Risk Assessment of *Elodea nuttallii* – submission for consideration of Union listing under EU IAS Regulation No. 1143/2014

Name of Organism:	*Elodea nuttallii* (Planch.) St. John – Nuttall's pondweed
Objective:	Assess the risks associated with this species for Union listing under EU Regulation No. 1143/2014
Version:	EU amendmed template for submission February, 2016. Version 1.2.1
Author(s)	IRELAND - Michael Millane, Joe Caffrey, Colette O'Flynn
Expert reviewers	Catherine McGavigan, Melanie Josefsson

EU Chapeau

Stage 1 - Organism Information

Stage 2 - Detailed Assessment

Section A - Entry
Section B - Establishment
Section C - Spread
Section D - Impact
Section E – Risk Summaries and Conclusion
Section F - Additional Questions

References

About the risk assessment

This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis for Ireland (NAPRA Ireland) tool (version 2.66) and the EU Non-native Organism Risk Assessment Scheme template.

Quality assurance procedure

In 2014, the *NAPRA Ireland* version of this risk assessment was drafted and then internally reviewed by an Inland Fisheries Ireland aquatic invasive species expert. This was then reviewed by an external third party expert. The final draft version was then made widely available for key stakeholder and general public consultation through a series of open meetings and online consultation. All consultation comments were documented and then reviewed by the external expert. The final *NAPRA Ireland* version was published online on 15/09/2014 and is accessible from: http://nonnativespecies.ie.
Prior to initial submission for its consideration as a species of Union concern, an EU Chapeau and inclusion of reference to ecosystem services added. This was reviewed by Dr. Joe Caffrey.
In consideration of initial comments received by the Scientific Forum, the risk assessment questions have been revised to focus at the European level. This revised version has been kindly reviewed by Melanie Josefsson (Swedish Environmental Protection Agency).

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
Magnitude of risk is rated as Minimal, Minor, Moderate, Major and Massive
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

DOCUMENT CONTROL SHEET

Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Michael Millane	Dr Joe Caffrey		21/03/2014
Expert review	Complete	Dr Michael Millane	Dr Catherine McGavigan	Dr Joe Caffrey	11/02/2014
Public Consultation 1	Complete	Dr Michael Millane	Dr Joe Caffrey		09/05/2014
Public Consultation 2	Complete	Dr Michael Millane	Dr Joe Caffrey		14/08/2014
Final	Complete	Dr Michael Millane	Dr Joe Caffrey	Dr Cathal Gallagher	15/09/2014
NAPRA EU amendments	Final	Colette O'Flynn	Dr Joe Caffrey		30/11/2015
NAPRA EU Re-submission	Complete	Colette O'Flynn	Melanie Josefsson	Ferdia Marnell, National Parks and Wildlife Service, Ireland	29/02/2016

EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	20 countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, United Kingdom (DAISIE 2016; GBIF 2015; Josefsson 2011).
2. In how many EU member states has this species currently established populations? List them.	17 countries: Austria, Belgium, Bulgaria, Denmark, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, United Kingdom (DAISIE 2016, GBIF 2015).
3. In how many EU member states has this species shown signs of invasiveness? List them.	9 countries: Belgium, Bulgaria, Denmark, France, Ireland, Netherlands, Poland, Sweden, United Kingdom (EPPO 2002; Gederaas et al. 2012; NOBANIS 2016; Petrova et al. 2013)
4. In which EU Biogeographic areas could this species establish?	Atlantic, Boreal, Continental, Pannonian and lower parts of the Alpine (Biogeographic Areas in Europe, 2011. European Environment Agency see: http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1)
5. In how many EU Member States could this species establish in the future [given current climate] (including those where it is already established)? List them.	28 countries: Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. Its current absence from Southern Europe (except southern France) may indicate that the environmental conditions of the Mediterranean biogeographic region may be limiting factors to its establishment (see response to Question 6 below).
6. In how many EU member states could this species become invasive in the future [given current climate] (where it is not already established)?	8 countries: Croatia, Czech Republic, Estonia, Finland, Latvia, Lithuania, Portugal, Spain. While *Elodea nuttallii* has a high tolerance to wide ranges of environmental conditions (Zehnsdorf, 2015) and can establish in a wide range of freshwater habitats (and slightly saline habitats), it has a preference for temperate or continental climates that are wet year round (Duenas, 2013). This may inhibit its potential to be invasive in Cyprus, Greece and Malta.

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	This risk assessment is for *Elodea nuttallii* (Planch.) St John **Synonyms:** *Anacharis occidentalis* (Pursh) St. John*, Anacharis nuttallii* Planchon*, Elodea columbiana* St. John,, *Elodea minor* Farw., *Anacharis occidentalis* (Pursh) Marie-Victorin*, Serpicula occidentalis* Pursh, *Elodea canadensis var. angustifolia (*Britton ex Rydb.) Farw. (DAISIE 2016, and Simpson and Duenas 2011). **Common names:** A*prólevelű átokhínár* – Hungarian, *Élodée à feuilles étroites* – French, *Elodée de Nuttall* – French, *Nuttall's Waterweed* – English, *Nuttall's waterweed/pondweed* – English, *Nuttall-Wasserpest* – German, *Nuttalls Wasserpest* – German, *Nuttall's pondweed* – English, *Peste d'acqua di Nuttall* – Italian, *Peste d'acqua di Nuttall* – Italian, *Schmalblättrige Wasserpest* – German, *Smalle waterpest* – Dutch, *Vodní mor americký* – Czech, *Western waterweed* - English (DAISIE 2016 and Duenas 2013). Taxonomy: Plantae – Magnoliophyta – Liliopsida – Alismatales – Hydrocharitaceae – Elodea – *Elodea nuttallii*
2	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	
3	Describe the organism.		*Elodea nuttallii* is a perennial, submerged aquatic species that typically grows in muddy substrates in meso- or eutrophic waters in depths of 3 metres or less. However, the plant displays plastic characteristics and can grow more vigorously and to depths of up to 6 m in eutrophic waters. The plant can also form dense stands which can reach the water surface. *Elodea nuttallii* stems are long and slender and often branched. Upper leaves normally in whorls of 3, can be 4 (rarely 5) and the lower leaves may be in 2's and opposite. The leaves have marginal teeth 0.05-0.1mm long, are widest at their base and tapering to a point, are mostly recurved, are usually folded along the midriff, and are 6-13mm long and 0.7–1.5 mm wide. Flowers are less than 8mm wide (Bowmer *et al*. 1995; Josefsson 2011; CAISIE 2013a). *Elodea nuttallii* is very similar and difficult to distinguish from *Elodea canadensis*. *Elodea nuttallii* is generally smaller and paler than *Elodea canadensis*, its leaves are generally shorter and narrower and its stalk is often more branched (Bowmer et al, 1984). Hybrids between *Elodea canadensis* and *Elodea nuttallii* may occur (Cook & Urmi-König, 1985). *E. nuttallii* can also be confused with *Elodea callitrichoides* which is present in Austria, France, Ireland and the UK. *Elodea callitrichoides* has leaves up to 25 mm

