Appendix A

Harmonia^{+PL} – procedure of negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

Questionnaire

A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

a01. Name(s) of the assessor(s):

first name and family name

Teresa Nowak
first name and family name

Łukasz Krajewski – external expert
first name and family name

Barbara Tokarska-Guzik

acomm01. Comments:

degree	affiliation	assessment date
Dr	University of Silesia, Katowice	11.12.2017
degree	affiliation	assessment date
	Department of Nature Protection and Rural Landscape, Institute of Technology and Life Sciences, Falenty	19.12.2017
degree	affiliation	assessment date
Prof.	University of Silesia, Katowice	23.12.2017

a02. Name(s) of the ***Species*** under assessment:

Polish name
Kabomba karolińska

Latin name
Cabomba caroliniana A. Gray

English name
Carolina fanwort

acomm02. Comments:

Latin names and English common names are given on the basis of taxonomic databases and publications (Ørgaard 1991 - P; The Plant List 2013; ITIS 2017; GISD 2017; Larson et al. 2017; Mikulyuk and Nault 2008 - B). The English name "fanwort" it is not used exclusively for this species. The species has many names in English, mostly ambiguous and also referring to other species (fanwort - any representative of the genus *Cabomba*, also water-shield - the name also used for *Brasenia schreberi*). The provided Polish name is usually used in publications (Krajewski 2012 - P) and on aquarium websites. In addition, for the *Cabomba* genus, also the name "pływiec" is used (Szweykowska and Szweykowski 2003 - P).

Polish name (synonym I)	Polish name (synonym II)
……	……
Latin name (synonym I) *Cabomba australis* Speg.	Latin name (synonym II) *Nectris caroliniana* (A. Gray) Steud.
English name (synonym I) Fanwort	English name (synonym II) Carolina water-shield Green cabomba

a03. **Area** under assessment:

Poland

acomm03. Comments:

The species recorded so far from various climatic parts of Europe beyond its native range: in England, the Netherlands, Belgium, France, Germany, Sweden, Hungary, Serbia (Hussner et al. 2010 - P, Mikulyuk and Nault 2008 - B). There is one locality noted so far in Poland (Krajewski 2012 - P). However, due to the possibility of the identification problems, the species may be omitted in botanical investigations. It is similar to some native macrophytes.

a04. **Status** of the *Species* in Poland. The *Species* is:

native to Poland	
alien, absent from Poland	
alien, present in Poland only in cultivation or captivity	
alien, present in Poland in the environment, not established	
alien, present in Poland in the environment, established	**X**

aconf01. Answer provided with a

low	medium	high	level of confidence
		X	

acomm04.	Comments: in „Comments" (questions acomm04-41) experts should provide **explanations for their answers and list sources of information**. In particular, Comments should explain the decision in cases when data is lacking, incomplete or uncertain, or if the available information is contradictory. Source of the information should also be provided here, with author and year of publication; data sources should be divided into P – published results of scientific research; B - databases; N – unpublished data; I - other; A – author's own data. Detailed information (including full bibliographic record) should be provided at the end of the questionnaire "Data sources". Guidance on data sources citation is available at the end of the *Harmonia*$^{+PL}$ – procedure of negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland. The assessment is based on the published data (Krajewski 2012 - P) and own observations (Nowak 2014 - A). The population recorded in Poland in 2011, occurs in post-industrial areas (Krajewski 2012 - P). This population had probably existed here before it was discovered in 2011, because it is relatively large, and occupies several dozen sq. m. Observations have confirmed that the population of the species is established (survive winters, increases the occupied area, and reproduces vegetatively). Although flowering was recorded, there is no data on seed maturation (Krajewski 2012 - P; Krajewski 2011-2017; Nowak 2014 - A). The recorded population occurs in three water reservoirs connected with each other. So far, this species presence has not been confirmed in other reservoirs occurring in neighboring areas.

