



lascach Intíre Éireann  
Inland Fisheries Ireland



## Risk Assessment of *Pistia stratiotes*

Name of Organism:	<i>Pistia stratiotes</i> L. – Water Lettuce
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 15/09/2014
Author(s)	Michael Millane and Joe Caffrey
Expert reviewer	Kevin Murphy

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### **About the risk assessment**

This risk assessment is based on the Non-native species APplication based Risk Analysis (NAPRA) tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

**Notes:** Confidence is rated as low, medium, high or very high.

Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.

The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.

N/A = not applicable.

This is a joint project by Inland Fisheries Ireland and the National Biodiversity Data Centre to inform risk assessments of non-native species for the European Communities (Birds and Natural Habitats) Regulations 2011. It is supported by the National Parks and Wildlife Service.

## DOCUMENT CONTROL SHEET

<b>Name of Document:</b>	Risk Assessment of <i>Pistia stratiotes</i>				
<b>Author (s):</b>	Dr Michael Millane and Dr Joe Caffrey				
<b>Authorised Officer:</b>	Dr Joe Caffrey				
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### Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Michael Millane	Dr Joe Caffrey		03/04/2014
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<b>Stage 1 - Organism Information</b> <i>The aim of this section is to gather basic information about the organism.</i>			
N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the risk assessment?		A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	<p><i>Pistia stratiotes</i> L.; <i>Apiospermum obcordatum</i> (Schleid.) Klotzsch, <i>Limnonesis commutata</i> (Schleid.) Klotzsch, <i>Limnonesis friedrichsthaliana</i> Klotzsch, <i>Pistia aegyptiaca</i> Schleid, <i>Pistia aethiopica</i> Fenzl ex Klotzsch, <i>Pistia africana</i> C. Presl, <i>Pistia amazonica</i> C. Presl, <i>Pistia asiatica</i> Lour., <i>Pistia brasiliensis</i> Klotzsch, <i>Pistia commutata</i> Schleid, <i>Pistia crispata</i> Blume, <i>Pistia cumingii</i> Klotzsch, <i>Pistia gardneri</i> Klotzsch, <i>Pistia horkeliana</i> Miq., <i>Pistia leprieuri</i> Blume, <i>Pistia linguiformis</i> Blume, <i>Pistia minor</i> Blume, <i>Pistia natalensis</i> Klotzsch, <i>Pistia obcordata</i> Schleid, <i>Pistia occidentalis</i> Blume, <i>Pistia schleideniana</i> Klotzsch, <i>Pistia spathulata</i> Michx., <i>Pistia stratiotes</i> var <i>cuneata</i> Engl., <i>Pistia stratiotes</i> var <i>obcordata</i> (Schleid.) Engl., <i>Pistia stratiotes</i> var <i>spathulata</i> (Michx.) Engl., <i>Pistia texensis</i> Klotzsch, <i>Pistia turpini</i> Blume, <i>Pistia turpinii</i> K. Koch, and <i>Pistia weigeliana</i> C. Presl.</p> <p>Water Lettuce (preferred common name), Floating Aroid, Nile Cabbage, Pistia, Shell Flower, Tropical Duckweed, Water Cabbage, Water Fern and Water Lily (Global Invasive Species Database 2005; Queensland Government 2011, CABI 2014).</p>
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N/A	
4	Describe the organism.		<i>Pistia stratiotes</i> is a free-floating perennial which forms colonies. It is stoloniferous and has long, feathery, hanging roots. The leaves are light green and velvety or hairy with many prominent longitudinal veins, obovate to spatulate-oblong, 15 cm long and forming a rosette. Flowers are inconspicuous, few in number and enclosed in a leaf-like spathe. The fruit is a green berry (EPPO 2007-2012).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	No formal risk assessments were previously carried out for this species in Ireland or Britain. However, Invasive Species Ireland (2010) rates this plant as of medium risk and has placed it on their amber list as its "impact on conservation goals remains uncertain due to lack of data showing impact or lack of impact". <i>Pistia stratiotes</i> was added to the European and Mediterranean Plant Protection Organization (EPPO) Alert List in 2007 and transferred to the List of Invasive Alien Plants in 2012 (EPPO 2007-2012).