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
			long and 2-5 mm broad in whorls of three, Leaves are flat, spreading and have some straight margins (Bowmer et al.1995) *Elodea nuttallii* can also be mistakenly identified as *Egeria densa, Hydrilla verticillata* and *Ceratophyllum sp*. and may be in trade under these species names. *Egeria densa* has longer leaves in whorls of 4–6. *Hydrilla verticillata* has tubers and spiny leaf edges, Ceratophyllum has forked needle-like leaves.
4	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	No European level risk assessment exists for this species. However, many European countries including Belgium, United Kingdom, Ireland, Norway and Poland have risk assessed this species at the national level (Branquart *et al*. 2010; GB Non-Native Species Secretariat 2011; Millane *et al*. 2014; Gederaas *et al*. 2012; Tokarska-Guzik B. *et al*. 2015).
5	If there is an earlier risk assessment is it still entirely valid, or only partly valid?	N/A	
6	Where is the organism native?		Temperate regions of North America (USDA, ARS 2013).
7	What is the current global distribution of the organism (excluding Europe)?		China, Japan (reviewed in Duenas 2013); Canada and United States (USDA, ARS 2013).
8	What is the current distribution of the organism in Europe?		Present in a total of 22 European countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Romania, Slovakia, Slovenia, Sweden, Switzerland and the United Kingdom (DAISIE 2016; EPPO 2016; GBIF 2015; Josefsson 2011). The level of distribution and establishment varies with the Netherlands, southern half of Great Britain, northern half of Belgium and western Germany having a widespread and common distribution while Ireland, Northern Ireland and Sweden have regionalised distributions. Countries such as Denmark and Norway have a rare distribution frequency (GBIF, 2015). The first record for Europe is from Belgium in 1939. *Elodea nuttallii* was then first reported in the Netherlands in 1941, Germany in 1953, France in the early 1950s, Great Britain in 1966, Denmark in 1974, Austria in 1977, Luxembourg in 1980, Ireland in 1984, Sweden in 1991, Romania in 1998, Slovakia in 2001, Croatia in 2006 and Norway in 2006 (Anderberg 1992; Duenas 2013; Kcic 2014; Muñoz Escobar *et. al.* 2011; Preston and Croft, 1997; www.neobiota.lu).
9	Is the organism known to be invasive anywhere in the world?	YES	Western, central and southern Europe and Japan (reviewed in Duenas, 2013). The European and Mediterranean Plant Protection Organization (EPPO) categorize the species as an A2 species which are determined 'as having a high potential for spread; as posing an important threat to plant health and/or the environment and

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
			biodiversity; and eventually as having other detrimental social impacts in the EPPO region' (EPPO, 2016)
10	Describe any known socio-economic benefits of the organism in the risk assessment area.		*Elodea nuttallii* is traded in the horticultural and aquarium sectors as an oxygenator/ornamental plant and Brunel (2009) notes that *Elodea nuttallii,* along with nine other aquatic plants, are 'traded in huge quantities in Europe' in the aquaria trade. No overall monetary value for trade in *Elodea nuttallii* in Europe could be found however Great Britain note annual sales of Nuttalls waterweed, along with Canadian waterweed (*Elodea Canadensis*) and curly waterweed (*Lagarosiphon major*), amount to between £2m and £5m (Simpson and Duenas, 2011). In Ireland, alternative native oxygenator species are listed (Invasive Species Ireland, 2013). Estonia, Poland, Spain and Switzerland have restricted trade on this species (EPPO, 2002).

Stage 2 - Detailed assessment: Section A - Entry

This section evaluates the probability of entry of an organism into Europe. Not to be confused with spread, the movement of an organism within Europe. 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	MEDIUM	Brunel (2009) notes this species as one of a group of aquatic plants that are imported into Europe for use in aquaria.
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. Horticultural and aquarium trade		*Elodea nuttallii* is imported into Europe *via* the ornamental aquatic plant trade for use in aquaria and as a pond plant oxygenator. In Ireland, it is available to the public in garden centres and pet shops (Wyse-Jackson, 2014). It is also sold periodically in some other retail outlets such as supermarkets and is available to buy over the internet (Authors 2015 pers. comm., 24th November).

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)? (If intentional, only answer questions 1.04, 1.08, 1.09 and 1.11)	INTENTIONAL	HIGH	*Elodea nuttallii* is imported for aquaria trade (Brunel, 2009).
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?	LIKELY	LOW	*Elodea nuttallii* is deliberately imported for trade and subsequently sold in Europe as an oxygenator/ornamental weed for artificial watercourses, garden ponds and aquaria so likelihood to get onto the pathway is very likely. However, while Brunel (2009) notes that *Elodea nuttallii,* along with nine other aquatic plants, are 'traded in huge quantities in Europe' in the aquaria trade, the exact extent of import trade just for this species in unclear.
1.05	How likely is the organism to enter Europe undetected or without the knowledge of relevant competent authorities?			

Pathway 1 - Horticultural and aquarium trade				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism is distributed deliberately *via* trade, survival is considered very likely.
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 *Elodea nuttallii* from viable plant material. The main growing season is from mid-April to mid-September. However, active growth can occur during the colder months of the year (Kunii 1981, 1982 and 1984; Simpson 1986). In Ireland the plant tends to die off during the winter months, although it will continue to grow in relatively sheltered still water habitats (J. Caffrey pers. comm. 2014). 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	Europe has a high density and abundance of natural freshwaters, many of which are suitable for the establishment of *Elodea nuttallii*. It can grow in lakes, reservoirs, ponds, rivers, streams, canals and ditches, but is most suited to meso- to eutrophic slow-flowing or static waters, but can even thrive in clear oligo-mesotrophic waters (Greulich and Trémolières 2006; Thiébaut et al. 1997; National Biodiversity Data Centre 2009). The practice of planting *Elodea nuttallii* in artificial watercourses or 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 either by natural spread or from the disposal of vegetative material into the wild. This pathway may also facilitate the deliberate introduction or planting of *Elodea nuttallii* into large waterbodies as an oxygenator or an ornamental plant.
1.09	Estimate the overall likelihood of entry into Europe based on this pathway?	LIKELY	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 Europe based on all pathways (comment on the key issues that lead to this conclusion).	LIKELY	HIGH	The primary pathway of entry into Europe is through deliberate trade *via* the aquatic plant ornamental and aquarium trade. However, due to a lack of available data it is unclear what the current extent of this trade is.

Stage 2 - Detailed assessment: Section B – Establishment *This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
2.01	Is the organism well established in Europe (if there is any uncertainty answer 'unsure')	YES	HIGH	Refer to Stage 1, question 8.
2.02	How likely is it that the organism will be able to establish in Europe based on the similarity between climatic conditions in Europe and the organism's current global distribution?	VERY LIKELY	HIGH	Based on its present widespread occurrence in its native range in temperate North America and introduced range in Europe, climatic conditions are not thought to be limiting.
2.03	How likely is it that the organism will be able to establish in Europe based on the similarity between other abiotic conditions in Europe and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on its present widespread occurrence in Europe, it is very likely there are no overriding abiotic factors to limit its further establishment in habitat types which are similar to those it occupies throughout its global range.
2.04	How likely is it that the organism will become established in protected conditions (In which the environment is artificially maintained, such as wildlife parks, glasshouses, aquaculture facilities, terraria, zoological gardens) in Europe? Subnote: gardens are not considered protected conditions	VERY LIKELY	VERY HIGH	*Elodea nuttallii* is deliberately imported for trade and subsequently sold in Europe as an oxygenator/ornamental weed for artificial watercourses and ponds and this species has already become established under such protected conditions in many European countries.