a05. The impact of the *Species* on major domains. The *Species* may have an impact on:

environmental domain	**X**
cultivated plants domain	
domesticated animals domain	**X**
human domain	
other domains	**X**

acomm05.	Comments: In the case of the Polish locality, impact on all marked domains is visible: the species displaces the native elements of flora, limits fish breeding potential, overgrows canals between the ponds (Krajewski 2012 - P, Krajewski 2011-2017; Nowak 2014 - A). Similar problems have been identified from the entire area beyond the native range of the species (GISD 2017, Larson et al. 2017, Mikulyuk and Nault 2008 - B). Also of interest is chemical defense of the species against herbivores and microorganisms (Morrison and Hay 2011 - P). In addition, attention is paid to the negative impact of the Fanwort invasions through changes in physical and chemical properties of water, decrease in oxygen content in water at die backing shoots, limiting the possibility of water acquisition and increasing the cost of its treatment, obstructing sailing through overgrowth of canals and infrastructure elements (Hogsden i in 2007, Santos et al. 2011 - P, GISD 2017, Larson et al. 2017 - B).

A1 | Introduction

Questions from this module assess the risk for the *Species* to overcome geographical barriers and - if applicable - subsequent barriers of captivity or cultivation. This leads to Introduction, defined as the entry of The Organism within the limits of The Area and subsequently into the wild.

a06. The probability for the *Species* to expand into Poland's natural environments, **as a result of self-propelled expansion** after its earlier introduction outside of the Polish territory is:

low	
medium	
high	**X**

aconf02.	Answer provided with a	low	medium	high **X**	level of confidence

acomm06. Comments:

Some of the European localities of *Cabomba caroliniana* are relatively close to Poland, e.g. in Hungary, Germany or Belgium (Király et al. 2008, Hussner et al. 2010, Scheers et al. 2016 - P). The habitat that is colonized by the species - including rivers, canals, water reservoirs can form combined systems, hence the spread is easier (Andelković et al. 2016 - P). An additional factor facilitating transfer of diasporas for larger distances may be floods or waterfowl (Mikulyuk and Nault 2008 - B).

The origin of the only locality in Poland is not known/clear (Krajewski 2012 - P), however, it cannot be excluded that it is due to natural spreading; the species is present in neighbouring Germany, but very close to the border with the Netherlands, in North Rhine-Westphalia (Hussner et al. 2010 - P), the Hungarian sites are much closer to the Polish one and they still spread (Steták 2012 - P). At the Polish site in Krążek (Dąbrowa Górnicza), the species probably spreads by canals from pond to pond (Krajewski 2011-2017 - A).

a07. The probability for the *Species* to be introduced into Poland's natural environments by **unintentional human actions** is:

low	
medium	
high	**X**

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

Fragments of *Cabomba caroliniana* shoots can be spread unintentionally by humans, e.g. directly by fishermen or by boats moving along waterways, which was confirmed from other parts of the range (van Valkenburg and Rotteveel 2009, Steták 2012, Bickel 2015 - P).

Perhaps also at the locality in Poland, in Krążek, it was accidentally moved between the ponds by anglers (Krajewski 2011-2017 - A).

a08. The probability for the *Species* to be introduced into Poland's natural environments by **intentional human actions** is:

low	
medium	
high	**X**

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

Cabomba caroliniana is used for ornamental purposes in aquariums or in aqua gardens and is thrown out/dumped by aquarists if it expands excessively (Steták 2012, Rotteveel 2007 - P). In the Netherlands, it was one of the most frequently sold plants of this type (Matthews et al. 2013 - P). Therefore, the intentional introduction of the species into the natural environment by humans is very probable (Rixon et al. 2005, Rotteveel 2007, Champion et al. 2010, June-Wells et al. 2012, Mc Cracken et al. 2013 - P). In Poland, the plant is also widely available in the commercial trade (web. 3 - I). There is no detailed data about the species introductions to ponds in outside water gardens in Poland.

It should be mentioned that in Hungary, before the Cabomba populations became invasive, they were first present only in thermal waters, only later they appeared in waters unheated by underwater sources (Király et al. 2008 - P), possibly after adaptation to colder climate. Thus, it is not clear how effectively individuals thrown out from aquarium, would form new populations without the adaptation stage, as a result of repeated introductions (this is a delicate plant and one of the more demanding aquarium cultivars).