<b>Stage 1 - Organism Information</b>			
<i>The aim of this section is to gather basic information about the organism.</i>			
N	QUESTION	RESPONSE	COMMENT
6	If there is an earlier risk assessment is it still entirely valid, or only partly valid?	NOT VALID	Refer to response to Question 5 above.
7	Where is the organism native?		The origin of <i>Pistia stratiotes</i> is uncertain but it is most recently considered to be a pan-tropical species occupying a native range across the tropical and sub-tropical regions of Asia, Africa and South America (reviewed in Evans 2013).
8	What is the current global distribution of the organism (excluding Ireland)?		<i>Pistia stratiotes</i> occurs across the tropical and sub-tropical regions of Asia, Africa and South America and has expanded its range to Australia, New Zealand, Europe and North America (reviewed in Evans 2013).  In Europe, the plant has been recorded in Czech Republic, France, Germany, Italy, Russia, Slovenia, Spain and the Netherlands (Šajna 2007 and references therein; EPPO 2007-2012). However, it is reported as being 'no longer present' in France, Germany and mainland Spain (EPPO 2007-2012).
9	What is the current distribution of the organism in Ireland?		<i>Pistia stratiotes</i> is not present in the wild in Ireland.
10	Is the organism known to be invasive anywhere in the world?	YES	Australia, Benin, Bermuda, Botswana, Brunei, Burkina Faso, Cambodia, China, Cook Islands, Cuba, French Polynesia, Guam, Kenya, Indonesia, Ivory Coast, Malaysia, New Caledonia, New Zealand, Palau, Philippines, Puerto Rico, Réunion, Spain (Canary Island), South Africa, Slovenia, Thailand, Taiwan, Uganda, USA, Vanuatu, Zambia and Zimbabwe (CABI 2014; Lang <i>et al.</i> 2014 submitted).  In Europe, the plant was previously reported as invasive in France (in Jalle de Blanquefort near Bordeaux), south-western Spain (near Cadiz) and The Netherlands during the warmer summer months in the summer (reviewed in Šajna 2007), but it appears to have since died out in the first two of these regions (EPPO 2007-2012).

## Stage 2 - Detailed assessment: Section A - Entry

This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	VERY FEW	VERY HIGH	<p>Internet searches strongly indicate that the aquarium trade is the principal active pathway responsible for the entry of <i>Pistia stratiotes</i> into Ireland and its subsequent distribution within the country. Horticultural trade of this plant appears to be minor as only one reference to its purchase could be found on the internet (<a href="http://www.garden.ie/post.aspx?id=3499&amp;idpost=14199">http://www.garden.ie/post.aspx?id=3499&amp;idpost=14199</a>).</p> <p>Boating, angling and other water based activities may also represent a potential pathway to transfer this plant from abroad. However, these pathways are considered of very low risk as <i>Pistia stratiotes</i> is not present in the wild in Britain and is extremely rare in mainland Europe where the vast majority of any such vectors for transfer would arise. Therefore, boating, angling and other water based activities as potential pathways for entry to Ireland are not considered in the present risk assessment.</p>
1.02	List significant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Aquarium and horticultural trades		<p><i>Pistia stratiotes</i> is principally imported into Ireland via the aquarium sector for sale to the public in garden centres and aquarium / pet shops. It is also regularly available to buy directly through the internet from such vendors or from individual hobbyists. Horticultural trade is minor as outlined above.</p>

## Pathway 1 - Aquarium and horticultural trades

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	VERY HIGH	<i>Pistia stratiotes</i> is deliberately imported for trade.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	MODERATELY LIKELY	MEDIUM	<i>Pistia stratiotes</i> is deliberately imported for trade and subsequently sold in Ireland in aquarium outlets or by such retailers or individual vendors on the internet as an oxygenator / ornamental plant for garden ponds and aquaria. The volume of imports or trade that occurs is unknown. Therefore, this is rated as 'moderately likely'.