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.05	How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Europe?	WIDESPREAD	VERY HIGH	Europe has a high density and abundance of natural freshwaters susceptible to colonisation by *Elodea nuttallii* which can facilitate its subsequent survival, development and multiplication. It is most suited to meso- to eutrophic slow-flowing or static waters (Greulich and Trémolières 2006; National Biodiversity Data Centre 2009) but in general it can grow in lakes, reservoirs, ponds, rivers, streams, canals and ditches (National Biodiversity Data Centre, 2009).
2.06	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in Europe?	N/A		
2.07	How likely is it that establishment will occur despite competition from existing species in Europe?	VERY LIKELY	HIGH	As this species is already well established in many European countries, it is very likely establishment would continue to occur despite competition from existing species. This species may however be out-competed by *Lagarosiphon major* (an alien invasive aquatic plant in Europe) (Branquart et. al., 2010).
2.08	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Europe?	VERY LIKELY	HIGH	There are no known natural predators, parasites or pathogens of this species in Europe that will have an adverse effect on its establishment.
2.09	How likely is it that establishment will occur despite existing management practices in Europe?	-	-	The species is already established in Europe.
2.10	How likely is it that management practices in Europe will facilitate the establishment of the organism?	LIKELY	HIGH	Mechanical control may release plant fragments which may spread within the water system and root. Improper disposal of harvested plants and fragments could also aid spread to new areas. All Elodea plant fragments should be removed from the water and decomposed on dry land, well away from water (CAPM, 2004).
2.11	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Europe?	VERY LIKELY	MEDIUM	As most of the European population of *Elodea nuttallii* is female (Josefsson, 2011) (a male colony is known in Germany (Preston and Croft 1997)) reproduction is solely by vegetative means (Simpson, 1984). Mechanical control conducted with disregard for the generation of vegetative fragments will facilitate the survival and re-establishment in a treated area and increase the potential for spread to adjacent areas. The absence of a capability to reproduce by sexual means and therefore maintain a seed reserve in infested habitats, increases the efficacy of the

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				following control methods. Manual removal (hand-picking) using scuba diving for treatment of infestations of low abundance (<1 m^2). The eradication of low density infestations can be achieved via manual removal (Vernon 2011; CAISIE 2013a). Light-excluding benthic barriers, such as jute matting, may effect control in sites (> 1 to c. 1000 m^2) where *Elodea nuttallii* colonisation is localised. Mechanical cutting and harvesting using trailing V-blades for treatment of dense, erect, canopy-forming weed stands (>1000 m^2) in soft bottom sediments (CAISIE (2013a). Mechanical control is useful for control as repeated harvesting can deplete available nutrients and reduce populations over time (Bowmer et al., 1995). Eradication of extensive infestations in large, open waters may be infeasible. Control trials using V-blades and jute matting were undertaken in the Grand Canal in Ireland to control variable *Elodea nuttallii* populations. The results of control trials using jute matting were not conclusive, with only limited control achieved. This was impacted by the shallow nature of the canal habitat and the passage of cruiser traffic over the trial sites. Control trials using V-blades undertaken in a 2.5 km stretch of the canal in May and August 2011 to mechanically cut *Elodea nuttallii* proved highly successful, recording a 92.7 % clearance of *Elodea nuttallii* in the middle channel of the canal. This weed control technique has been adopted by Waterways Ireland as part of its routine weed management programme in the Grand Canal and Barrow Navigation (CAISIE, 2013b). Biological control using herbivorous fish such as grass carp and other bottom feeding fish can give good results, but can increase eutrophication (Di Nino et al., 2000). Chemical control of *E.nuttallii* is possible, but most often not an option. There are major environmental risks for non-target species and water quality with the use of chemicals and herbicides in water and is therefore restricted. *Elodea* species are difficult to control with chemicals and herbicides because of the thick layers of bacteria, algae and detritus on the leaves. Repeated applications over several years may be required to eradicate *E. nuttalii*.
2.12	How likely is it that the biological characteristics of the organism will	VERY LIKELY	HIGH	The ability of *Elodea nuttallii* to reproduce asexually from vegetative fragments, to out-compete native plant species and its high desiccation

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	facilitate its establishment?			tolerance can facilitate its establishment. It has also been observed that, when introduced to a new habitat, the establishment of *Elodea* buds is rapid, since the propagules sink into the sediment and grow rapidly (Barrat-Segretain *et al*., 2002).
2.13	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	VERY HIGH	Within systems, internal spread by natural means is common, principally occurring *via* vegetative fragmentation from the sloughing off of the canopy and subsequent re-rooting or *via* turion production in the autumn (Simpson 1984). Between watersheds, there is a very low potential for natural spread, although it could be transferred over land *via* plant fragments attached to water fowl mainly geese and swans (Larson and Willén 2006 in Josefsson, 2011). Anthropogenic-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters by infested boats (Josefsson, 2011) and by infested angling angling gear (J. Caffrey 2016, pers. comm., February).
2.14	How likely is it that the organism's adaptability will facilitate its establishment?	VERY LIKELY	VERY HIGH	*Elodea nuttallii* can establish in a wide range of freshwater habitats (i.e. lakes, reservoirs, ponds, rivers, streams, canals and ditches), but is most suited to meso- to eutrophic slow-flowing or static waters (Greulich and Trémolières 2006; National Biodiversity Data Centre 2009). The species is well adapted to a broad array of environmental conditions (Cook and Urmi-König 1985; Simpson 1990). According to Simpson (1988), Vanderpoorten *et al*. (2000) and Di Nino *et a*l. (2007), *E. nuttallii* exposed to environmental stresses show great phenotypic plasticity variations (e.g. increases in leaf area with decreases in internode length).
2.15	How likely is it that the organism could establish despite low genetic diversity in the founder population?	LIKELY	MEDIUM	Although reproduction is solely vegetative in Europe, there is no evidence to suggest low genetic diversity in the founder population will inhibit any future establishment. According to Vanderpoorten et al. (2000), populations of *E. nuttallii* may exhibit a high level of genetic polymorphism. It is also probable that genetic diversity is assured as this species has been introduced from a range of different importers and potentially from a variety of different locations – suggesting a potentially broad genetic diversity (although there is no proof of this).
2.16	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Europe? If	VERY LIKELY	VERY HIGH	It has already demonstrated this capacity in many European countries.

Stage 2 - Detailed assessment: Section B – Establishment

This section evaluates the probability of establishment of an organism within Europe. For organisms which are already well established in Europe, only complete questions 2.05 and 2.11 then move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	possible, specify the instances of invasion elsewhere in the justification box			
2.17	If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared terrapin, a species which cannot reproduce in GB but is established because of continual release, is an example of a transient species.	N/A		
2.18	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	VERY HIGH	Based on the species current level of establishment in Europe and its ability to establish in a wide range of freshwater habitats and environmental conditions, its continued ability to establish is very likely.

