

## Risk Assessment of *Lagarosiphon major*

<b>Name of Organism:</b>	<i>Lagarosiphon major</i> (Ridley) Moss – Curly-leaved Waterweed
<b>Objective:</b>	Assess the risks associated with this species in Ireland
<b>Version:</b>	Final 15/09/2014
<b>Author(s)</b>	Michael Millane and Joe Caffrey
<b>Expert reviewer</b>	Jan-Robert Baars

### Stage 1 - Organism Information

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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

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<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		14/01/2014
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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>			
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>COMMENT</b>
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	<i>Lagarosiphon major</i> (Ridley) Moss <i>ex</i> Wager, <i>Lagarosiphon</i> , Curly-leaved Waterweed, African Curly Leaved Waterweed, South African Pondweed, Curly Water Thyme and Curly Waterweed. Often sold as <i>Elodea crispata</i> (no such scientific name exists), Oxygen Weed or African Elodea.
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>Lagarosiphon major</i> (Ridley) Moss is a rhizomatous, perennial, submerged aquatic plant. The plant reaches its maximum growth in clear water up to a depth of 6.5m, but may only grow to 1 metre depth in murky water. It has numerous threadlike roots, which are adventitious (i.e. branching from the stem) and, along with rhizomes (i.e. horizontal stems in the sediment), anchor it to the bottom. Stems are brittle and sparsely branched, 3-5 mm in diameter and curved towards the base (J-shaped). The stems grow towards the water surface and the plant can form dense surface canopies. The leaves are 2-3 mm wide and 5-20 mm long and occur in alternate spirals along the stem. They generally have tapered tips curving downwards towards the stem, except in low alkalinity water where they are straight. The three-petalled female flowers are very small, clear-white on the surface, and grow on very thin white to almost translucent filament-like stalks. Neither the male flower, which floats freely to the surface, nor fruit or seeds, have been recorded outside of its native range (reviewed in Global Invasive Species Database 2006).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	YES	Two preliminary risk assessments were previously carried out for Ireland as follows. A stage one and two risk assessment as part of <i>Ireland's National Plant Conservation Strategy - Target 10 - Managing Invasive Alien Species</i> (Botanic Gardens 2007); and a prioritisation risk assessment as part of the <i>Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland</i> (Kelly <i>et al.</i> 2013). The former assessment designated <i>Lagarosiphon major</i> as a "most significant invasive plant" and the latter assessment designed the plant as a 'high risk' invasive species.

<b>Stage 1 - Organism Information</b>			
<i>The aim of this section is to gather basic information about the organism.</i>			
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>COMMENT</b>
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTLY VALID	Only preliminary risk assessments were previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?		Botswana - native and invasive (USDA, ARS 2013), Lesotho - native and invasive (USDA, ARS, 2013), South Africa (Obermeyer, 1964; James et al. 1999; Cook, 2004), Zambia - native and invasive (USDA, ARS 2013) and Zimbabwe - native and invasive (Csurhes and Edwards 1998).
8	What is the current global distribution of the organism (excluding Ireland)?		Australia (Csurhes and Edwards 1998), Britain and Northern Ireland (Csurhes and Edwards 1998), France (Csurhes and Edwards 1998), Italy (Airo and Sconfiotti 1995), Netherlands (Matthews <i>et al.</i> 2012), New Zealand (McGregor and Gourlay 2002), Reunion (CBNM 2013), Switzerland (Egloff 1975) and the countries listed in answer to Question 7.
9	What is the current distribution of the organism in Ireland?		Recorded in a total of 29 x10km squares in the National Invasive Species Database (National Invasive Species Database 2013). Lough Corrib remains the only location where it has established in the wild (Caffrey <i>et al.</i> 2011). Otherwise, it is confined to artificial watercourses and garden ponds (Caffrey <i>et al.</i> 2011; National Invasive Species Database 2013).
10	Is the organism known to be invasive anywhere in the world?	YES	France (Csurhes and Edwards, 1998), Italy (Airo and Sconfiotti, 1995), New Zealand (McGregor and Gourlay 2002), Switzerland (Egloff, 1975), Britain and Northern Ireland (Csurhes and Edwards, 1998) and in parts of its native range (refer to Question 7).