Pathway 1 - Aquarium and horticultural trades				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism is distributed deliberately <i>via</i> trade in an aquatic or moist environment, survival is considered very likely. The plant has some capacity to survive in mud (Rivers 2002).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	<p>A review of the literature, suggests that <i>Pistia stratiotes</i> may only establish in Ireland during the warmer months of the year (May to September) and may have an extremely limited or no capacity to overwinter under natural conditions. Its optimal growth temperature ranges from 22 to 30°C but it can endure temperature extremes of 15°C and 35°C (EPPO 2007-2013). There is only one documented occurrence of the plant overwintering in Central Europe and that was in association with a thermal stream in Slovenia where annual water temperatures did not drop below 17°C (Šajna 2007). Elsewhere in Europe, only two cases of overwintering have been documented: 1) in Russia in the Kazachii channel of the Volga delta as a result of warm water discharge from a heating and electric power station (Pilipenko 1993 as cited in Šajna 2007); and 2) in Germany in the River Erft, which is a tributary of the River Rhine, in association with a warm water mine discharge where annual water temperatures do not drop below 10°C (Hussner and Heilitag 2013). In the River Erft, <i>Pistia stratiotes</i> was found to become sparser, with reduced biomass, in winter only to re-establish fully in summer. Here, plant vegetation above water was highly susceptible to frost damage (Hussner and Heilitag 2013). The plant does not survive freezing conditions, but seeds are able to survive in ice at -5°C for a few weeks (Pieterse <i>et al.</i> 1981). The same study found that the viability of <i>Pistia stratiotes</i> seeds was not affected by a period of 2 months in water at 4°C. From this, it was concluded that the seeds would likely survive a Dutch winter but the plant is unlikely to become a serious pest in the country due to the rarity of seed formation and the adverse conditions for germination (Pieterse <i>et al.</i> 1981).</p> <p>As mentioned previously, in Europe the plant was reported as invasive in France (in Jalle de Blanquefort near Bordeaux), south-western Spain (near Cadiz) and The Netherlands during the warmer summer months (reviewed in Šajna 2007), but it appears to have since died out in first two</p>

Pathway 1 - Aquarium and horticultural trades				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				<p>of these regions (EPPO 2007-2012).</p> <p>Trade imports and purchases for aquaria may occur throughout the year. Purchases for horticultural use in outdoor ponds are likely to occur in the late spring to summer period.</p>
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	MODERATELY LIKELY	HIGH	<p><i>Pistia stratiotes</i> can grow in a wide variety of aquatic habitats but prefers relatively stagnant waters (CABI 2014). It occurs in ponds, lakes, reservoirs, water courses (streams, rivers and canals) and wetlands and can survive extended periods in mud or moist soil (reviewed in Rivers 2002, Global Invasive Species Database 2005, EPPO 2007-2012 and CABI 2014). It prefers slightly acidic waters (6.5 - 7.2 pH) and moderate hardness (5 - 20 mg/l CaCO<sub>3</sub>) (Global Invasive Species Database 2005), but can tolerate hardness down to 1 and up to 25 mg/l CaCO<sub>3</sub> (CABI 2014).</p> <p>The most likely mechanisms of transfer to a suitable habitat are as the result of a deliberate act of introduction via an aquarium dump or by planting out to a natural water; or inadvertent escape from confined waters (e.g. garden pond) to external waters as a result of flooding (the plant is predominantly free-floating which increases its capacity for spread). In theory, there are many waters in Ireland that are potentially suitable for colonisation. However, as outlined previously, long-term perpetual establishment may be severely constrained by water temperature.</p>
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	VERY LIKELY	VERY HIGH	It is already deliberately imported for trade.
1.10	Do other pathways need to be considered?	NO		

Overall likelihood				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	VERY LIKELY	VERY HIGH	<p><i>Pistia stratiotes</i> is principally imported into Ireland via the aquarium sector for sale to the public in garden centres and aquarium / pet shops. It is also available to buy directly through the internet from such vendors or from individual hobbyists. The presence of this species in the horticultural trade is considered minor. Boating, angling and other water based activities may represent a potential pathway to transfer this plant from abroad. However, these pathways are considered of very low risk as <i>Pistia stratiotes</i> is not present in the wild in Britain and is extremely rare in mainland Europe where the vast majority of any such vectors for transfer would arise.</p>

## Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')?	NO	-	Refer to Question 9.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local <u>climatic conditions</u> and the organism's current global distribution?	MODERATELY LIKELY	HIGH	<p><i>Pistia stratiotes</i> predominantly occurs across the tropical and sub-tropical regions of the world (reviewed in Evans 2013) which experience warmer summers and milder winters than Ireland. Based on experiences elsewhere in Europe (see response to Question 1.07), local climatic conditions, notably low winter temperatures, will most likely inhibit widespread establishment by preventing survival over winter under natural conditions. It is likely, in Ireland, that the species would have the characteristics of a summer annual which requires replanting each year. In the River Erft in Germany it has been suggested that <i>Pistia stratiotes</i> has recently adapted to become more cold resistant as it increased its capacity to overwinter. Nevertheless, temperatures in this water do not drop below 10°C (Hussner and Heilitag 2013).</p>
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local <u>abiotic conditions</u> and the organism's current global distribution?	MODERATELY LIKELY	HIGH	The sole limiting abiotic factor inhibiting widespread establishment of <i>Pistia stratiotes</i> in Ireland is temperature, with winter water temperatures being too low for survival over the winter period. Summer temperatures appear to be adequate for survival and vegetative reproduction but may inhibit seed germination unless water temperatures reach or exceed 20°C (refer to responses to Questions 1.07, 1.08 and 2.02),
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	UNLIKELY TO MODERATELY LIKELY	HIGH	Refer to response to Question 1.08.
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	UNLIKELY TO MODERATELY LIKELY	MEDIUM	There is a general paucity of information available to assess this, but two experimental studies have shown that <i>Pistia stratiotes</i> has only moderate competitive ability against other free-floating plants of temperate to warm-water habitats, including <i>Eichhornia crassipes</i> , <i>Salvinia auriculata</i> , <i>Salvinia minima</i> , <i>Limnobium laevigatum</i> and <i>Lemna minor</i> (Agami and Reddy 1990; Milne et al. 2007).
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	UNLIKELY TO MODERATELY LIKELY	LOW	There are no known specialist natural predators, parasites or pathogens of this species (see CABI 2014) in Ireland that will have an adverse effect on its establishment. Some non-specialist species in Ireland may be able to use <i>Pistia stratiotes</i> as a food source. In a thermal stream in Slovenia,

## Stage 2 - Detailed assessment: Section B – Establishment

*This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				no loss of plant biomass to herbivory or pathogens, or damage to single plants, was observed (Šajna 2007). There is limited evidence to suggest that <i>Pistia</i> plants may be more prone to invertebrate damage in cooler conditions: A comparative study undertaken in 2013 found that 100% of <i>Pistia stratiotes</i> plants examined from northern Argentina wetlands had insect damage, whilst only 83.3% of plants from tropical wetlands in Zambia had damage attributable to insect herbivory (C. Franceschini and K. Murphy: pers. comm)
2.07	How likely is it that establishment will occur despite existing management practices?	UNLIKELY	HIGH	In general, the State management of waterways is undertaken cognisant of ensuring biosecurity measures are in place to mitigate for the spread of aquatic invasive species. An increase in awareness of the threat from aquatic invasive species by some private entities has also reduced this risk. Increased awareness by aquarium stakeholders should reduce any risk further.
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	UNLIKELY	HIGH	Refer to Question 2.07.
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	UNLIKELY	HIGH	<i>Pistia stratiotes</i> can be controlled using chemical, physical/mechanical and biological means (reviewed in Global Invasive Species Database 2005 and CABI 2014). The biological characteristic that allows for its persistence after mechanical control is that it can reproduce vegetatively from plant fragments that remain <i>in situ</i> after treatment. Seeds, if present and able to germinate, may persist in an area subject to control by either approach, requiring continued control over a number of years to increase the probability of achieving eradication. In Ireland, winter temperatures may limit or inhibit the long-term establishment of <i>Pistia stratiotes</i> ; therefore, an eradication programme may be successful.
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	MODERATELY LIKELY	HIGH	The susceptibility of <i>Pistia stratiotes</i> to frost (Hussner and Heiligttag 2013), its apparent lack of ability to over-winter in Ireland under natural conditions and its requirements of at least 20°C for seed germination (Pieterse <i>et al.</i> 1981) are likely to limit or inhibit long-term establishment of this species in the country. Alternatively, its ability to reproduce both by seed and vegetatively (Hussner and Heiligttag 2013; reviewed in CABI 2014), could increase its capacity to establish if water temperatures were suitable. The seeds have some drought tolerance which may also