Stage 2 - Detailed assessment: Section C - Spread

This section evaluates the probability of spread of an organism within Europe. 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	How important is the expected spread of this organism in Europe by natural means (minimal, minor, moderate, major or massive)? (Please list and comment on the mechanisms for natural spread.)	MODERATE	MEDIUM	Within systems, internal spread by natural means is common, principally occurring *via* vegetative fragmentation from the sloughing off of the canopy and subsequent re-rooting or *via* turion production in the autumn (Simpson 1984). Dispersal is very fast and effective due to its ability to reproduce vegetatively (Josefsson, 2011). Between watersheds, there is a very low potential for natural spread, although it could be transferred overland *via* plant fragments attached to water fowl mainly geese and swans (Larson and Willén 2006 in Josefsson, 2011).
3.02	How important is the expected spread of this organism in Europe by human assistance (minimal, minor, moderate, major or massive)? (Please list and	MAJOR	HIGH	Anthropogenic-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters. The movement of boats (Josefsson, 2011) and angling gear has a high potential to inadvertently spread *Elodea nuttallii* within and between

Stage 2 - Detailed assessment: Section C - Spread

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
	comment on the mechanisms for human assisted spread.)			watersheds (J. Caffrey 2016, pers. comm., February). A. Green (2016), notes the importance of waterbirds in the rapid spread of *Elodea Canadensis* in Europe, a congener species to *Elodea nuttallii*.
3.03	Within Europe, how difficult would it be to contain the organism (very easy, easy, with some difficulty, difficult, very difficult)?	With some difficulty	MEDIUM	*Elodea nuttallii* is widespread in many freshwater water systems in Europe and it is also recorded in isolated ponds (National Biodiversity Centre, 2009) and artificial and protected habitats (see Q 2.05). Containment in colonised areas of large open water systems may be unlikely. However, external spread can be mitigated through the implementation of routine biosecurity measures. Eradication in small isolated waters (e.g. ponds) is feasible.
3.04	What proportion (%) of the area/habitat in Europe suitable for establishment, if any, has already been colonised by the organism?	11% - 33%	MEDIUM	Of the suitable inland freshwater habitats in Europe, the area established would be in the lower end of the 11% to 33% range.
3.05	What proportion (%) of the area/habitat in Europe 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, 11-33, 34-67, 68-90, 91-100)	11% - 33%	MEDIUM	There are suitable inland freshwater habitats in Europe to allow for further establishment of this species. As it is highly likely that the internal spread of *Elodea nuttallii* within contiguous or open water systems where it currently exists will continue, the proportion of area established five years from now is expected to be in the upper end of the 11% to 33% range. Its potential for spread from small artificial waters where it is present is considered low as these are generally confined systems. The level of human mediated spread of this species to new waterbodies/systems would significantly affect the level of establishment.
3.06	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 years	HIGH	Since its introduction into Europe in the first half of the 20th Century, *Elodea nuttallii* has been spreading rapidly in European waterbodies (Muñoz Escobar, 2011). Considering this rapid spread, its presence in mainland Europe including in countries with highly connected waterbodies and high levels of boat movement, it is highly likely that if left unchecked, the level of human mediated spread of this species to new waterbodies/systems would be significant within the next 40 years.
3.07	In this timeframe, what proportion of the endangered area (including any currently occupied areas) is likely to have been invaded by this organism?	34% - 67%	HIGH	Refer to Questions 3.05 and 3.06.

Stage 2 - Detailed assessment: Section C - Spread

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.08	Based on the answers to questions on the potential for establishment and spread in Europe, define the area endangered by the organism.	-	HIGH	Most slow-flowing or static freshwater habitats in Europe are susceptible to colonisation by *Elodea nuttallii.* It is most suited to meso- to eutrophic slow-flowing or static waters (Greulich and Trémolières 2006; National Biodiversity Data Centre 2009) but in general it can grow in lakes, reservoirs, ponds, rivers, streams, canals and ditches (National Biodiversity Data Centre, 2009).
3.09	Estimate the overall potential for future spread for this organism in Europe (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	RAPIDLY	HIGH	Since its introduction into Europe in the first half of the twentieth century, *Elodea nuttallii* has spread rapidly in Europe. This has been largely aided by initial intentional introduction whereby then human mediated unintentional spread plays a significant role. Where *Elodea nuttallii* is already present within a system, further natural internal spread will likely be rapid suitable waters. Human-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters with movement of boats and angling gear having a high potential to inadvertently spread *Elodea nuttallii.* If restrictions on sale and import are enforced and biosecurity measures are routinely implemented, the rate of further range extensions to uncolonised systems will likely be reduced as the principal mechanism of spread is human-mediated.

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, including the cost of any current management?	MAJOR	MEDIUM	There is a paucity of information available on the economic loss caused by *Elodea nuttallii* within its global distribution. In general, dense stands 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 (reviewed in Josefsson, 2011 and National Biodiversity Data Centre, 2009). Scrape damage to boat hulls caused by calcium encrusted stands of *Elodea* species has been

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				reported from lake Mälaren, Sweden (Josefsson and Andersson 2001). There are however some site specific figures for cost of management. In Ireland, Waterways Ireland (WI) has been involved in a programme to control *Elodea nuttallii* in Upper Lough Erne in Northern Ireland for several years where dense stands have hampered recreational boating and angling. In 2010, the cost of removing the plant from the navigation channel in the lake was approximately £91,000 GBP (Kelly *et al*. 2013b). For two lake sites in Germany, the cost of controlling the species including disposal in 2005 was approximately €205,000 (Podraza, 2008). Extrapolating from the examples of site specific management cost, the likely cost of impact on tourism and on clearing of drains and intake pipes etc., the likely cost, where the species is present in high densities, yields up in the €1million to13 million per year cost category for considering a MAJOR cost according to the classification provided in the 'Impact Assessment Guidance' from UK (GB NNSS, 2016).
4.02	How great is the economic cost of the organism currently in Europe excluding any costs associated with managing the organism from your answer (include any past costs in your response)?	MODERATE	LOW	While there is a paucity of information available on the economic loss caused by *Elodea nuttallii* to date in Europe excluding any costs associated with managing the species, where dense infestations of *Elodea nuttallii* occur, angling, boat and other water recreational activities may be limited and this could have a resulting negative impact on tourism and leisure activities. 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) and recreational boating is estimated to be worth €70 million to the Irish economy (Martin,2012). Due to the lack of empirical data available, a LOW confidence level is given.
4.03	How great is the economic cost of the organism likely to be in the future in Europe? Exclude any costs associated with managing the organism from your answer.	MAJOR	MEDIUM	This is difficult to quantify (see answers to Questions 4.01 and 4.02) but the cost of impact to tourism, boating and angling is likely to be MAJOR. 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 are the economic costs of managing this organism currently in Europe?	MODERATE	LOW	Due to the lack of available information, this is difficult to quantify. Extrapolating from the examples of site specific management cost given

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				in answer to Q 4.01, the likely cost to EU countries where the species is present yields in the €100 thousand to €1 million per year cost category according to the classification provided in the 'Impact Assessment Guidance' from UK (GB NNSS, 2016). Due to the lack of empirical data, a LOW confidence level is given.
4.05	How great are the economic costs of managing this organism likely to be in the future in Europe?	MASSIVE	MEDIUM	Considering the availability of suitable habitat and pathway of introductions and vectors of spread in Europe, and, considering the known and estimated costs of control for this species, it is likely that the cost of managing *Elodea nuttallii* in the future in Europe would be MASSIVE (greater than €13 million per year). This is difficult to quantify and depends on the range expansion of the plant, future levels of infestation in colonised waters and the timeframe to be considered.
4.06	How important is environmental harm caused by the organism within its global distribution excluding Europe?	HIGH	MEDIUM	In Japan, it has been reported that the biomass of native plants declined drastically after the invasion of *Elodea nuttallii* (Kadono, 2004). In China, it is an invasive species that can accumulate biomass quickly and produce more asexual propagules at elevated nutrient levels and, can suppress and out-compete the native taxa (Wang et al., 2016). It is not known as a weed species in its native range.
4.07	How important has the impact of the organism on biodiversity (e.g. decline in native species, changes in community structure, hybridisation) currently in Europe (include any past impact in your response)?	MAJOR	HIGH	Where dense, light-excluding stands of *Elodea nuttallii* occur native plant species have been displaced (CAISIE 2013b). *Elodea nuttallii* tends to dominate native macrophyte communities, which may lead to their local extinction. It often forms dense, monospecific stands and displaces other aquatic plants from many localities (Simpson 1984 & 1990; Barrat-Segretain 2005). *Elodea nuttallii* produces shading effects during phases of rapid growth and mass occurrence. The plant competes with and displaces indigenous vegetation, thus reducing biodiversity (Josefsson and Andersson 2001). In Norway, *Elodea nuttallii* is categorised as a Severe Impact species and is considered to have a negative effect upon the population of *Baldellia repens*, a freshwater plant only found at a few locations in Hordaland county, and which is classified as being endangered (EN) on the Red List for species' (Gederaas et al. 2012). In Belgium, *Elodea nuttallii* is categorized as Black List high impact species (A3) with a high impact on species through competition. It is 'reported to outcompete several native aquatic plants like Myriophyllum and Potamogeton species. Dense beds provide a poor habitat for aquatic animals and are not consumed by fish' (Branquart et al. 2010).