**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)?	MANY	VERY HIGH	Horticultural and aquarium trade, boating, angling and other water activities.
1.02	List <u>significant</u> pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Horticultural and aquarium trade 2. Boating 3. Angling		<i>Lagarosiphon major</i> is imported into Ireland <i>via</i> the horticultural and aquarium sectors for sale to the public in garden centres and pet shops. It is also sold periodically in some other retail outlets, such as supermarkets, and is available to buy on the internet. The risk of introduction by boats and anglers arises from any travel to Ireland from an infested area abroad where equipment is inadvertently contaminated with viable plant material.

**Pathway 1 - Horticultural and aquarium trade**

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>Lagarosiphon major</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?	VERY LIKELY	VERY HIGH	<i>Lagarosiphon major</i> is deliberately imported for trade and subsequently sold in a wide range of outlets in Ireland as an oxygenator / ornamental weed for artificial watercourses, garden ponds and aquaria.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness or expertise by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present. There is some confusion as to nomenclature, as it is often incorrectly sold as <i>Elodea crispera</i> or as an 'oxygenating weed'.
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, survival is considered very likely.

<b>Pathway 1 - Horticultural and aquarium trade</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	VERY LIKELY	VERY HIGH	There is no known seasonal restriction to inhibit the establishment of this organism from viable plant material. Trade imports and purchases may occur throughout the year.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	Ireland has a high density and abundance of freshwaters, many of which are suitable for the establishment of this organism as it has a wide tolerance of environmental conditions (excluding highly eutrophic, acidic or fast flowing systems). The practice of planting <i>Lagarosiphon major</i> in artificial watercourses and private ponds, which are often proximal to these natural systems, and its use in aquaria, increases the likelihood of it transferring from this pathway to a suitable habitat.
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?	YES		

<b>Pathway 2 – Boating</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
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)?	ACCIDENTAL	HIGH	The overland or cross-channel movement of boats, boat trailers and boat engines from an infested to uninfested area has the potential to inadvertently spread this organism if viable plant material is attached. This includes the import of used boats from abroad.
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	HIGH	In the absence of implementing appropriate biosecurity measures, there is an increased potential for the inadvertent spread of viable plant material overland or cross-channel on boating equipment from infested to uninfested waters.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness or expertise by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.

Pathway 2 – Boating				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	It is considered that viable plant material (c. 5 cm in length) can survive in a damp environment in boats and on related equipment for at least seven days (M. Millane, personal observation).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	There is no known seasonal restriction to inhibit the establishment of this organism from viable plant material. Boat movements may occur throughout the year.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	MODERATELY LIKELY	HIGH	Ireland has a high density and abundance of freshwaters, many of which are suitable for the establishment of this organism as it has a wide tolerance of environmental conditions (excluding highly eutrophic, acidic or fast flowing systems). Boat movements act as a direct pathway to transfer this organism from an infested water to a suitable habitat elsewhere. As plant material can remain viable for at least seven days in damp conditions (M Millane, <i>personal observation</i> ), transfer is dependent on the environmental conditions and duration of transport.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	HIGH	This pathway depends on the transfer of viable plant material surviving an overland or cross-channel journey in association with boats from an infested water outside Ireland to an uninfested water in the country. In Britain's freshwaters, it is recorded in 473 x 10 km squares (GB Non-Native Species Secretariat 2011) and in Northern Ireland it is recorded in 8 x 10 km squares (National Invasive Species Database 2013). As there is no specific information available on the movement of boats from infested areas abroad to Ireland, it is considered moderately likely that the organism can enter <i>via</i> this pathway.
1.10	Do other pathways need to be considered?	YES		