A2 | Establishment

Questions from this module assess the likelihood for the *Species* to overcome survival and reproduction barriers. This leads to *Establishment*, defined as the growth of a population to sufficient levels such that natural extinction within The Area becomes highly unlikely.

a09. Poland provides **climate** that is**:**

non-optimal	
sub-optimal	
optimal for establishment of the *Species*	**X**

aconf05. Answer provided with a

low	medium	high	level of confidence
		X	

acomm09. Comments:

The Carolina fanwort comes from areas with tropical and subtropical climate (optimal range of average annual temperatures is 13°C - 27°C), but it also spread to temperate areas, tolerating lower temperatures, even below 0°C, causing freezing of water. Populations from the northeastern part of the USA and Canada occur at an average annual temperature of 6°C; the daily temperature in winter falls to -10°C and -15°C (Ørgaard 1991; Wilson et al. 2007; Weber et al. 2008; Schooler et al. 2009, Bickel and Schooler 2015 - P, Mikulyuk and Nault 2008, GISD 2017, Larson et al 2017 - B). In Europe, the species is also found in cooler climates, including harsher than the climate of Poland, e.g. southern Sweden - Skåne and the vicinity of Stockholm (Wilson et al. 2007, Király et al. 2008, Sundberg 2016 - P); potentially its range can cover the whole of Central Europe, reaching the majority of Fennoscandia (Rotteveel 2007 - P).

Exceptional efficiency of vegetative reproduction – fragmentation of shoots, persistent organs, rapid growth (Wilson et al. 2007 - P) – suggest a high probability of survival in a new area. Based on the map of climatic similarity included in the manual for this assessment (*Harmonia*$^{+PL}$ procedure), it can be stated that the climate in the current introduced range of *C. caroliniana* is similar to that prevailing in Poland.

The species is already established in Poland, blooms, bears fruit (it has not been tested if it produces fertile seeds), but it is spread mainly by fragmentation of shoots (Krajewski 2011-2017 - A), as in the whole introduced range (Rotteveel 2007; Király et al. 2008 - P).

a10. Poland provides **habitat** that is:

non-optimal	
sub-optimal	
optimal for establishment of the *Species*	**X**

aconf06.	Answer provided with a	low	medium	high **X**	level of confidence

acomm10. Comments:

Optimal habitat conditions for the assessed species are is in waters down to 3 m deep (although they can grow in reservoirs up to 10 m deep) stagnant or slow flowing, although it was also noted from rivers with faster current (Hogsden et al. 2007; Wilson et al. 2007 - P, Mikulyuk and Nault 2009 - B, web. 1 and 2 - I). It prefers oligotrophic (nutrient-poor) waters, but also occurs in eutrophic ones, with pH 4-8 (Wilson et al. 2007 - P). At the same time, the coolest areas of the North American range are estimated at the bottom of water reservoirs where the species is found; in winter it is approx. 4°C, under the ice and snow cover (Wilson et al. 2007 - P). Similar conditions can be found in waters in Poland; additionally, in industrial areas there are reservoirs with warmer water, e.g. Koninskie Lakes, supplied with cooling waters from the nearby power plants, where the temperature does not drop below 7°C (Najberek and Solarz 2011 - P). They are, therefore, a potentially optimal habitat for the Carolina fanwort.

The only locality recorded so far in Poland is in a unique habitat (old basins for flotation of lead-zinc ores), with mineral spring water, rich in bicarbonates, calcium and magnesium, opalescent, and additionally with extremely high concentrations of heavy metals in sediments, especially with zinc - hydrozincite (Lis and Pasieczna 1999 - P; Krajewski 2011-2017 - A).

A3 | Spread

Questions from this module assess the risk of the *Species* to overcome dispersal barriers and (new) environmental barriers within Poland. This leads to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered different from range expansions that stem from new introductions (covered by the *Introduction* module).

a11. The capacity of the *Species* to disperse within Poland by natural means, **with no human assistance**, is:

very low	
low	
medium	**X**
high	
very high	

aconf07.	Answer provided with a	low	medium **X**	high	level of confidence

acomm11. Comments:

The species clearly spreads in the Danube basin in Hungary and in Serbia, about 150-400 km to the south from the Polish borders (Steták 2012, Andelkovic et al. 2016 - P), as well as in the Netherlands and Germany, over 600 km to the west from the Polish borders (van Valkenburg and Rotteveel 2009, Hussner et al. 2010, Scheers et al. 2016 - P). In England the species is present since 1969 (Preston et al. 2002 - P) but it has not spread and has the status of naturalized plant (Stace and Crawley 2015 - P).