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				Elodea nuttallii is also known to replace other invasive species as the dominant species in an impacted ecosystem; it has replaced the non-native *Elodea canadensis* at many sites due to increased eutrophication, and is in turn being replaced by *Lagarosiphon major* (Thiebaut et al., 1997, James et al,1999 & 2006), which is already listed as an IAS of Union Concern. *As L. major* is eradicated, there will be new habitats available for *E. nuttallii* to further spread. Thus, listing of both species can have added value for combatting invasive alien aquatic species. Likewise, the risk that as *Elodea nuttallii* is removed from a water system, *Elodea canadensis* may expand its spread as the stronger competitor disappears. An integrated program for removal of these species should be considered. Impacts have been recorded on invertebrate communities (reviewed in Simpson and Duenas, 2011). *E.nuttallii* also has allelopathic qualities which may inhibit the growth of cyanobacteria, algae (Erhard and Gross, 2006) and aquatic herbivorous invertebrates (Erhard, Pohnert and Gross, 2007; Schulz & Dibble, 2012). *Elodea nuttalli* may also increase habitat complexity by forming dense stands which change densities and the community structure of invertebrates and fish. This may affect fish foraging, growth and abundance as well as reducing macroinvertebrate richness and abundance (Schulz & Dibble, 2012).
4.08	How important is the impact of the organism on biodiversity likely to be in the <u>future</u> in Europe?	MAJOR	HIGH	If *Elodea nuttallii* establishes dense populations in as yet uncolonised freshwaters in Europe or continues its expansion in colonised waters, significant impacts on biodiversity, as outlined in answer to Question 4.07, are likely.
4.09	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism in Europe from the time of introduction to the present?	MODERATE	MEDIUM	Dense populations of plants can reduce water movement, cut off light, produce anoxic conditions and trap sediments in a system. Plant decomposition at the end of the growing season typically induces a secondary eutrophication leading to the accumulation of end products toxic to many plants (Thiébaut, 2005 and Branquart *et al*., 2010). The resulting anoxic conditions can lead to the release of phosphorus, earlier bound to reduced iron, to the water column thus further increasing availability of nutrients. This in turn can contribute to mass microalgae blooms and increased eutrophication (Larson & Willén 2006). All Elodea species are efficient in taking up heavy metals from the sediment and

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				releasing them to the water column, thus affecting water quality (CAPM 2004; Zhang et al. 2008). In a 2015 study, comparing invaded and uninvaded areas, it was found 'that whilst *Elodea nuttallii* significantly altered freshwater communities, observed differences were small relative to other factors such as nutrient levels, inter-annual variation and differences between sites' (Kelly *et al*, 2015). Where dense stands of *Elodea nuttallii* are present, the ecosystem services impacted may be Regulation and Maintenance (both for impacting on biological and chemical conditions and water flows) and Cultural (recreational use of the waterbodies). More specifically, these relate to: • As in answer to Question 4.07, *E. nuttallii* can displace native species and affect the chemical composition of the waterbody. Therefore the Regulation and Maintenance service impacted is: Maintenance of physical, chemical biological conditions: Lifecycle maintenance, habitat and gene pool protection. While empirical evidence is lacking, it is probable that dense stands of *E. nuttallii* adversely impact spawning success among certain indigenous fish species, particularly those that utilise clean gravel substrates (salmonids) (J. Caffrey 2015, pers. comm., 30th November). • Dense stands of *E. nuttallii* can also reduce water flow therefore the Regulation and maintenance service impacted is: Mediation of flows – Liquid flows • Due to dense stands in recreational waterbodies there has been a negative impact on angling and boating activities (see Question 4.04), this results in ecosystem service losses to Cultural - Physical and intellectual interactions with ecosystems and land-/seascapes [environmental settings]: Physical and experiential interactions. Ecosystem service terminology following CICES v4.3, Haines-Young and Potschin, 2013.
4.10	How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism likely to be in Europe in the	MODERATE / MAJOR	MEDIUM	Failure to reduce the current level of infestation in European lakes, rivers and canals and any further spread of *Elodea nuttallii* will likely see even more adverse impacts on ecosystem function and losses to ecosystem services to those already observed (refer to Questions 4.07 and 4.09 for more information). A range of studies are required to comprehensively

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
	future?			address this subject.
4.11	How important has decline in conservation status (e.g. sites of nature conservation value, WFD classification, etc.) caused by the organism been in Europe from the time of introduction to the present?	MINIMAL	MEDIUM	There has been no documented decline in conservation status caused by *Elodea nuttallii* to date. However, in the Belgium risk assessment summary for *Elodea nuttallii*, Branquart *et al*. (2010) note that 'endangered' Natura 2000 freshwater habitats include: • Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea* (code: 3130) • Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition* - type vegetation (code: 3150) • Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (code: 3260) As *Elodea nuttallii* can establish and become invasive in a wide variety of freshwater habitats, high value conservation areas such as Natura 2000 sites would be vulnerable to invasion.
4.12	How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the future in Europe?	MODERATE	HIGH	There is a strong likelihood based on known impacts that future invasions of *Elodea nuttallii* will result in detrimental impacts to native habitats and species in Europe. This may 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	Social harm is caused by *Elodea nuttallii's* dense and extensive stands interfering with water recreation, boating, fishing, swimming and water extraction (Josefsson, 2011) and reduces amenity values of water bodies (CABI 2015).
4.14	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	HIGH	Highly unlikely - there is no evidence for this.
4.15	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	MINIMAL	HIGH	

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.17	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	Some positive impacts are also documented for Elodea species such as their efficient up-take of heavy metals and nutrients and especially in bioaccumulation of cadmium and tolerance to copper (CAPM 2004 in Josefsson, 2011). A HIGH level of confidence is given as it is understood that at the wide scale level, the negative impacts of *Elodea nuttallii* would outweigh any benefits that have been purported for this species.
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 Europe?	-	-	*Elodea nuttallii* is not known to be significantly naturally controlled by any predator, parasite or pathogen in Europe.
4.19	Indicate any parts of Europe where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	All suitable waterbodies in Europe could be impacted.	HIGH	Many freshwaters are vulnerable to colonisation by and suffer impacts from *Elodea nuttallii* in Europe. It can grow in lakes, reservoirs, ponds, rivers, streams, canals and ditches, but is most suited to meso- to eutrophic slow-flowing or static waters. Therefore, the waterbodies that meet these conditions are most likely to be affected. Areas that already have and could have well established populations of *Elodea nuttallii* and coupled with high level of human population/use of the waterbodies for recreational, navigation or water consumption purposes may experience a greater intensification of the economic and social impacts.
4.20	Estimate the overall potential impact of this organism in Europe. Use the justification box to indicate any key issues.	MAJOR	HIGH	Experience from areas where *Elodea nuttallii* has already established in Europe, indicate that this invasive species has the potential to cause ecological, environmental and socio-economic impacts should it become further established in Europe.