<b>Pathway 3 - Angling</b>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
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)?	ACCIDENTAL	HIGH	The overland or cross-channel movement of angling equipment from an infested to uninfested area has the potential to inadvertently spread this organism if viable plant material is attached. It is considered that viable plant material can survive in a damp environment on angling equipment (e.g. landing or keep net, stink bag, angling box and stand, boots and waders) for at least seven days (M. Millane, personal observation). Plant fragments as small as c. 5 cm in length which are less detectable are viable to regenerate into full plants (M. Millane, personal observation).
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	HIGH	In the absence of implementing appropriate biosecurity measures, there is an increased potential for the inadvertent spread of viable plant material overland or cross-channel on angling equipment from infested to uninfested waters.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness or expertise 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?	MODERATELY LIKELY	HIGH	It is considered that viable plant material as small as c. 5 cm in length can survive in a damp environment on angling equipment for at least seven days (M. Millane, personal observation).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	HIGH	There is no known seasonal restriction to inhibit the establishment of this organism from viable plant material. Movement in association with anglers may occur throughout the year.
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	Ireland has a high density and abundance of freshwater fisheries, many of which are suitable for the establishment of this organism as it has a wide tolerance of environmental conditions (excluding highly eutrophic, acidic or fast flowing systems). The movement of anglers acts as a direct pathway to transfer this organism from an infested water to a suitable habitat elsewhere. As plant material can remain viable for at least seven days in damp conditions (M Millane, <i>personal observation</i> ), transfer is dependent on the environmental conditions and duration of transport.



Pathway 3 - Angling				
N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	HIGH	This pathway depends on the transfer of viable plant material surviving an overland or cross-channel journey in association with angling equipment from an infested water outside Ireland to an uninfested water in the country. In Britain's freshwaters, it is recorded in 473 x 10km squares (GB Non-Native Species Secretariat 2011) and in Northern Ireland in is recorded in 8 x 10 km squares (National Invasive Species Database 2013). As there is a paucity of specific information available on the movement of anglers from infested areas abroad into these jurisdictions, it is considered moderately likely that the organism can enter <i>via</i> this pathway.
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	The primary pathway of entry into Ireland is through deliberate trade <i>via</i> the horticultural and aquarium sectors. The movement of boats and anglers from infested areas outside Ireland may also facilitate entry as viable plant material can survive in a damp environment out of water for at least seven days.

**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.*

<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	NO	-	Lough Corrib remains the only natural freshwater in Ireland where <i>Lagarosiphon major</i> is currently established (Caffrey <i>et al.</i> 2011).
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?	VERY LIKELY	VERY HIGH	The species is perennial in Ireland and winter conditions do not kill the plant. It is present in 29 10 km squares in Ireland (National Invasive Species Database 2013), and climatic conditions are not thought to be limiting.
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?	VERY LIKELY	VERY HIGH	The species is capable of utilising Dissolved Inorganic Carbon sources with very high efficiency of removal. Light is not limiting, and other geological factors are not thought to be limiting. There are probably no such abiotic limiting factors present in the country to limit its establishment in suitable habitats (GB Non-Native Species Secretariat 2011).
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	VERY HIGH	In Ireland, there is an abundance of freshwater habitats (e.g. lakes, slow flowing rivers, ponds, canals and other artificial watercourses) susceptible to colonisation by <i>Lagarosiphon major</i> which can facilitate its subsequent survival, development and multiplication. Separate systems are often geographically proximal.
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	VERY HIGH	<i>Lagarosiphon major</i> can out-compete and extirpate native plant species (Caffrey <i>et al.</i> 2010).
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	VERY LIKELY	VERY HIGH	There are no known natural predators, parasites or pathogens of this species in Ireland that will have an effect on its establishment.
2.07	How likely is it that establishment will occur despite existing management practices?	UNLIKELY	HIGH	In general, the state management of waters in Ireland (particularly where <i>Lagarosiphon major</i> is present) is undertaken cognisant of ensuring biosecurity measures are in place to mitigate for the spread of aquatic invasive species. An increase in awareness by some private entities of the threat from aquatic invasive species has also reduced this risk.
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.

**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
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	MODERATELY LIKELY	MEDIUM	Mechanical control conducted with disregard for the potential generation and spread of viable vegetative fragments is a risk factor. The use of jute matting benthic barriers to control <i>Lagarosiphon major</i> has been successfully employed to effect local eradication (Caffrey <i>et al.</i> 2010). The inability of the plant to reproduce sexually (i.e. produce seeds) outside of its native range reduces its ability to persist in an area after control. Complete eradication of large infestations is unlikely but control can substantially reduce the abundance of established populations and their concomitant impacts (Caffrey <i>et al.</i> 2011).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	VERY HIGH	The ability of <i>Lagarosiphon major</i> to reproduce asexually from vegetative fragments, to out-compete native plant species, to survive extended periods in damp environments out of water and its perennial nature can facilitate its establishment (Caffrey <i>et al.</i> 2010; Caffrey <i>et al.</i> 2011).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	MODERATELY LIKELY	VERY HIGH	Refer to Question 3.02.
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	VERY HIGH	<i>Lagarosiphon major</i> has a wide ecological tolerance (reviewed in Global Invasive Species Database 2006) which allows it to establish populations in most freshwater environments in Ireland (excluding highly eutrophic, acidic or fast flowing systems).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	VERY LIKELY	VERY HIGH	Although reproduction is solely vegetative in Ireland, there is no evidence to suggest low genetic diversity in the founder population will inhibit any future 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	VERY LIKELY	VERY HIGH	It has already demonstrated this capacity in Ireland.
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	N/A		
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	Refer to Questions 2.04, 2.10 and 2.12.