## Stage 2 - Detailed assessment: Section B – Establishment

*This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				facilitate establishment. Hussner and Heiligttag (2013) reported that 90% of seeds could germinate under suitable conditions after being dried at room temperature for a three week period.
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	UNLIKELY OR MODERATELY LIKELY	HIGH	Within catchments, the principal means of natural spread is through sexual reproduction (i.e. seeds) and asexual reproduction (vegetative offshoots connected by stolons to the mother plant) or via plant drift downstream as it is a floating species (Hussner and Heiligttag 2013; reviewed in CABI 2014). In the River Erft in Germany, between 1,000 and 10,000 plants per day were estimated to drift downstream from an infested area (Hussner and Heiligttag 2013). This indicates a high natural dispersal potential. Between watersheds, there is a moderate potential for natural spread as seeds may be transferred epizoochorically via migrating water fowl. Anthropogenic-mediated transfer is the principal pathway to facilitate the spread and establishment of the plant to uncolonised waters. As previously stated, the capacity for establishment in Ireland is low because climatic conditions here are unsuitable for widespread establishment of this species.
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	UNLIKELY	HIGH	<i>Pistia stratiotes</i> is unlikely to adapt sufficiently to facilitate it becoming widely established in suitable habitats in Ireland, principally because of its low-temperature intolerance, as evident elsewhere in Europe. Having said that, in the River Erft in Germany it has been suggested that the species has recently adapted to become more cold resistant as it has increased its capacity to overwinter. Nevertheless, temperatures in this water do not drop below 10°C (Hussner and Heiligttag 2013).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	UNKNOWN	LOW	There is no evidence to suggest that low genetic diversity in any founder population would inhibit establishment.
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	MODERATE LIKELY	HIGH	<i>Pistia stratiotes</i> is considered to be unlikely to establish widely in Ireland due to its intolerance of winter temperatures. Transient populations or ephemeral populations which establish in summer and dieback in autumn are possible. This assertion is based on experiences elsewhere in Europe (e.g. Šajna 2007; Hussner and Heiligttag 2013; and those reported in CABI 2014).

**Stage 2 - Detailed assessment: Section B – Establishment**

*This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	LIKELY	HIGH	Refer to response to Question 2.14 above.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	Under current climatic conditions, It is considered that this species is unlikely to establish widely in Ireland in suitable habitats because of its likely inability to overwinter here. Transient populations or ephemeral populations which establish in summer and dieback in autumn are possible.

## Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	11% - 33%, (of 10 km squares)	HIGH	<i>Pistia stratiotes</i> can grow in a wide variety of aquatic habitats but prefers relatively stagnant waters (CABI 2014). It occurs in ponds, lakes, reservoirs, water courses (streams, rivers and canals) and wetlands and can survive extended periods in mud or moist soil (reviewed in Rivers 2002, Global Invasive Species Database 2005, EPPO 2007-2012 and CABI 2014). It prefers slightly acidic waters (6.5 - 7.2 pH) and moderate hardness (5 - 20 mg/l CaCO <sub>3</sub> ) (Global Invasive Species Database 2005), but can tolerate hardness down to 1 and up to 25 mg/l CaCO <sub>3</sub> (CABI 2014). However, as outlined previously, long-term establishment of this species may be severely constrained or inhibited by water temperature and only transient populations may occur.
3.02	How important is the expected spread of this organism in Ireland by <u>natural</u> means (minimal, minor, moderate, major or massive)?	MINIMAL	HIGH	If water temperatures were sufficient for successful reproduction, natural spread within catchments would be rated as 'major' as this is a floating species with the capacity for both sexual and asexual reproduction (refer to response to Question 2.11 for information on natural spread).
3.03	How important is the expected spread of this organism in Ireland by <u>human assistance</u> (minimal, minor, moderate, major or massive)?	MODERATE	VERY HIGH	Anthropogenic-mediated transfer is the principal pathway which could facilitate the establishment of the plant from aquaria or ponds to the wild.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MINOR	HIGH	If only transient populations can occur in the wild because Irish climatic conditions are unsuitable for successful reproduction, containment is very feasible. If the plant could reproduce in the wild in Ireland, containment would be extremely difficult within catchments or large waters but feasible in small isolated waters.
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	N/A	HIGH	This species has not been recorded in the wild in Ireland to date.