RISK SUMMARIES

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.

	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	LIKELY	HIGH	The primary pathway of entry into Europe is through deliberate trade *via* the aquatic plant ornamental and aquarium trade. However, due to a lack of available data it is unclear what the current extent of this trade is.
Summarise Establishment	VERY LIKELY	VERY HIGH	Based on the species current level of establishment in Europe and its ability to establish in a wide range of freshwater habitats and environmental conditions, its continued ability to establish is very likely.
Summarise Spread	RAPIDLY	HIGH	Since its introduction into Europe in the first half of the twentieth century, *Elodea nuttallii* has spread rapidly in Europe. This has been largely aided by initial intentional introduction whereby then human mediated unintentional spread plays a significant role. Where *Elodea nuttallii* is already present within a system, further natural internal spread will likely be rapid suitable waters. Human-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters with movement of boats and angling gear having a high potential to inadvertently spread *Elodea nuttallii.* If restrictions on sale and import are enforced and biosecurity measures are routinely implemented, the rate of further range extensions to uncolonised systems will likely be reduced as the principal mechanism of spread is human-mediated.
Summarise Impact	MAJOR	HIGH	Experience from areas where *Elodea nuttallii* has already established in Europe, indicate that this invasive species has the potential to cause ecological, environmental and socio-economic impacts should it become further established in Europe.
Conclusion of the risk assessment	HIGH	HIGH	This non-native species poses a risk of HIGH impact to native biodiversity as well as having the potential to cause negative socio-economic impacts in slow-flowing or still waters due to its capacity to spread rapidly and establish dense infestations. The species was introduced into Europe as an ornamental and oxygenating plant and while this species is still available for trade in Europe, the extent of that trade into Europe is unclear. Its current widespread presence in western Europe and its potential to spread and establish throughout much of the rest of Europe is likely to continue due to internal trade and human-mediated spread to currently uninfected waters. However, trade restrictions and biosecurity measures, should mitigate against the level of spread.

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?	Increasing water temperature	LOW	As temperature influences macrophyte growth and species distribution, the predicted increased temperature under climate change is expected to affect shallow lake and pond macrophyte communities (McKee et al., 2002). A study that investigated the effects of simulated climate warming on macrophytes planted in artificial microcosms that were heated to simulate climate warming to 3 degrees C above ambient year-round and 3 degree above ambient during summer only, found that warming did not significantly influence the growth or abundance of *Elodea nuttallii*. Increases in nutrients were more important in influencing *Elodea nuttallii* growth. They concluded that 'as a functional components of north temperate shallow lake and pond ecosystems, elodeid macrophyte communities may be broadly resilient to the small increases in temperature associated with climate warming.' (McKee et al, 2002). Global climate niche modelling project that the suitable range of *Elodea nuttallii* in the island of Ireland will decrease by 32% by 2080 (based on the International Panel on Climate Change high emissions climate change scenario) but when regional environmental niche modelling was included, no significant change in suitable habitat range up to 2080 was shown (Kelly *et al*. 2014). An overall conclusion of this study was that while climate variables are important in defining global range of species, factors related to land use, human influence and nutrient levels were of greater importance in regional projections (Kelly *et al*. 2014). In Slovenia, *Elodea nuttallii* achieved greater biomass in years which had a combination of milder winters and warmer springs (Grudnik *et al*. 2014). Based on the above studies, research that considers both global climate and environmental factors may more accurately predict the impacts of climate on *Elodea nuttalii* distribution in Europe.
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	Impact on biodiversity and distribution in southern Europe	MEDIUM	Increased biomass may further deplete native macrophyte biodiversity. Autumn die back and mineralisation could also increase oxygen stress for native fish populations particularly in lakes that experience increased water temperatures as a result of climate change. With increased water temperatures, freshwater systems in southern regions of Europe may become less suitable to the establishment of *Elodea nuttallii*.
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		There is a paucity of information available to elucidate the impact of *Elodea nuttallii* on ecosystem functioning in Europe. Such research may strengthen confidence in the impact section (Stage 2, Section D) of the risk assessment. There is also a lack of data on the cost of impact to ecosystem services such as the on angling, boating/navigation both for recreational, tourism and livelihood use.

References

Anderberg, A. 1992. Smal Vattenpest, *Elodea nuttallii*, en ny vattenväxt I den svenska floras. *Svensk Botanisk Tidsskrift* 86:43-45.

Baek, J. (2012). Survival of *Elodea nuttallii*: Competition with indigenous species and exposure to limiting factors. West Valley High School, Fairbanks, Alaska

Barrat-Segretain, M.H. (2005). Competition between invasive and indigenous species: impact of spatial pattern and developmental stage. *Plant Ecology* 180:153–160.

Botanic Gardens (2007). Ireland's National Plant Conservation Strategy - Target 10 - Managing Invasive Alien Species. Botanic Gardens, Glasnevin, Dublin. http://www.botanicgardens.ie/gspc/targets/inspc10home.htm [Accessed 17/01/2014].

Bowmer, K.H. Jacobs, S.W.L. and Sainty, G.R. (1995). Identification, Biology and Management of *Elodea canadensis*, Hydrocharitaceae. *Journal of Aquatic Plant Management* 33:13-19.

Branquart, E., Stiers, I., Triest. L., Vanderhoeven. S., Van Landuyt. W., Van Rossum, F. and Verloove. F. (2010). *Elodea nuttallii* - Invasive Species in Belgium. Available online: http://ias.biodiversity.be/species/show/57 [Accessed 16/02/2016]

Brunel, S. (2009). Pathway analysis: aquatic plants imported in 10 EPPO countries. *Bullletin OEPP/EPPO Bulletin* 39:201- 213

Caffrey, J.M., Barrett, P.R.F., Ferreiro, S., Moreira, K., Murphy, J. and Wade, P.M. (1999). Biology, Ecology and management of Aquatic Plants. *Hydrobiologia* 415:35-40.

Caffrey, J.M. and Coyne, J. (2010). The Distribution of Nuttall's Pondweed (*Elodea nuttallii*) in the river Lee Catchment. Internal report, Central Fisheries Board, Dublin. 16 pp.

Caffrey, J.M., Acevedo, S. and Gallagher, K. (2006). Nuttall's Pondweed (*Elodea nuttallii*): An Aggressive Invasive Species in the Carrigadrohid Reservoir. Internal report, Central Fisheries Board, Dublin. 9 pp.

CAPM (Centre for Aquatic Plant Management) (2004). Information Sheet 25: *Elodea nuttallii,* Nuttall's Pondweed. http://www.nerc-wallingford.ac.uk/research/capm/pdf%20files/25%20Elodea%20nuttallii.pdf *in* Josefsson, M. (2011). NOBANIS - Invasive Species Fact Sheet – *Elodea canadensis, Elodea nuttallii and Elodea callitrichoides*. Online Database of the European Network on Invasive Alien Species – NOBANIS http://www.nobanis.org/files/factsheets/Elodea.pdf [Accessed 17/01/2014].