**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%)?	68% - 90% of 10 km squares	VERY HIGH	As it can tolerate a wide range of environmental conditions (reviewed in Global Invasive Species Database 2006), the majority of Ireland's freshwaters (excluding highly eutrophic, acidic or fast flowing systems) are considered suitable for the establishment of <i>Lagarosiphon major</i> . The ecological requirements of <i>Lagarosiphon major</i> are similar to <i>Elodea canadensis</i> and the known distribution of this non-native plant (361 x 10km squares on the island of Ireland [National Invasive Species Database 2013]) indicates the potential of <i>Lagarosiphon major</i> to occur at such an extent as indicated (68-90%).
3.02	How important is the expected spread of this organism in Ireland by <u>natural</u> means (minimal, minor, moderate, major or massive)?	MODERATE	HIGH	Within systems, internal spread by natural means is common, principally occurring <i>via</i> vegetative fragmentation and locally, to a lesser extent, from canopy collapse and subsequent re-rooting adjacent to infested areas (Caffrey <i>et al.</i> 2011). Between watersheds, there is a very low potential for natural spread, although it could be transferred <i>via</i> plant fragments attached to water fowl.
3.03	How important is the expected spread of this organism in Ireland by <u>human assistance</u> (minimal, minor, moderate, major or massive)?	MASSIVE	VERY HIGH	Deliberate introduction to garden ponds and aquaria is common. In Britain, "deliberate introduction to sites outside gardens is probably common as the aggressive nature of the plant means that pond clearances will generate large volumes of viable plant material for disposal" (GB NNSS Organism Risk Assessment, 2011). The movement of boats and angling gear has a high potential to inadvertently spread <i>Lagarosiphon major</i> within and between watersheds.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MODERATE	HIGH	<i>Lagarosiphon major</i> currently has a limited distribution and is largely confined to small, isolated artificial watercourses. It is recorded on the island of Ireland in a total of 29 10km squares (National Invasive Species Database 2013) and Lough Corrib remains the only location where it has established in the wild (Caffrey <i>et al.</i> 2011). Therefore, containment is very feasible if routine biosecurity measures to limit its further spread are implemented and proposed restrictions on its importation and sale are enforced. Further to this, effective methods now exist to control and eradicate <i>Lagarosiphon major</i> as demonstrated in Lough Corrib (Caffrey <i>et al.</i> 2010; Caffrey <i>et al.</i> 2011).

**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
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0% -10%	VERY HIGH	Refer to Question 3.04.
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%	MODERATE HIGH	The ongoing weed control programme in Lough Corrib has substantially reduced the area of lake infested by the plant (by over 90%) thus lowering its capacity for internal and external spread, although the <i>Lagarosiphon</i> -free lower lake remains vulnerable to widespread colonisation (Caffrey <i>et al.</i> 2011; CAISIE 2013). Despite this, there exists a moderate to high risk of spread from Lough Corrib to nearby lakes (notably Loughs Mask and Carra and to a lesser extent, the Shannon lakes and further afield) <i>via</i> angling boat movements. It is likely that such spread would only be detected when significant <i>Lagarosiphon major</i> beds establish. Its potential for natural spread from confined artificial waters (e.g. ponds) is generally considered low, however anthropogenic-mediated transfer from such locations increases this risk and is likely the reason as to how <i>Lagarosiphon major</i> originally entered Lough Corrib.
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.	10 years	HIGH	In the absence of restrictions on sale and the implementation of routine biosecurity measures, significant further spread is considered likely (Refer to Question 3.06).
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0% - 10%		Refer to Questions 3.06 and 3.07.
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	The majority of freshwater systems (excluding highly eutrophic, acidic or fast-flowing systems) in Ireland are vulnerable to the establishment of <i>Lagarosiphon major</i> .
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	SLOWLY	HIGH	If restrictions on sale are enforced and biosecurity measures are routinely implemented, further range extensions will be slow as the principal mechanism of spread is human-mediated. However, the plant it is introduced to larger systems like the Shannon future spread could be moderate or rapid through natural and human-assisted means.