**Stage 2 - Detailed assessment: Section C - Spread**

*This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.06	What proportion of the area in Ireland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0% - 10%	VERY HIGH	This species has not been recorded in the wild in Ireland to date and is highly unlikely to establish reproducing populations in the next five years.
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	40-80 years	MEDIUM	A significant increase in water temperatures and milder winters in Ireland would be required to facilitate any long-term establishment and subsequent spread of this species in Ireland. This depends on the rate of climate change.
3.08	In this timeframe, what proportion of the endangered area (including any currently occupied areas) is likely to have been invaded by this organism?	UNKNOWN	-	Refer to responses above and below.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	HIGH	In theory, <i>Pistia stratiotes</i> can grow in a wide variety of aquatic habitats in Ireland (refer to response to Question 3.01). However, it is considered highly unlikely to establish sustainable populations in Ireland under present climatic conditions. The only areas of concern presently would be in the vicinity of localised warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations).
3.10	Estimate the overall potential for future spread for this organism in Ireland (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	VERY SLOWLY	HIGH	Refer to responses to Questions 3.07 and 3.09.

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MAJOR	HIGH	<p>According to a review by CABI (2014), "<i>P. stratiotes</i> can seriously interfere with paddy crops (Holm <i>et al.</i> 1977; Waterhouse 1993). Although no accurate measurement is available of the loss of water needed for agriculture through transpiration from beds of <i>P. stratiotes</i>, losses are believed to be considerable (Holm <i>et al.</i> 1977)".</p> <p><i>P. stratiotes</i> is one of the major aquatic weeds in tropical and sub-tropical regions. It rapidly forms dense mats which may completely cover the surface of the water. Consequently, such dense stands of <i>Pistia</i> may have serious negative effects on the multifunctional human use of water bodies. These harmful effects include impediment of the transport of irrigation and drainage water, interference with hydro-electric schemes from artificial lakes, hindering navigation and fishing and the creation of habitats favourable for the transmittance of water-borne diseases (Mbatis and Neuenschwander 2005). In this context it should be noted that larvae of <i>Mansonia</i> mosquitos may directly obtain oxygen from the roots of <i>Pistia</i> (Gangstad and Cardarelli 1990)."</p>
4.02	How great has the economic cost of the organism been in Ireland from the <u>time of introduction to the present</u> ? Exclude any costs associated with managing the organism from your answer.	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
4.03	How great is the economic cost of the organism likely to be in the <u>future</u> in Ireland? Exclude any costs associated with managing the organism from your answer.	MINOR	MEDIUM	In Ireland, <i>Pistia stratiotes</i> is unlikely to establish populations that incur economic costs except in the vicinity of localised warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations).
4.04	How great have the economic costs of managing this organism been in Ireland from the <u>time of introduction to the present</u> ?	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
4.05	How great is the economic cost of managing this organism likely to be in the <u>future</u> in Ireland?	MINOR	MEDIUM	As stated in response to Question 4.03, in Ireland <i>Pistia stratiotes</i> is unlikely to establish sustainable populations except in the vicinity of warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations). If this occurs some economic costs may be incurred to control an infestation.

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.06	How important is environmental harm caused by the organism within its global distribution?	MODERATE / MAJOR	VERY HIGH	According to a review by CABI (2014), " <i>P. stratiotes</i> causes changes in both the physiochemical and biological characteristics of water bodies it inhabits. Cai (2006) reports that growth of <i>P. stratiotes</i> causes increases in transparency, nitrate, ammonium, total nitrogen, total phosphorus and total bacteria, as well as a decrease in pH, DO, permanganate index, total plankton and plankton species diversity. The plant also influenced the size structure of planktonic communities, causing a miniaturization of plankton volume. Dray and Center (2002) review additional ecological impacts of <i>P. stratiotes</i> and note that they include increased rates of siltation, slowing of water velocities, degradation of fish nesting sites, increased nutrient loading, thermal stratification, increases in alkalinity and fish and macroinvertebrate mortality."
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Ireland?	MINOR	HIGH	As stated elsewhere, <i>Pistia stratiotes</i> is unlikely to establish infestations that will have a substantial impact on biodiversity in Ireland. Local impacts as outlined in response to Question 4.06 may occur where dense colonies form.
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the <u>future</u> ?	MINOR	HIGH	As stated elsewhere, <i>Pistia stratiotes</i> is unlikely to establish infestations that will have a substantial impact on ecosystem function in Ireland. Local impacts as outlined in response to Question 4.06 may occur where dense colonies form.
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.

