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A second population of *Cabomba caroliniana* Gray (Cabombaceae) in Belgium with options for its eradication

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Abstract

We report a sizeable population of Carolina fanwort *Cabomba caroliniana* from Belgium. The new population was discovered in June 2013 and represents the only occurrence in the Atlantic region of this country. A previous record dates back to 1998 but by 2006 this population was eliminated unintentionally by dredging works. *Cabomba caroliniana* is expected to become a regulated invasive alien species of EU concern, in which case it will need to be eradicated. We briefly describe the site conditions, discuss possible measures for eradication and present a decision support scheme.

Key words: macrophytes, invasive alien species, Carolina water-shield, fanwort, eradication

Introduction

Carolina fanwort *Cabomba caroliniana* Gray (Cabombaceae) is a fully submerged ground-rooted aquatic plant from slow flowing and stagnant freshwater in temperate and subtropical South America. It is commonly used as a freshwater aquarium ornamental plant throughout the world. Its finely dissected submerged leaves are oppositely positioned and supported by short petioles (Figure 1). Floating leaves and flowers are produced occasionally. Stems arise from fragile rhizomes and may grow to several meters in length allowing the plant to reach to the surface from a considerable depth. *Cabomba caroliniana* is highly adaptive and competitive, grows quickly and densely, and easily spreads by rhizome or stem fragments (Mikulyuk and Nault 2015). The species is considered invasive in several European, Asian and Pacific countries (China, India, Japan), as well as in parts of the USA, Canada and Australia (Ørgaard 1991; ISSG 2005; Brundu 2015). Impacts include biodiversity loss, hampered drainage and loss of recreational amenities. In Europe, *C. caroliniana* is established in Austria, France, Hungary, the Netherlands and Great Britain (EPPO 2007); it is also present in southwest Germany (Hussner et al. 2009). In Belgium, the species is currently listed as absent with a medium ecological impact (Vanderhoeven et al. 2015). Overwintering is mainly vegetative in cold temperate climates (Wilson et al. 2007). The species is traded widely and release from aquaria, or use as a pond plant, are important pathways of introduction into the natural environment (EPPO 2007). *Cabomba caroliniana* is widespread in the Netherlands, where it has been recorded in 65 1 × 1 km squares since 1986 and has expanded very rapidly since 2006 (Matthews et al. 2013a): it already causes substantial problems in a few places, invoking considerable management costs (van Valkenburg et al. 2011; van Valkenburg and Rotteveel 2010).

Site description

Cabomba caroliniana was found in the village centre of Sint-Pauwels in May 2013 (Oost-Vlaanderen,

Figure 1. Fresh material of *Cabomba caroliniana* from the Sint-Pauwels site (material collected on 15 December 2015). Photograph by Jo Packet.

Belgium) (Table 1, Figure 2) as the only submerged macrophyte in an isolated, L-shaped, four meter wide ditch (c. 1200 m^2, greatest depth 1.2 m; Figure 3). Its cover attained 65% in October 2014. The only other hydrophytes at the site were the native *Lemna minor* and the invasive *L. minuta*, covering most of the water surface. Riparian vegetation included the native species *Glyceria maxima* (locally abundant), *Typha latifolia* (frequent) and *Sparganium erectum* (occasional); some willows *Salix* sp. shade parts of the ditch but this did not hamper *Cabomba* growth. The substrate consisted of c. 20 cm of organic mud on sand. The water was turbid (Secchi-depth = 0.6 m) with a pH of 7.3 and electric conductivity (EC) of 522 µS/cm (multimeter WTW Multi 340i). Due to the extensive lemnid cover and decomposition of organic matter, oxygen concentration was very low (1 mg/l, 10.6% saturation; 5 p.m.) despite a working aeration device. A sample from April 2016 showed slightly higher values for EC (754 µS/cm) and pH (7.8) with moderate oxygenation (79%; 5.30 p.m.). Total phosphorus was high (236 µg/l) but total nitrogen was not particularly elevated (1.1 mg/l).

Cabomba caroliniana was previously recorded in Belgium in an abandoned fishing pond at more than 50 km from the present location (Holsbeek, province Vlaams-Brabant; Verloove 2002; Denys et al. 2003; Table 1, Figure 2). It disappeared along with all other aquatic vegetation after dredging and restocking in 2006 to resume coarse fish angling.