**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

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	MEDIUM	The tangible costs are difficult to accurately quantify. The characteristic dense growths of <i>Lagarosiphon major</i> can impede angling, restrict the passage of boats (both impacting on tourism or other income), inhibit drainage thus exacerbating flood risk, reduce the water storage capacity of reservoirs, block intakes to hydroelectric systems and require measures to be implemented to protect or restore impacted species or habitats (Csurhes and Edwards 1998; Champion and Clayton 2000). In Britain, the estimated cost of mechanical control per hectare is £1,000 (GB Non-Native Species Secretariat 2011).
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.	MODERATE	MEDIUM	This is difficult to quantify. The presence of extensive and dense stands of <i>Lagarosiphon major</i> in Lough Corrib rendered numerous areas of the lake unfishable for anglers (Caffrey <i>et al.</i> 2011) and this is likely to have deterred some anglers from fishing in the region.
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.	MODERATE	MEDIUM	Unknown (see Question 4.01 for an overview of known economic impacts likely to occur should <i>Lagarosiphon major</i> spread in Ireland). The widespread establishment of <i>Lagarosiphon major</i> in the lower lake of Lough Corrib may restrict the normal drainage of water through the catchment and exacerbate future flooding events (Caffrey <i>et al.</i> 2011). The spread of <i>Lagarosiphon major</i> to other freshwaters may deter some anglers from fishing. It is worth noting that the economic value of recreational angling to Ireland (including sea angling) is estimated at €755 million per annum (Inland Fisheries Ireland 2013). Further to this, infestations may impede boating on navigable inland waters. Recreational boating is estimated to be worth €70 million to the Irish economy (Martin 2012). There may also be financial implications if conservation goals such as those specified in the EC Habitats Directive and the EU Water Framework Directive are under threat.
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> ?	MAJOR	VERY HIGH	The estimated cost of control, research and rehabilitation operations to manage <i>Lagarosiphon major</i> in Lough Corrib since 2005 is in the region of €2.5 million (Inland Fisheries Ireland, unpublished).

<b>Stage 2 - Detailed assessment: Section D - Impact</b>				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
4.05	How great is the economic cost of managing this organism likely to be in the <u>future</u> in Ireland?	MAJOR	HIGH	The projected annual cost to manage <i>Lagarosiphon major</i> in Lough Corrib is estimated at €200,000 (Millane <i>et al.</i> 2013). The successful outcome of an ongoing biocontrol programme (Mangan and Baars 2013) which aims to identify a biological agent to control the weed as well as the ongoing control and eradication efforts may significantly reduce this cost in the medium to long term.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	VERY HIGH	<p>“This species is causing and will continue to cause considerable ecological damage to all invaded freshwater habitats (Csurhes and Edwards 1998; Champion and Clayton 2000, Caffrey <i>et al.</i> 2011). Most habitats in the introduced range are floristically poor, e.g. gravel pits, and the presence of this dominant species further reduces floristic diversity. Problems caused by this plant include very high pH (up to 10.4) can be generated by active transport of bicarbonate ions, which limits productivity by other macrophytes due to carbon shortages. It is not known what effect this has on associated fauna. The ability to dramatically change the chemical status of water bodies, including nutrient and pH changes, means that water quality is also affected by the presence of the species in any volume. Data from an impact assessment carried out for Australia (<a href="http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_lagarosiphon">http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_lagarosiphon</a>) states, “The physical properties of the plant are not harmful to humans, however, “it has the ability to accumulate considerable amounts of arsenic from the surrounding medium.” Tests conducted on sheep in New Zealand revealed the arsenic does not pose a serious threat to health”. Also it “can form a light-blocking canopy so dense and thick (3 feet thick) that <i>Lagarosiphon major</i> easily out competes even tall non-canopy forming native species.” “<i>Lagarosiphon major</i> successfully out-competed native species wherever it has colonised New Zealand lakes in the depth zone 2-6 m normally occupied by native milfoils (<i>Myriophyllum</i> spp.) and pondweeds (<i>Potamogeton</i> spp.)” Would have a major impact on the floral strata in aquatic situations. Heavy infestations of <i>Lagarosiphon</i> deplete oxygen levels in water, killing fish. Its presence may also impact on water birds causing a serious reduction in habitat” (extract from GB Non-Native Species Secretariat 2011).</p>