Data on the expansion from a single source (Type A)
It is possible to estimate on the basis of the data from Poland that the spread of the Cabomba does exceed several kilometers (though it is assumed that unintentional releases by human have played significant role in its expansion); dispersal is medium.

Data on the population expansion (Type B)
On the basis of data documenting spontaneous colonization of several kilometers of water canals in Hungary within one year (Király et al. 2008 - P), the dispersal is medium.

Data on estimation of the biological mobility of the species (Type C)
As a water plant, it efficiently spreads vegetatively, via rhizomes and stem fragments. It has an extremely high regenerative potential: new plant can develop from 10 mm piece of the stem plant with at least one pair of leaves (Wilson and Walter 2001, Király i in. 2008; Bickel 2015 - P); the greatest distances can be covered due to floods or water fowl migrations (Mikulyuk i Nault 2008 - B) - dispersion high.
However, the general ability of species to disperse should be classified to be medium, taking into consideration all the mentioned data.

a12. The frequency of the dispersal of the *Species* within Poland by **human actions** is:

low	**X**
medium	
high	

aconf08. Answer provided with a

low	medium	high
	X	

level of confidence

acomm12. Comments:

So far, there has been only one species locality in Poland (Krajewski 2012 - P), and the effects of its monitoring do not allow for this type of conclusions – there are no new localities in the adjacent area. There is also no data on the introduction of this species to the ponds in outside water gardens, from where it could spread to the natural environment. Data from outside Poland consider mainly the distance by which it expands its area of occurrence. It is also difficult to separate cases of spontaneous spread and spread by animal vectors, from human-mediated spreading.

A4a | Impact on environmental domain

Questions from this module qualify the consequences of the *Species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened. See, for example, Red Lists, protected species lists, or Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered on the local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as a (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of the *Species* on native species, through **predation, parasitism or herbivory is:**

inapplicable	**X**
low	
medium	
high	

aconf09. Answer provided with a

low	medium	high

level of confidence

acomm13. Comments:
It is a non-parasitic plant species.

a14. The effect of the *Species* on native species, through **competition** is:

low	
medium	
high	**X**

aconf10. Answer provided with a

low	medium	high
		X

level of confidence

acomm14. Comments:
The species with very high competitive capacity, displacing other species in optimal conditions almost completely, and dominant in the communities of aquatic vegetation (Hogsden et al. 2007; Scooler and Julien 2011; Bickel 2015 - P).
In the Polish locality, the species clearly competes with other macrophytes for space. It forms dense patches, preventing the development of native species (Krajewski 2012 - P; Nowak 2014 - A). On the basis the spread of the Fanwort in this site, it can be assumed that the mass appearance of the species in natural habitats such as swamps, rivers, other watercourses with natural banks and estuaries, could cause habitat changes that are difficult to reverse. In Poland, the plant has been recorded from water reservoirs of anthropogenic origin. In Germany, it appeared in a lake, in a nature reserve. However, in the Netherlands, where it was recorded in several Natura 2000 areas, potentially negative impacts on endangered species and on natural habitats are underlined (Hussner et al. 2010, Matthews et al. 2013 - P). The Carolina fanwort also has allelopathic properties and inhibits the growth of other vascular plants in its surroundings.
At the locality in Poland (Krążek settlement), the species has already caused a sharp decline in the population of *Nymphaea candida* and the disappearance of *Chara globularis* (Krajewski 2011-2017 - A); the plant is able to regrow from very small fragments of fragile stems that have only one pair of leaves (Király et al. 2008 - P).

a15. The effect of the *Species* on native species, through **interbreeding** is:

no / very low	**X**
low	
medium	

high	
very high	

aconf11.	Answer provided with a	low	medium	high X	level of confidence

acomm15. Comments:

In the European part of the secondary range of *Cabomba caroliniana* there are no related species in the native flora with which this species could hybridize (Wiersema 1997 - P). It is the only representative of the *Cabombaceae* family in Poland, hence hybridization with any other species is very unlikely (Krajewski 2011-2017 - A).

a16. The effect of the *Species* on native species by **hosting pathogens or parasites** that are harmful to them is:

very low	**X**
low	
medium	
high	
very high	

aconf12.	Answer provided with a	low X	medium	high	level of confidence

acomm16. Comments:

No data for the Polish population exist. However, it cannot be excluded that information of pathogens or parasites will be found in future. The presence of common phytopathogens, for which the plant can be a vector (Mackey and Swarbrick 1997 - P), was found on the Carolina fanwort in warmer areas. This assessment is, therefore, done on the basis of data available from outside Poland and on the expert knowledge.

a17. The effect of the *Species* on ecosystem integrity, by **affecting its abiotic properties** is:

low	
medium	
high	**X**

aconf13.	Answer provided with a	low	medium	high X	level of confidence

acomm17. Comments:

The dense patches of *Cabomba caroliniana* can completely shade the lower layers of water (Hogsden et al. 2007 - P). Invasion of the species also negatively affects water quality by changing nutrient content and hypoxia (Wilson et al. 2007 - P, web. 1 and 2 - I, Larson et al. 2017, Mikulyuk and Nault 2008 - B). The species overgrowing water column produces considerable biomass and in temperate climate *Cabomba* seasonal dieback and its decomposing reduce oxygen dissolved in water, causing oxygen-deficient and foul smelling water (van Oosterhout 2009 - P, GISD 2015 - B).

a18. The effect of the *Species* on ecosystem integrity, by **affecting its biotic properties** is:

low	
medium	
high	**X**

aconf14.	Answer provided with a	low	medium	high **X**	level of confidence

acomm18. Comments:
Transformations of biotic factors of the ecosystem are most visible in case of the mass occurrence of the plant: it disturbs the structure of plant communities, and also changes food availability for aquatic animals, while not providing food itself because of having harmful properties (web. 1 - I; Mikulyuk and Nault 2008 - B); however, information is not clear in this respect. At the locality in Poland, the species creates dense, uniform patches, displacing other species (Krajewski 2011-2017 - A).

A4b | Impact on cultivated plants domain

Questions from this module qualify the consequences of the species on cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of the species in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when The Organism's development causes local yield (or plant) losses below 20%, and 'high' when losses range > 20%.

a19. The effect of the *Species* on cultivated plants targets through **herbivory or parasitism** is:

inapplicable	
very low	**X**
low	
medium	
high	
very high	

aconf15.	Answer provided with a	low	medium	high X	level of confidence

acomm19. Comments:
It is a non-parasitic plant species.

a20. The effect of the *Species* on cultivated plants targets through **competition** is:

inapplicable	
very low	**X**
low	
medium	
high	
very high	

aconf16.	Answer provided with a	low X	medium	high	level of confidence

acomm20. Comments:
In Poland, there are no plants cultivated in water habitats, although this practice should not be ruled out in future. However, in case of amateur cultivation of plants for ornamental purposes, the Carolina fanwort may have a negative impact. In North America, it may compete with wild rice (*Zizania aquatica*) (Larson et al. 2017 - B).

a21. The effect of the *Species* on cultivated plants targets through **interbreeding** with related species, including the plants themselves is:

inapplicable	
no / very low	**X**
low	
medium	
high	
very high	

aconf17.	Answer provided with a	low	medium	high X	level of confidence

acomm21. Comments:
There are no crops related to *Cabomba caroliniana* in Poland.

a22. The effect of the *Species* on cultivated plants targets by **affecting the cultivation system's integrity** is:

very low	**X**
low	
medium	
high	
very high	

aconf18.	Answer provided with a	low **X**	medium	high	level of confidence

acomm22. Comments:
This problem currently does not apply to this part of the Fanwort's range in Europe (see acomm20). No data is available on this subject. However, in other areas of the secondary range, e.g. in Australia, where it is a dangerous invasive alien species, overgrowing of watercourses, including canals, and also ditches in fields, may cause floods (GISD 2017 - B).

a23. The effect of the *Species* on cultivated plants targets by hosting **pathogens or parasites** that are harmful to them is:

very low	**X**
low	
medium	

high	
very high	

aconf19.	Answer provided with a	low	medium **X**	high	level of confidence

acomm23. Comments:
There are no known pathogens / parasites of the species.