Stage 2 - Detailed assessment: Section D - Impact				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.12	How important is decline in conservation status caused by the organism likely to be in the <u>future</u> in Ireland?	MINOR	HIGH	As stated elsewhere, <i>Pistia stratiotes</i> is unlikely to establish infestations that will have a substantial impact on conservation status in Ireland. Where dense colonies form, detrimental impacts to native habitats and species may occur, which could result in the downgrading of ecological status under the Water Framework Directive and have implications for Natura 2000 sites.
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	MODERATE	HIGH	Refer to response to Question 4.01.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	NONE	VERY HIGH	This species has not been recorded in the wild in Ireland to date.
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MINIMAL	VERY HIGH	Highly unlikely - there is no evidence for this.
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	MINOR	HIGH	It has ancient use as medicine for humans and is used as fodder for cattle and pigs (Sculthorpe 1971 as cited in CABI 2014). It may create habitats favourable for the transmittance of water-borne diseases (Mbatis and Neuenschwander 2005 as cited in CABI 2014) and harbour the larvae of <i>Mansonia</i> mosquitos (Gangstad and Cardarelli 1990 as cited in CABI 2014)."
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	MINIMAL	HIGH	

<b>Stage 2 - Detailed assessment: Section D - Impact</b> <i>This section evaluates the probability of impact of an organism within Ireland.</i>				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MINIMAL	HIGH	<p>There are no known specialist natural predators, parasites or pathogens of this species (see CABI 2014) in Ireland that will have an adverse effect on this species or reduce its impacts. Some non-specialist species in Ireland may be able to use <i>Pistia stratiotes</i> as a food source. In a thermal stream in Slovenia, no loss of plant biomass to herbivory or pathogens, or damage to single plants was observed (Šajna 2007). However see response to Question 2.06 for recent data on insect herbivory damage to <i>Pistia</i> suggesting that this may be significant in warm temperate to tropical conditions.</p>
4.19	Indicate any parts of Ireland where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.		HIGH	<p><i>Pistia stratiotes</i> is unlikely to establish sustainable populations except in the vicinity of localised warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations). If this occurs some local economic, environmental and social impacts are possible. Sporadic ephemeral populations could occur in suitable habitats as a result of human-mediated introductions, and if locally abundant, could cause some such impacts until they die off.</p>
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MINIMAL	HIGH	<p>At present, <i>Pistia stratiotes</i> is unlikely to establish populations except in the vicinity of localised warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations). If this occurs some local impacts are possible. Sporadic ephemeral populations are possible in suitable habitats as a result of human-mediated introductions, and if locally abundant, could also cause some impacts until they die off.</p>

## Stage 2 - Detailed assessment: Section E – Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland.	MINOR	HIGH	The overall risk of <i>Pistia stratiotes</i> becoming invasive in Ireland is considered to be low. At present, <i>Pistia stratiotes</i> is unlikely to establish sustainable populations except in the vicinity of localised warm water discharges (e.g. hot water outflows from fuel-powered electricity generating stations). If this occurs some local impacts are possible. Sporadic transient populations or ephemeral populations are possible in suitable habitats as a result of human-mediated introductions, and if locally abundant, could cause some impacts until they die off.

## Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?		HIGH	Climate change is expected to increase water temperatures over time, with increased periods of drought in summer and higher rainfall in winter leading to more flooding events (Desmond <i>et al.</i> 2008). A review of the literature suggests that <i>Pistia stratiotes</i> may only currently establish transient or ephemeral populations in Ireland during the warmer months of the year (May to September) and may have an extremely limited or no capacity to overwinter or produce germinating seeds under natural conditions, as is the case in mainland Europe (refer to response to Question 1.07). From this, it is evident that increasing water temperatures may increase the reproductive and over-wintering capability of <i>Pistia stratiotes</i> , and enhance its long-term establishment.
6.02	What is the likely timeframe for such changes (5, 10, 15 , 20, 50 or 100 years)?	50 - 100 YEARS	LOW	
6.03	What aspects of the risk assessment are most likely to change as a result of climate change		HIGH	A revaluation of the establishment, spread and impact sections of this risk assessment would be required if significant climate change occurred (i.e. an increase in water temperatures or mild winters).
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	YES		Information on the frequency of the <i>Pistia stratiotes</i> trade that occurs for horticultural purposes would strengthen the pathways section of this risk assessment. An experimental assessment of the ability of <i>Pistia stratiotes</i> to survive and reproduce in outdoor environments in Ireland or accounts of this from experienced horticulturalists may also be useful to strengthen this risk assessment.

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