**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
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	MAJOR	VERY HIGH	In Ireland, key invasive attributes of <i>Lagarosiphon major</i> include its ability to quickly colonise suitable habitats, its very rapid growth rate, its capacity to create a dense, light-excluding canopy layer on the water surface and its ability to disperse widely via plant fragments. Research conducted in Lough Corrib has revealed the plant's capacity to totally displace native charophyte-dominated macrophyte communities at infested sites. This is an important keystone habitat in the lake (Krause and King 1994; Caffrey <i>et al.</i> 2010; Caffrey <i>et al.</i> 2011). In addition, the dense growth form of the plant substantially alters the habitat features of infested areas, affecting the resident macroinvertebrate fauna by significantly altering their community structure (Baars <i>et al.</i> 2009; Keenan 2010). In turn, this has the potential to negatively influence fish community composition, rendering the habitat more suitable to cyprinid fishes, pike and perch than to salmonids, for which this lake is renowned both nationally and internationally. Because this lush growth occurs in winter, when previously few tall plants occupied the water column, it creates a new temporal habitat for invertebrates and also fish – particularly the young of cyprinids, perch and pike. (Caffrey <i>et al.</i> 2009; O'Grady <i>et al.</i> 2009; Keenan 2010). <i>Lagarosiphon major</i> habitat also promotes the density of other invasive species (like <i>Dreissena polymorpha</i> Pallas and <i>Crangonyx pseudogracilis</i> Bousfield (Baars <i>et al.</i> 2009; Keenan 2010). An infestation can reduce the seed bank of native macrophytes (notably charophyte species) and post-control this reduces the natural rehabilitation from seed (Keenan 2010).
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Ireland?	MAJOR	VERY HIGH	If <i>Lagarosiphon major</i> establishes in other suitable freshwaters in Ireland, detrimental impacts on biodiversity as outlined in answer to Question 4.07 are highly likely. There may also be implications for the classification of ecological status under the EU Water Framework Directive and the conservation status of certain species and habitats and under the EU Habitats Directive.
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	MAJOR	VERY HIGH	Refer to Question 4.07 for an outline on the alteration to habitat and impact to native species caused by <i>Lagarosiphon major</i> in Lough Corrib. There is a paucity of information available to elucidate the impact of this invasive species on nutrient cycling and trophic interactions (although for the latter, it can alter macroinvertebrate community structure which has the potential to negatively influence fish community composition [Baars <i>et al.</i> 2009; Caffrey <i>et al.</i> 2010; Keenan 2010]). The plant architecture may



**Stage 2 - Detailed assessment: Section D - Impact**

*This section evaluates the probability of impact of an organism within Ireland.*