Eradication strategies

Because of the isolated character of the site and its strictly esthetical use, this population of *Cabomba* could be considered low risk (Euphresco DeCLAIM 2011). However, it may act as a source for secondary dispersal to other sites. The plant can survive in a free-floating state for six to eight weeks (Australian Department of the Environment and Heritage 2003) and desiccation tolerance is considerable under certain conditions (Bickel 2015). Viable fragments, especially when clumped or embedded in sediment, can spread to other localities by various vectors, e.g. with maintenance works. Fortunately, the vicinity offers little opportunity for further establishment. Nevertheless, intentional distribution may occur via naïve visitors. Moreover, *Cabomba caroliniana* has been proposed for the list of regulated species of EU concern supplementing the new European IAS Regulation on the prevention of introduction and spread of invasive alien species (European Union 2014). If this list is ratified, the observed population will need to be eradicated because it represents the only one in the Belgian part of the Atlantic bioregion. Local authorities were made aware of its presence in 2013.

We could not find any documentation of successful eradication of *C. caroliniana*, making it difficult to assess eradication probabilities associated with different methods (cf. Drolet et al. 2014). Filling

Table 1. Observations of *Cabomba caroliniana* in Belgium.

Date	Year	Locality	Latitude	Longitude	Observer
5/08/1998	1998	De Zicht	50.9211	4.7429	Luc Denys
27/05/2013	2013	Sint-Pauwels	51.1919	4.0952	Kevin Scheers
25/06/2014	2014	Sint-Pauwels	51.1919	4.0952	Kevin Scheers
23/10/2014	2014	Sint-Pauwels	51.1919	4.0952	Kevin Scheers
20/12/2015	2015	Sint-Pauwels	51.1919	4.0952	Kevin Scheers
26/04/2016	2016	Sint-Pauwels	51.1919	4.0952	Kevin Scheers

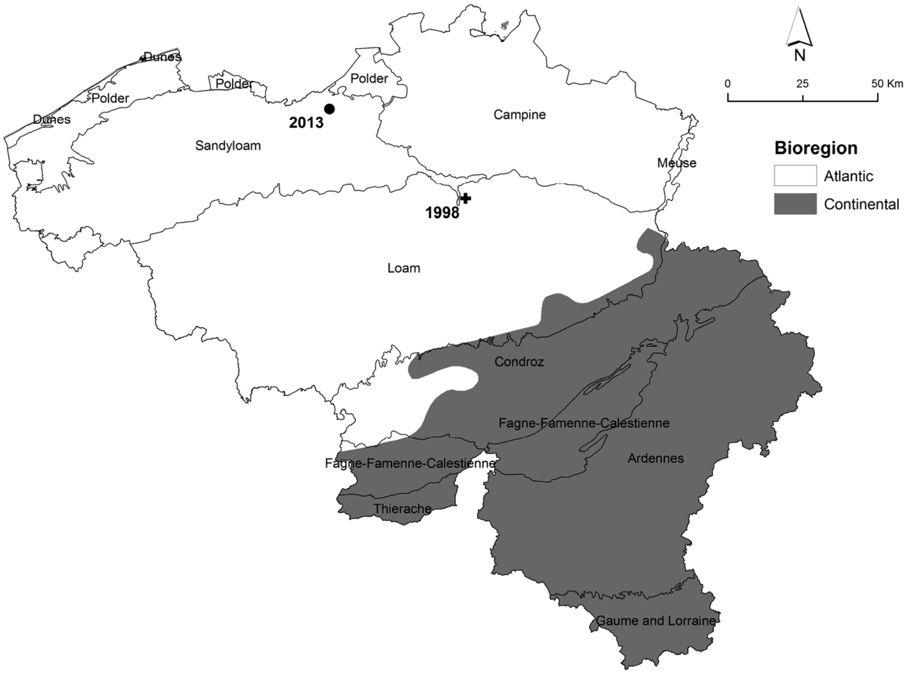

Figure 2. Records of *Cabomba caroliniana* in Belgium (background shows bioregions and ecoregions based on Couvreur et al. 2004) with the year of observation (● = present, + = disappeared).