A4c | Impact on domesticated animals domain

Questions from this module qualify the consequences of The Organism on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

a24. The effect of the *Species* on individual animal health or animal production, through **predation or parasitism** is:

inapplicable	**X**
very low	
low	
medium	
high	
very high	

aconf20.	Answer provided with a	low	medium	high	level of confidence

acomm24. Comments:
It is a plant species.

a25. The effect of the *Species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

very low	
low	**X**
medium	
high	
very high	

aconf21.	Answer provided with a	low	medium **X**	high	level of confidence

acomm25. Comments:
The Carolina fanwort may be food for aquatic animals and waterfowl, although the data on this subject are ambiguous (web 1 - I). For example, it can eaten by the Grass carp *Ctenopharyngodon idella*. In addition, due to its proven chemical protection against herbivores, the Carolina fanwort may negatively affect the condition of herbivores (e.g. farmed fish) (Morrison and Hay 2011 - P).

a26. The effect of the *Species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

inapplicable	**X**
very low	
low	
medium	
high	
very high	

aconf22.	Answer provided with a	low	medium	high	level of confidence

acomm26. Comments:
There is no data on this subject.

A4d | Impact on human domain

Questions from this module qualify the consequences of The Organism on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

a27. The effect of the *Species* on human health through **parasitism** is:

inapplicable	**X**
very low	
low	
medium	
high	
very high	

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27. Comments:
The species is not a human parasite.

a28. The effect of the *Species* on human health, by having properties that are hazardous upon **contact**, is:

very low	**X**
low	
medium	
high	
very high	

aconf24.	Answer provided with a	low	medium	high **X**	level of confidence

acomm28. Comments:
Non-parasitic and non-poisonous plant species.

a29. The effect of the *Species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

inapplicable	**X**
very low	
low	
medium	
high	
very high	

aconf25.	Answer provided with a	low	medium	high	level of confidence

acomm29. Comments:
There are no known pathogens / parasites common to humans and the species.

A4e | Impact on other domains

Questions from this module qualify the consequences of the *Species* on targets not considered in modules A4a-d.

a30. The effect of the *Species* on causing damage to **infrastructure** is:

very low	
low	
medium	
high	
very high	**X**

aconf26.	Answer provided with a	low	medium	high **X**	level of confidence

acomm30. Comments:
The shoots of the Carolina fanwort can clog canals between water reservoirs, technical infrastructure on dams, pumps and aerators. Overgrowing communication and irrigation canals it increases, among others, the flood risk (Schooler 2006; Schooler and Julian 2011 – P; GISD 2015; Larson et al. 2017 - B). Within the Polish site, overgrowing of the canal between the reservoirs was observed (Nowak 2014 – A).

A5a | Impact on ecosystem services

Questions from this module qualify the consequences of The Organism on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made

about management of the species.

a31. The effect of the *Species* on **provisioning services** is:

significantly negative	**X**
moderately negative	
neutral	
moderately positive	
significantly positive	

aconf27. Answer provided with a

low	medium	high
		X

level of confidence

acomm31. Comments:

The Carolina fanwort, due to the restricted occurrence, is currently not a major threat in Poland in relation to ecosystem services. If shallow water habitats will be used for cultivation purposes in future, then the negative impact of the species will increase. In other parts of its introduced range, significantly more impacts have been identified. In fish farming, both positive (protection of the fry by providing shelter) and negative impacts (difficulty in movement, lack of oxygen in the water) interactions were reported (Larson et al. 2017 - B). Another problem related to the mass occurrence of the Fanwort is reduction of the retention capacity of water reservoirs, as well as limitation of their accessibility and lowering of the quality of drinking water, thus increasing the costs of its treatment (GISD 2017, Larson et al. 2017 - B). The species is used for ornamental purposes in aquarium all over the world, so its trade is of great economic importance (Larson et al 2017 - B).