CDK, Urmi-König K. (1985). A revision of the genus *Elodea* (Hydrocharitaceae). *Aquatic Botany*, 21(2):111-156.

CAISIE (2013a). Best practice for control of Nuttall's pondweed. Control of Aquatic Invasive Species and Restoration of Natural Communities in Ireland Project LIFE/NAT/IRL/000341. http://caisie.ie/wp-content/uploads/2013/06/D-10.7-Effective-control-measures-for-Nuttalls-pondweed.pdf [Accessed 17/01/2014].

CAISIE (2013b). Control of Aquatic Invasive Species and Restoration of Natural Communities in Ireland, EU LIFE+ Project NAT/IRL000341 Final Report to the European Commission. Inland Fisheries Ireland 73 pp.

Cook, C.D.K and Urmi-König, K. (1985). Range extension of aquatic vascular plant species. *Journal of Aquatic Plant Management* 23:1-6

DAISIE European Invasive Alien Species Gateway, 2016. *Elodea nuttallii*. Available from: http://www.europe-aliens.org/speciesFactsheet.do?speciesId=1091 [Accessed 15/02/2016].

Desmond, M., O'Brien, P. and McGovern, F. (2008). A Summary of the State of Knowledge on Climate Change Impacts for Ireland. EPA Climate Change Research Programme 2007-2013. Environmental Protection Agency, Wexford pp. 20.

Di Nino, F., Muller S., Thiébaut G., (2005). Response of *Elodea nuttallii* (Planch) H. St. John to manual harvesting in the north-east of France. *Hydrobiologia* 551:147-157

Di Nino F, Thiébaut G, Muller S. (2007). Phenology and phenotypic variation of genetically uniform populations of *Elodea nuttallii* (Planch.) H. St John at sites of different trophic states. *Archiv für Hydrobiologie*, 168:335-343.

Duenas, M.A. (2013). *Elodea nuttallii* In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc [Accessed 17/01/2014].

EPPO (European Plant Protection Organization) (2002). *Elodea nuttallii* datasheet. Available online: https://gd.eppo.int/taxon/ELDNU. [Accessed: 15/02/2016]

EPPO Available online: (European Plant Protection Organization). (2016). EPPO A1/A2 Lists of pests recommended for regulation as quarantine pests http://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm#A1A2Listshttp://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm#A1A2Lists [Accessed: 15/02/2016]

Erhard, D. and Gross, E. (2006). Allelopathic activity of Elodea Canadensis and *Elodea nuttallii* against epiphytes and phytoplankton. *Aquatic Botany* 85:203 – 211.

Erhard, D., Pohnert, G., Gross, E.M. (2007). Chemical defense in *Elodea nuttallii* reduces feeding and growth of aquatic herbivorous Lepidoptera. *Journal of Chemical Ecology* 33:1646 – 1661.

Gederaas, L., Moen, T.L., Skjelseth, S. & Larsen, L.-K. (eds.). (2012). *Alien species in Norway – with the Norwegian Black List 2012*. The Norwegian Biodiversity Information Centre, Norway.

GB Non-Native Species Secretariat (2011). GB non-native risk assessment scheme: *Elodea nuttallii*. Food and Environment Research Agency, UK. https://secure.fera.defra.gov.uk/nonnativespecies/ [awaiting publication]

GB Non-Native Species Secretariat. (2016). Impact Assessment Guidance. Food and Environment Research Agency, UK. Available online: http://www.nonnativespecies.org/index.cfm?sectionid=51

Greulich, S. and Trémolières, M. (2006). Present distribution of the genus *Elodea* in the Alsatian Upper Rhine floodplain (France) with a special focus on the expansion of *Elodea nuttallii* St. John during recent decades. *Hydrobiologia* 570:249-255.

Grudnika, Z.M., Jelenkoa, I.and Mateja Germa, M. (2014). Influence of abiotic factors on invasive behaviour of alien species *Elodea nuttallii* in the Drava River (Slovenia). *International Journal of Limnology* 50:1-8.

Haines-Yong, R. and Potschin, M. (2013): CICES V4.3–Revisedr eport prepared following consultation on CICES Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003. Online: http://unstats.un.org/unsd/envaccounting/seearev/GCComments/CICES_Report.pdf [Accessed: 25/11/2015]

Inland Fisheries Ireland. (2013). Socio-economic study of Recreational Angling in Ireland. Report prepared by Tourism Development International on behalf of Inland Fisheries Ireland, Dublin. 122 pp.

Invasive Species Ireland. (2013). Alternative plants. Available online: http://invasivespeciesireland.com/what-can-i-do/be-plant-wise/know-what-you-grow/alternative-plants/ [Accessed: 18/02/2016]

James, C.S., Eaton, J.W., Hardwick, K.1999. Competition between three submerged macrophytes *Elodea canadensis* Michx, *Elodea nuttallii* (Planch.) St John and *Lagarosiphon major* (Ridl.) Moss. In:

James, C.S., Eaton, J.W., Hardwick, K. 2006. Responses of three invasive aquatic macrophytes to nutrient enrichment do not explain their observed field displacements. *Aquatic Botany* 84: 347-353.

Josefsson, M. (2011). NOBANIS - Invasive Species Fact Sheet – *Elodea canadensis, Elodea nuttallii and Elodea callitrichoides*. Online Database of the European Network on Invasive Alien Species – NOBANIS http://www.nobanis.org/files/factsheets/Elodea.pdf [Accessed 17/01/2014].

Josefsson, M. and Andersson, B. (2001). The environmental consequences of alien species in the Swedish lakes Mälaren, Hjälmaren, Vänern and Vättern. *Ambio* 30:514-521.

Kamiński D. (2009). *Elodea nuttallii* (Hydrocharitaceae) nowy gatunek w wodach Wisły. Fragm. *Flor. Geobot*. Polonica 17 (1):182-183, 2010.

Kadono, Y. (2004). Alien Aquatic Plants Naturalized in Japan: History and Present Status. *Global Environmental Research* 8(2):163-169.

Kcic, A., Horvati´c, J., Jelaska, S.D. (2014). Distribution and morphological variation of invasive macrophytes *Elodea nuttallii* (Planch.) H., St.John and *Elodea canadensis* Michx in Croatia. *Acta Botanica Croatica* 73(2):437 – 446.

Kelly, J., O'Flynn, C. and Maguire, C. (2013a). Risk analysis and prioritisation for invasive and non-native species in Ireland and Northern Ireland. A report prepared for the Northern Ireland Environment Agency and National Parks and Wildlife Service as part of Invasive Species Ireland. 59 pp.

Kelly, J., Tosh, D., Dale, K. and Jackson, A. (2013b). The economic cost of invasive and non-native species in Ireland and Northern Ireland. A report prepared for the Northern Ireland Environment Agency and National Parks and Wildlife Service.

Kelly, R., Leach, K., Cameron, A., Maggs, C.A. and Reid, N. (2014). Combining global climate and regional landscape models to improve prediction of invasion risk. *Diversity and Distributions* 1-11.

Kelly, R., Harrod, C, Maggs.and C.A. & Reid, N. (2015). Effects of *Elodea nuttallii* on temperate freshwater plants, microalgae and invertebrates: small differences between invaded and uninvaded areas. *Biological Invasions*, Vol 17, no. 7, pp. 2123-2138.

Kunii, H. (1981). Characteristics of the winter growth of detached *Elodea nuttallii* (Planch.) St. John in Japan. *Aquatic Botany* 11:57-66.