Figure 3. Habitat of *Cabomba caroliniana* at Sint-Pauwels. Photograph by Kevin Scheers.

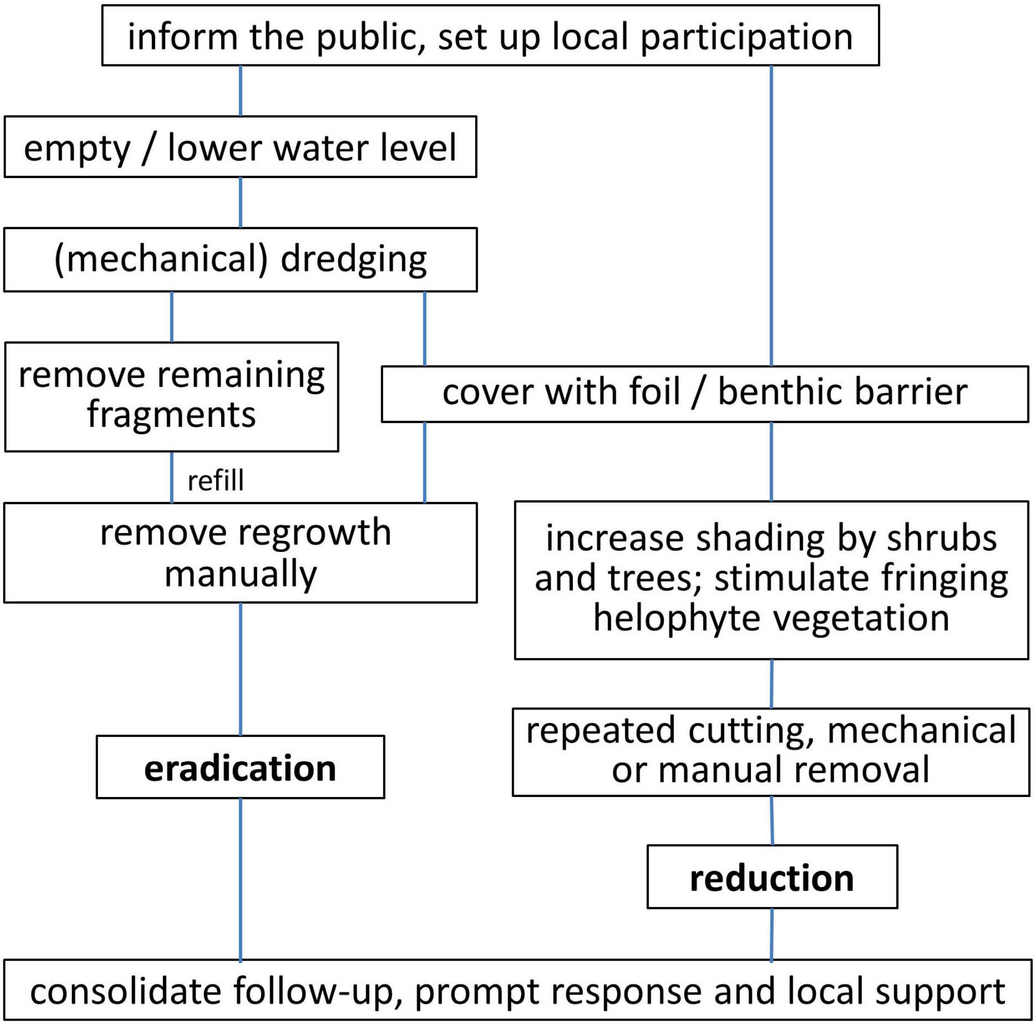

Figure 4. Decision support scheme of possible management measures and supporting actions to eradicate or control *Cabomba caroliniana* at the Sint-Pauwels site. Filling up the ditch, herbicide treatment and biocontrol are less suited for this site and, therefore, not included (see text).