a32. The effect of the *Species* on **regulation and maintenance services** is:

significantly negative	
moderately negative	**X**
neutral	
moderately positive	
significantly positive	

aconf28. Answer provided with a

low	medium	high
		X

level of confidence

acomm32. Comments:

The invasion of the Carolina fanwort, especially in different types of canals, rivers, etc., increases the risk of flooding, thus it has a negative effect. Reduction in reservoir retention by the species, and consequent flooding was reported (GISD 2015 - P). However, there are also many positive effects, e.g. contributing to regeneration of habitats overgrown only by algae. It may also be used for phytoremediation (cleaning up water; Mikulyuk and Nault 2008 - B; web. 1 - I), including heavy metals – cadmium, zinc and lead (Kaladharan et al. 2005 - P). In the only Polish site in Krążek settlement, where the species occurs in old ore-floating ponds (Krajewski 2012 - P), concentrations of these metals in sediments are extremely high (> 200,000 mg of Zn / kg sediment; Lis and Pasieczna 1999 - P).

a33. The effect of the *Species* on **cultural services** is:

significantly negative	

moderately negative	**X**
neutral	
moderately positive	
significantly positive	

aconf29. Answer provided with a

low	medium	high
		X

level of confidence

acomm33. Comments:

The use of the species for ornamental purposes is of great aesthetic importance for humans. However, when the plant's shoots die, it loses its aesthetic value and at the same time hinders recreation (fishing, swimming, sailing) (Mikulyuk and Nault 2008; van Valkenburg, Rotteveel 2009; GISD 2017; Larson et al. 2017 - B, web. 1 and 2 - I; Krajewski 2011-2017 - A).

A5b | Effect of climate change on the risk assessment of the negative impact of the *Species*

Below, each of the Harmonia+ modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest to take into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes of atmospherical variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2 °C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of the *Species*.

a34. INTRODUCTION – Due to climate change, the probability for the *Species* to overcome geographical barriers and - if applicable - subsequent barriers of captivity or cultivation in Poland will:

decrease significantly	
decrease moderately	
not change	
increase moderately	
increase significantly	**X**

aconf30. Answer provided with a

low	medium	high
		X

level of confidence

acomm34. Comments:

Due to climate warming, the probability of overcoming geographical barriers by the Carolina fanwort increases because the conditions will become similar to the climate in its natural range (Wilson et al. 2007, Rotteveel 2007 - P). This assessment is also confirmed by studies using modeling (Hallstan 2005 - P).

a35. ESTABLISHMENT – Due to climate change, the probability for the *Species* to overcome barriers that prevented its survival and reproduction in Poland will:

decrease significantly	
decrease moderately	
not change	

increase moderately	
increase significantly	**X**

aconf31. Answer provided with a

low	medium	high
	X	

level of confidence

acomm35. Comments:
Climate warming should facilitate establishment of the species because the conditions will become similar to the climate in its natural range (Mikulyuk i Nault 2008 - B; web. 1 - I).

a36. SPREAD – Due to climate change, the probability for the *Species* to overcome barriers that prevented its spread in Poland will:

decrease significantly	
decrease moderately	
not change	
increase moderately	
increase significantly	**X**

aconf32. Answer provided with a

low	medium	high
		X

level of confidence

acomm36. Comments:
It is assumed that climate change will facilitate the spread of the species. However, habitat conditions are more important than climate (Jacobs and Macisaac 2009 - P, web. 1 - I), and habitats are potentially optimal for the Carolina fanwort in Poland.

a37. IMPACT ON ENVIRONMENTAL DOMAIN – Due to climate change, the consequences of the *Species* on wild animals and plants, habitats and ecosystems in Poland will:

decrease significantly	
decrease moderately	
not change	
increase moderately	
increase significantly	**X**

aconf33. Answer provided with a

low	medium	high
		X

level of confidence

acomm37. Comments:
Cabomba caroliniana is identified as an invasive alien species in some areas of its introduced range, which results from a negative impact, mainly on the natural environment. Climate change should therefore be expected to intensify the negative impact (cf. acomm05).

