it.

Learn what invasive aquatic species look like and then monitor rivers, lakes, streams, and other waterbodies. Early detection of aquatic invasive plants like Eurasian water-milfoil can make it easier and less expensive to remove or control them. To learn how to identify aquatic invasives, see the Invasive Aquatic Plant Species Quick Reference Guide: https://www.ontarioinvasiveplants.ca/wp-content/uploads/2019/04/reducedQuickReferenceGuide_AquaticPlants.pdf

☑ Stop the spread.

Inspect your boat, motor, trailer, and boating equipment such as anchors and fishing gear, centerboards, rollers, and axles. Remove any visible plants parts before leaving the waterbody. **Wash or dry** your boat, tackle, downriggers, trailer, and other boating equipment to kill harmful species not visible at the boat launch.

Some aquatic species can survive more than two weeks out of water. Therefore, it is important to:

1. **Rinse** your boat and any equipment that normally gets wet with hot tap water (greater than 50°C), or
2. **Spray** your boat and trailer with a high-pressure water jet or
3. **Dry** your boat and equipment in the sun for at least 5 days before transporting to another waterbody.

☑ Use native species.

Try to use local native species in your water garden. Don't buy or transplant aquatic invasive plants like flowering rush, and if you have removed them, replace with native species. Encourage your local garden centre to sell non-invasive or native plants. The Grow Me Instead guides list alternatives to plant instead of invasive aquatic species.

Tracking the Spread (Outreach, Monitoring, Mapping)

Several reporting tools have been developed to assist the public and resource professionals to report invasive plant sightings, track the spread, detect it early, and respond to it quickly. These include:

1) **EDDMapS Ontario:** an online reporting tool and FREE mobile application (iPhone and Android) where users can report sightings, review distribution maps, and explore educational resources of aquatic invasive plants and other invasive species. This tool, at www.eddmaps.org/ontario, is free to use.

2) **The Invading Species Hotline:** a toll-free telephone number (1-800-563-7711) where individuals can report sightings verbally.

3) **iNaturalist:** an online reporting tool (www.iNaturalist.ca).

If you suspect you have encountered flowering rush or another invasive aquatic plant, please take a photograph (preferably with the plant out of water and including the leaves, stem, and flowers, if present), mark your location, and call the Invading Species Hotline at 1-800-563-7711.

Additional Resources:

Invasive Aquatic Plant Species: A Quick Reference Guide
https://www.ontarioinvasiveplants.ca/wp-content/uploads/2019/04/reducedQuickReferenceGuide_AquaticPlants.pdf

Ontario Ministry of Natural Resources and Forestry. 2010. Field Guide to Aquatic Invasive Species: 3rd Edition. Ontario, Canada: Queen's Printer for Ontario
http://www.invadingspecies.com/download/field-guide-to-aquatic-invasive-species-3rd-edition/

Ontario Ministry of Natural Resources and Forestry. 2017. Remove invasive aquatic plants. Available at:
https://www.ontario.ca/page/remove-invasive-aquatic-plants

Best Management Practices Documents Series from the OIPC

Autumn Olive
Black Locust
European Black Alder
Garlic Mustard
Giant Hogweed
Common (European) Buckthorn
Dog-strangling Vine
Invasive Honeysuckles
Reed Canary Grass
Japanese Knotweed
Multiflora Rose
Phragmites (Common Reed) (EN, FR)
Phragmites (Common Reed) Best Management Practices for Ontario Roadways
Purple Loosestrife
Scots Pine
Spotted Knapweed
White Sweet Clover
Wild Parsnip
White Mulberry
Eurasian Water-Milfoil
European Frog-Bit

Additional Publications from the Ontario Invasive Plant Council

Invasive Aquatic Plant Species: A Quick Reference Guide
Invasive Terrestrial Plant Species: A Quick Reference Guide
Invasive Plant Technical Bulletin Series
A Landowner's Guide to Managing and Controlling Invasive Plants in Ontario
A Quick Reference Guide to Invasive Plant Species
Clean Equipment Protocol for Industry
Creating an Invasive Plant Management Strategy: A Framework for Ontario Municipalities
Grow Me Instead! Beautiful Non-Invasive Plants for Your Garden, a Guide for Southern Ontario (EN, FR)
Grow Me Instead! Beautiful Non-Invasive Plants for Your Garden, a Guide for Northern Ontario
The Landowners Guide to Controlling Invasive Woodland Plants

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Reviewers and Contributers

Alison Morris, Ontario Federation of Anglers and Hunters

Francine MacDonald, Ministry of Natural Resources and Forestry

Heather Braun, Environment and Climate Change Canada

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Kellie Sherman, Canadian Council of Invasive Species

Hayley Anderson

Iola Price, Ontario Invasive Plant Council

John F Foster, Ontario Invasive Plant Council

Jenn McPhee, WSP Canada

Jennifer Andreas, Washington State University Puyallup Research and Extension Center

Kyle Borrowman, Ducks Unlimited

Leah Elwell, Invasive Species Action Network

Madeline Sutton, Environment and Climate Change Canada

Photographs

Amy MacPherson, City of Ottawa

Bill McIlveen

Derek Stone, The Riverwood Conservancy

Heather Pankhurst, Central Lake Ontario Conservation Authority

Janet Mason, Ottawa Stewardship Council

John F Foster, Ontario Invasive Plant Council

Kyle Borrowman, Ducks Unlimited Canada

Mike Tidwell

Naomi Langlois-Anderson, South Nation Conservation

Peter Rice, University of Montana

Rosario Castanon Escobar, Rideau Valley Conservation Authority

Tim Haye

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