Kunii, H. (1982). The critical water temperature for the active growth of *Elodea nuttallii* (Planch.) St. John. *Japanese Journal of Ecology* 32:111-112.

Kunii, H. (1984). Seasonal growth and profile structure development of *Elodea nuttallii* (Planch.) St. John in pond Ojaga-ike, Japan. *Aquatic Botany* 18:239-247.

Larson, D. and Wilén, E. (2006). Främmande och invasionsbelägna arter i Sverige, 2006, Svensk botanisk tidskrift, 100: 5 – 15. *In* Josefsson, M. (2011). NOBANIS - Invasive Species Fact Sheet – *Elodea canadensis, Elodea nuttallii and Elodea callitrichoides*. Online Database of the European Network on Invasive Alien Species – NOBANIS http://www.nobanis.org/files/factsheets/Elodea.pdf [Accessed 17/01/2014].

Larson, D. (2007). Predicting the threats to ecosystem function and economy of alien vascular plants in freshwater environments. Literature review. Sveriges Lantbruksuniversitet report 2003:7.

Martin, J. (2012). Waterways Forward Conference, Paris, France, 7-8 November 2012.

McKee, D., Hatton, K., Eaton, J.W., Atkinson, D.,, Atherton, A., Harvey, I., Moss, B. (2002) Effects of simulated climate warming on macrophytes in freshwater microcosm communities. *Aquatic Botany* 74: 71-83.

Minchin, D (2007) Investigation into the distribution and abundance of alien biota in Lough Derg: an assessment of impacts, 2005-6 Lough Derg Science Group. A Report to the Shannon River Basin District Steering Group. 38 pp.

Millane, D., Caffrey, J. and O'Flynn, C. (2014). NAPRA Ireland risk assessment for *Elodea nuttallii.* Available online: http://nonnativespecies.ie [Accessed 15/02/2016]

Muñoz Escobar, M., Voyevoda, M., Fühner. C., and Zehnsdorf, A. (2011). Potential uses of *Elodea nuttallii*-harvested biomass. *Energy, Sustainability and Society*, 1:4 Available online: http://www.energsustainsoc.com/content/1/1/4 [Accessed 18/02/2016]

National Biodiversity Data Centre (2009). Species profile for *Elodea nuttallii*, Nuttall's Waterweed, Tím uisce chaol. Available online: http://species.biodiversityireland.ie/profile.php?taxonId=41365 [Accessed 17/01/2014].

NIEA (2011). Lough Erne - Nuttall's Pondweed (*Elodea nuttallii*) - Commonly asked questions. Northern Ireland Environment Agency. Department of Environment, UK. http://www.doeni.gov.uk/niea/lough_erne_caq_s.pdf [Accessed 17/01/2014].

Petrova, A., Vladimirov, V. and Georgiev, V. (2013). *Invasive Alien Species of Vascular Plants in Bulgaria*. © Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences. ISBN 978-954-9746039-3

Podraza, P., Brinkmann, T., Evers, P., von Felde, D., Frost, U., Klopp, R., Knotte, H., Kühlmann, M., Kuk, M., Lipka, P., Nusch, E.A., Stengert, M., Wessel, M., and van de Weyer, K. (2008). *Untersuchungen zur Massenentwicklung von Wasserpflanzen in den Ruhrstauseen und Gegenmaßnahmen*. F & E- Vorhaben im Auftrag des Ministeriums für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes NRW (MUNLV). (Aktenzeichen: 54.173/25-5230). Abschlussbericht 2008. Available online: http://www.waterrecreatie.be/html/documents/elodea_abschlussbericht.pdf [Accessed 18/02/2016]

Preston, C.D and Croft, J.M. (1997). *Aquatic plants in Britain and Ireland*. Harley Books, Colchester, UK, 1997, 368 pp.

Sand-Jensen, K. (2000). An introduced vascular plant – the Canadian waterweed (*Elodea canadensis*). In Weidema, I. (ed.) Introduced species in the Nordic countries. NordTema 2000:13:96-100.

Schulz, R. and Dibble, E., (2012). Effects of invasive macrophytes on freshwater fish and macroinvertebrate communities: the role of invasive plant traits. *Hydrobiologia* 684:1-14

Simpson, D.A. (1984). A short history of the introduction and spread of *Elodea* Michx in the British Isles. *Watsonia* 15:1-9.

Simpson, D.A. (1986). Taxonomy of *Elodea* Michx in the British Isles. *Watsonia* 16:1-14.

Simpson D.A. (1988). Phenotypic plasticity of *Elodea nuttallii* (Planch.) H. St John and *Elodea canadensis* Michx in the British Isles. *Watsonia*, 17:121-132.

Simpson, D.A. (1990). Displacement of *Elodea canadensis* Michx. by *Elodea nuttallii* (Planch.) St John in the British Isles. *Watsonia* 18:173-177.

Simpson and Duenas (2011). GB Non-native Organism Risk Assessment for *Elodea nuttallii*. Food and Environment Research Agency, UK.

https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=618 [Accessed 17/01/2014].

Thiébaut, G., (2005). Does competition for phosphate supply explain the invasion pattern of Elodea species? *Water Research* 39:3385-3993

Thiebaut, G., Rolland, T., Robach, F., Tremolieres, M., Muller, S. (1997). Some consequences of the introduction of the two macrophyte species, *Elodea canadensis* Michaux and *Elodea nuttallii* St. John, in continental aquatic ecosystems: example of the Alsace plain and the northern Vosges (North East France). Bulletin Francais de la Péche et de la Pisciculture 344/345:441 – 452.

Tokarska-Guzik et al. (2015). Propozycja listy roślin gatunków obcych, które mogą stanowić zagrożenie dla przyrody Polski i Unii Europejskiej. Available online: http://www.gdos.gov.pl/igo [Accessed 8/12/2015].

USDA, ARS (2013). National Genetic Resources Program. Germplasm Resources Information Network - (GRIN). National Germplasm Resources Laboratory, Beltsville, MD, USA. http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?417508 [Accessed 17/01/2014].

USDA-NRCS, 2009. The PLANTS Database. Baton Rouge, USA: National Plant Data Center. http://plants.usda.gov/

Vanderpoorten A, Lambinon J, Tignon M. (2000). Morphological and molecular evidence of the confusion between *Elodea callitrichoides* and *E. nuttallii* in Belgium and Northern France. *Belgian Journal of Botany*, 133:41-52.

Verloove F. 2006. Catalogue of neophytes in Belgium (1800-2005). *Scripta Botanica Belgica* 39

Wang, H., Wang, Q., Bowler, P.A. and Xiong, W. (2016). Invasive aquatic plants in China. *Aquatic Invasions*, Vol 11, in press. Available online: http://www.aquaticinvasions.net/2015/ACCEPTED/AI_2016_Wang_etal_correctedproof.pdf [Accessed: 27/02/2016]

Wyse-Jackson, P. (2014) *Ireland's Generous Nature. The Past and Present Uses of Wild Plants in Ireland*. Missouri Botanical Garden Press.

Zhang, Z. Wu Z.B., He, L. (2008). The accumulation of alkylphenols in submerged plants in spring in urban lakes, China. *Chemosphere* 73:859 -863.

Zehnsdorf, A., Hussner, A., Eismann, F., Rönicke, H. and Melzer, A. (2015). Management options of invasive *Elodea nuttallii* and *Elodea Canadensis. Limnilogica – Ecology and Management of Inland Waters*. Vol. 51, March 2015, Pages 110-117.