a38. IMPACT ON CULTIVATED PLANTS DOMAIN – Due to climate change, the consequences of the *Species* on cultivated plants and plant domain in Poland will:

decrease significantly	
decrease moderately	

not change	**X**
increase moderately	
increase significantly	

aconf34. Answer provided with a

low	medium	high
	X	

level of confidence

acomm38. Comments:
This assessment is under the assumption that in future there will be no crops in the habitats of the fanwort in Poland (web. 1 - I).

a39. IMPACT ON DOMESTICATED ANIMALS DOMAIN – Due to climate change, the consequences of the *Species* on domesticated animals and animal production in Poland will:

decrease significantly	
decrease moderately	
not change	
increase moderately	
increase significantly	**X**

aconf35. Answer provided with a

low	medium	high
		X

level of confidence

acomm39. Comments:
As a result of the spread of the species, the impact on fish farming may increase.

a40. IMPACT ON HUMAN DOMAIN – Due to climate change, the consequences of the *Species* on human in Poland will:

decrease significantly	
decrease moderately	
not change	**X**
increase moderately	
increase significantly	

aconf36. Answer provided with a

low	medium	high
X		

level of confidence

acomm40. Comments:
Impact on people should not change (cf. a28) with climate.

a41. IMPACT ON OTHER DOMAINS – Due to climate change, the consequences of the *Species* on other domains in Poland will:

decrease significantly	
decrease moderately	
not change	

increase moderately	
increase significantly	X

aconf37.	Answer provided with a	low	medium	high X	level of confidence

acomm41. Comments:
On the basis of the current levels of threats, with climate warming, the negative impact on other domains will increase (Mikulyuk and Nault 2008 - B, cf. a30).

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	1.0	1.0
Establishment (questions: a09-a10)	1.0	1.0
Spread (questions: a11-a12)	0.25	0.5
Environmental impact (questions: a13-a18)	0.6	0.8
Cultivated plants impact (questions: a19-a23)	0.0	0.5
Domesticated animals impact (questions: a24-a26)	0.25	0.5
Human impact (questions: a27-a29)	0.0	1.0
Other impact (questions: a30)	1.0	1.0
Invasion (questions: a06-a12)	0.75	0.83
Impact (questions: a13-a30)	1.0	0.76
Overall risk score	0.75	
Category of invasiveness	very invasive alien species	

A6 | Comments

This assessment is based on information available at the time of its completing. It has to be taken into account. however. that biological invasions are. by definition. very dynamic and unpredictable. This includes introductions of new alien species and detection of their negative impact. As a result. the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

Below you can include your own comments on the assessment.

acomm42.	Comment: This assessment for Poland is largely based on extrapolation of information from other temperate-climate areas where the Carolina fanwort is an alien species. However, drawing solid conclusion on invasiveness of the species on the basis on the only one Polish locality may raise doubts. For this reason, classification as 'very invasive alien species' may seem too far-fetched, particularly that the maximum value (1.0) was scored in one question in the 'Other impact' module (a30). Score for 'Environmental impact' (questions a13 –a18) was 0.6, which would allow classification of the species as 'moderately invasive alien species'. At the same time, the species scored zero in 'Cultivated plants impact' (questions: a19-a23) and Human impact (questions: a27-a29), and very low in 'Domesticated animals impact' (0.25; questions: a24-a26). Taking into account the history of establishment of the species in other countries (e.g. Wilson et al. 2007; Király et al. 2008; Stace and Crawley 2015 - P), it is a long process. There are many uncertainties about the Polish population, including its origin and genetic similarity to other populations in Europe. Scientific research would provide more solid evidence in this respect. Detailed analyses of floras of water reservoirs is also recommended to collect more data on the species distribution. While currently it seems that the species does not pose a threat in Poland, this cannot be excluded in future, particularly that the scores for the modules related to the invasion process were relatively high: 1.0 for 'Introduction' (questions: a06-a08) and for 'Establishment' (questions: a09-a10) and 0.38 for 'Spread' (questions: a11-a12). Taking into account the precautionary principle, removal of the species from the only known pond is recommended and this should be followed by monitoring this site over the next few years. At the same time, water reservoirs suitable for the Carolina fanwort should be monitored within the radius of a few dozen kilometers.

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