up the ditch, which is a remnant of an eighteenth century fortification, is not an option because of its cultural and historical value. Eradication may be achieved by (temporary) drawdown, but probably only if sediments can dry completely for a considerable time or when sediment and plant material are subsequently removed (Dutartre et al. 2006; Dugdale et al. 2013), in which case adequate disposal will be necessary. At Sint-Pauwels, temporary drainage might be achieved quite easily and the site is not so large as to prohibit sediment removal, so this appears to be a recommendable option. However, evacuation of a large volume of water may present a problem for the local sewerage system. Light deprivation might be achieved by covering with a light-blocking synthetic foil or geo-textile (Schooler 2008). Less damageable, gas-permeable benthic barriers (Caffrey et al. 2010; Laitala et al. 2012) may also be of use. The effectiveness of matting remains to be determined, and may vary with extent and duration of matting, root persistence and the establishment of plants on top of the cover. Nonetheless, the limited dimensions of the ditch would probably allow it to be treated completely. Repeated clearing using an excavator equipped with a mowing bucket, the removal of soft sediment or the use of pressurized air to detach and uproot *Cabomba* (Hydro-venturi method; van Valkenburg et al. 2011) can lower biomass, but complete removal is unlikely as long as any fragments remain. Increased shading by trees or shrubs can also lead to reduced abundance of *C. caroliniana*, but the leaf litter could further impair the already problematic water quality. Development of a tall helophyte belt (e.g. *Phragmites*, *Typha*) along the shore, in order to reduce the open water area, might be a better option. This would also limit the risk of translocation of plants by reducing human access to the plants. This would, however, reduce the esthetical value of the site.

Another technique consists in the application of herbicides, which is subject to stringent regulations and forbidden for public authorities in Flanders since 2015. Exemptions for eradication of invasive species are possible, provided non-chemical methods cannot be applied, or when resulting costs would be disproportionately high. Such cannot be claimed in this case. Biocontrol methods include introduction of the monophagous weevil *Hydrotimetes natans* (Cabrera-Walsh et al. 2011) or herbivorous fish, such as grass carp *Ctynopharyngodon idella* (van Dyke et al. 1984; Hanlon et al. 2000), a species tolerant of low oxygen levels (Cudmore and Mandrak 2004). In Flanders, the release of grass carp, a non-native species, is regulated by fisheries legislation. Although carp overgrazing might be relatively cheap, it is not selective and high densities of grass carp can limit habitat quality for other organisms by complete loss of vegetation, and changes in sediment composition and hydrochemistry (Pípalová 2006). Subsequent removal of all specimens is often difficult. Introduction of weevils would probably not lead to permanent removal and, despite the relatively good biosafety track record of biological weed control (Suckling and Sforza 2014), non-target effects cannot be ruled out (Louda et al. 1997, 2003). This may limit support for swift practical application. The use of other biocontrol agents is also regulated and subject to preliminary risk assessment, which is time and resource-demanding.

Figure 4 presents a decision support scheme of possible methods and supporting actions leading to eradication or reduced abundance of Carolina fanwort. Not all methods are equally suited for the Sint-Pauwels site. Actions that cause complete alteration of the site or methods that require substantial deregulation or facing public disapproval are unlikely to be applied. This includes filling up, biocontrol and herbicide treatment. Successful eradication will require a suite of measures, each adding to the likelihood of success, and several of which can be combined. However, the result of one method will often depend on the thoroughness of preceding steps. Non-recurrent action may not suffice for eradication, in which case vigilance and cooperation in site management by the local community can present a significant bonus. However, even if no action is undertaken, the possibility of spontaneous decline cannot be ruled out entirely in the hypereutrophic conditions at Sint-Pauwels. The highly turbid conditions and strong development of lemnids and periphyton are suboptimal for a light-demanding species such as *C. caroliniana* (Matthews et al. 2013a, 2013b). Likewise, high turbidity, following the reduction of vegetative regeneration capacity by dredging, may have contributed to the complete disappearance of the species at the Holsbeek site.

Overall, we consider the risk of Carolina fanwort becoming widespread in Flanders to be relatively low. Introductions have occurred only rarely so far and potential habitat is more scattered and hydrologically much less connected than in The Netherlands. This suggests invasion could develop less swiftly in Flanders. If a trade ban is imposed for *C. caroliniana* in Europe, as proposed, this should also limit additional introductions. Finally, since the incidence of reinvasion is important in the determination of eradication success of invasive plants (Pluess et al. 2012) we consider the eradication probability at Sint-Pauwels to be high if action is undertaken promptly.

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