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				affect local flow dynamics thereby increasing fine sediment deposition around an infested area (J-R Baars, pers. comm.). In addition, the plant can create a hitherto unavailable novel habitat for some invasive species such as <i>Dreissena polymorpha</i> and <i>Crangonyx pseudogracilis</i> thereby facilitating an increase in their abundance and the potential for concomitant trophic impacts (e.g. decline in plankton and cyprinid fish abundances (Keenan 2010; CAISIE 2013).
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the <u>future</u> ?	MAJOR	VERY HIGH	Any further spread of <i>Lagarosiphon major</i> in Ireland will likely see similar impacts on ecosystem function to that observed in Lough Corrib (refer to Questions 4.07 and 4.09 for more information).
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.	MAJOR	VERY HIGH	<p>The invasion of Lough Corrib by <i>Lagarosiphon major</i> (its only record to date in the wild in Ireland) has posed a major threat to its conservation status as a Special Area of Conservation and Special Protection Area under the EU Habitats Directive. The Annex 1 listed habitat "hard oligo-mesotrophic waters with benthic vegetation of <i>Chara</i> spp." has been seriously degraded in regions of the lake where <i>Lagarosiphon major</i> established. This keystone vegetation forms extensive beds throughout the shallower areas of the lake (&lt; 5m). It is particularly important in supporting a healthy resident wild brown trout population as well as range of invertebrate and waterfowl species (Krause and King 1994; Caffrey <i>et al.</i> 2009; O'Grady <i>et al.</i> 2009; Keenan 2010; CAISIE 2013) .</p> <p>The control and eradication measures implemented in Lough Corrib since 2008 have mitigated for the decline in conservation status by treating over 90% of the original 92 hectare area infested by the invasive weed in addition to facilitating the rehabilitation of the native habitat (CAISIE 2013). It is likely that in the absence of such a programme, the Water Framework Directive status of the lake (which currently is rated as of 'moderate ecological status' as a result of the presence of a significant roach population) would remain under further threat.</p>
4.12	How important is decline in conservation status caused by the organism likely to be in the <u>future</u> in Ireland?	MAJOR	VERY HIGH	There is a strong likelihood based on known impacts that future invasions of <i>Lagarosiphon major</i> will result in substantial detrimental impacts to native habitats and species in Ireland. This may result in the downgrading of ecological status under the Water Framework Directive and have implications for Natura 2000 sites.

<b>Stage 2 - Detailed assessment: Section D - Impact</b>				
<i>This section evaluates the probability of impact of an organism within Ireland.</i>				
<b>N</b>	<b>QUESTION</b>	<b>RESPONSE</b>	<b>CONFIDENCE</b>	<b>JUSTIFICATION</b>
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?	MINOR	HIGH	
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINOR	MEDIUM	
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)?	MODERATE	HIGH	Some invertebrate invasive species such as <i>Dreissena polymorpha</i> use <i>Lagarosiphon major</i> as a substrate and therefore, it can act as a vector to spread such damaging species.
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	VERY HIGH	
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	<i>Lagarosiphon major</i> is not naturally controlled by any predator, parasite or pathogen in Ireland.
4.19	Indicate any parts of 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	The majority of freshwaters in Ireland (except highly eutrophic, acidic or fast-flowing systems) are vulnerable to colonisation. Lakes, slow flowing rivers and canals are particularly under threat. It is highly likely that economic and environmental impacts similar to that seen in Lough Corrib will occur in these waters.
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	VERY HIGH	Experience of the invasion of Lough Corrib by <i>Lagarosiphon major</i> (where over 92 hectares of the lake became infested [Caffrey <i>et al.</i> 2011]) clearly indicates that this invasive species has the potential to cause significant ecological, environmental and socio-economic impacts should it become established in other natural freshwaters in Ireland.

**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 (noting answers given in 1.11, 2.16, 3.10 & 4.20).	MAJOR	VERY HIGH	Refer to Question 4.20.

**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?		LOW	<p>Climate change is expected to increase water temperatures over time in Ireland, with increased periods of drought in summer and higher rainfall in winter leading to more flooding events (Desmond <i>et al.</i> 2008). As <i>Lagarosiphon major</i> is a relatively cold water-dwelling species, this might have some negative effect on its ability to thrive in a warmer climate. Increased or more intense flooding events heighten the chance of natural dispersal as fragmentation occurs during periods of intense wind/wave activity. Flooding may be exacerbated where dense infestations are present as drainage may be impeded.</p> <p>Global climate and regional environmental niche modelling which both project that there will be little change in the suitable range for <i>Lagarosiphon major</i> in the island of Ireland by 2080 (based on the International Panel on Climate Change high emissions climate change scenario) (Kelly <i>et al.</i> 2014).</p>
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	50 YEARS	LOW	
6.03	What aspects of the risk assessment are most likely to change as a result of climate change		MEDIUM	Natural spread (refer to response to Question 3.02).
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.			A wide range of research on the control and ecological impacts of <i>Lagarosiphon major</i> has been carried out in Lough Corrib by Inland Fisheries Ireland (formerly the Central and Regional Fisheries Boards) and by other research bodies since it was discovered in the lake in 2005. This wide-ranging research has been used in compiling the risk assessment for this species.

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