Risk Assessment of *Elodea nuttallii*

Name of Organism:	*Elodea nuttallii* (Planch.) St John – Nuttall's Pondweed
Objective:	Assess the risks associated with this species in Ireland
Version:	NAPRA EU amendment Final 30/11/2015
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Expert reviewer	Catherine McGavigan

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About the risk assessment

This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis (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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Version Control Table

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NAPRA EU amendments	Final	Colette O'Flynn	Dr Joe Caffrey		30/11/2015

EU CHAPPEAU	
QUESTION	**RESPONSE**
1. In how many EU member states has this species been recorded? List them.	18: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden, United Kingdom
2. In how many EU member states has this species currently established populations? List them.	11: Austria, Belgium, Finland, France, Germany, Ireland, Luxembourg, Netherlands, Slovenia, Sweden, United Kingdom.
3. In how many EU member states has this species shown signs of invasiveness? List them.	9: Denmark, Finland, France, Germany, Ireland, Italy, Poland, Romania, United Kingdom
4. In which EU Biogeographic areas could this species establish?	Atlantic, Boreal, Continental (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: 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 biogeograhic 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)?	25: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. 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	*Elodea nuttallii* (Planch.) St John *Anacharis occidentalis* (Pursh) St. John*, Anacharis nuttallii* Planchon*, Elodea columbiana, Elodea minor* Farw., *Anacharis occidentalis* (Pursh) Marie-Victorin*, Serpicula occidentalis* Pursh, *Elodea canadensis var. angustifolia (*Britton ex Rydb.) Farw.(Simpson and Duenas 2011); free-flowered waterweed, Nuttall waterweed, Nuttall's pondweed, slender waterweed, waterweed esthwaite, western elodea, western waterweed (Duenas 2013).
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. Leaves grow in whorls of 3 or 4. They are rarely more than 10 mm long being widest at their base and tapering to a point, are usually folded along the midrib, are mostly recurved and have undulate margins. (Bowmer *et al*. 1995; Josefsson 2011; CAISIE 2013a).
4	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 *Ireland's National Plant Conservation Strategy - Target 10 - Managing Invasive Alien Species* (Botanic Gardens 2007); and a prioritisation risk assessment as part of the *Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland* (Kelly *et al*. 2013a). The former assessment designated *Elodea nuttallii* as a “most significant invasive plant” and the latter assessment designed the plant as a ‘high risk’ invasive species for Ireland.
5	If there is an earlier risk assessment is it still entirely valid, or only partly valid?	PARTIAL	Only preliminary risk assessments were previously conducted in Ireland (refer to Question 5).
6	Where is the organism native?		Temperature regions of North America (USDA, ARS 2013).
7	What is the current global distribution of the organism (excluding Ireland)?		Austria, Britain, Belgium, China, Czech Republic, Denmark, France, Germany, Hungary, Italy, Japan, Luxembourg, Netherlands, Northern Ireland, Poland, Romania, Slovakia, Sweden and Switzerland (reviewed in Duenas 2013); Canada and United States (USDA, ARS 2013).

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
8	What is the current distribution of the organism in Ireland?		Present in a total of 37 10km squares in Ireland (National Biodiversity Data Centre (2009). It is widespread in the River Barrow Navigation, Grand and Royal Canals, Carrigadrohid Reservoir, the cross-border Shannon- Erne waterway, Annalee catchment, upper Lough Erne, Lough Derg on the River Shannon and many other Irish catchments. It is currently considered to be one of the most abundant and widespread aquatic invasive species in Ireland (J Caffrey pers. comm.). It was first recorded in the island of Ireland in Lough Neagh in 1984 (National Biodiversity Data Centre 2009).
9	Is the organism known to be invasive anywhere in the world?	YES	Western, central and southern Europe and Japan (reviewed in Duenas 2013)
10	Describe any known socio-economic benefits of the organism in the risk assessment area.		*Elodea nuttallii* is imported into Ireland *via* the horticultural and aquarium sectors for trade as an oxygenator/ornamental plant for sale to the public in garden centres, pet shops and garden festivals (Wyse Jackson, 2014). It is also sold periodically in some other retail outlets, such as supermarkets, and is available to buy on the internet (M. Millane 2015, pers. comm., 24th November).

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 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 2. Boating 3. Angling		*Elodea nuttallii* is imported into Ireland *via* the horticultural and aquarium sectors for sale to the public in garden centres, pet shops and garden festivals. 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	*Elodea nuttallii* 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	*Elodea nuttallii* 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	HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	VERY LIKELY	VERY HIGH	As the organism is distributed deliberately *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;

Pathway 1 - Horticultural and aquarium trade				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				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.). 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 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 (Greulich and Trémolières 2006; 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 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		

Pathway 2 – Boating				
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)?	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 on boating equipment from infested to uninfested waters.

Pathway 2 – Boating				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	As *Elodea nuttallii* has a high resilience to desiccation (Baek 2012; Barrat-Segretain 2007), it is considered that viable plant material can survive in a damp environment in boats and on related equipment for at least several days.
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 (refer to Pathway 1, Question 1.07). 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	As noted in Pathway 1 , Question 1.08, Ireland has a high density and abundance of natural freshwaters, many of which are suitable for the establishment of this organism. Boat movements act as a direct pathway to transfer this organism from an infested water to a suitable habitat elsewhere. As *Elodea nuttallii* has a high resilience to desiccation, transfer would be dependent on the environmental conditions and duration of transport.
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	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 abroad to an uninfested water in Ireland. In Northern Ireland, *Elodea nuttallii* is recorded in 29 x 10 km squares (National Biodiversity Data Centre 2009). In Britain's freshwaters, it is recorded in *circa* 1000 10km squares (Simpson and Duenas 2011). There is no specific data available on the movement of boats from infested areas abroad to Ireland. However, it is considered likely that the organism can enter *via* this pathway especially through the cross-border Shannon-Erne waterway where regular boat traffic comes into Ireland after travelling south through Lough Erne which is infested with the plant.
1.10	Do other pathways need to be considered?	YES		

Pathway 3 – Angling				
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)?	ACCIDENTAL	HIGH	The overland 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 several days as the plant has a high tolerance to desiccation (Baek 2012; Barrat-Segretain 2007).
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 / LIKELY	HIGH	This pathway depends on the transfer of viable plant material surviving an overland / 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 *circa* 1000 x 10km squares (Simpson and Duenas 2011). As there is a paucity of specific information available on the movement of anglers between these jurisdictions, it is considered moderately likely that the organism can enter *via* this pathway from Britain but this may be more likely from Northern Ireland due to the regular cross-border movement of anglers from infested areas e.g. from Lough Erne (J. Caffrey pers. comm.).
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	VERY LIKELY	VERY HIGH	Awareness by the relevant competent authorities at points of entry to recognise and identify this species is limited or non-existent at present.
1.06	How likely is the organism to survive during passage along the pathway?	MODERATELY LIKELY	HIGH	As *Elodea nuttallii* has a high resilience to desiccation (Baek 2012; Barrat-Segretain 2007), it is considered that viable plant material can survive in a damp environment on angling equipment for at least several days.
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 (refer to Pathway 1, Question 1.07). Movement in association with anglers may occur throughout the year.

Pathway 3 – Angling				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	As noted in Pathway 1 , Question 1.08, Ireland has a high density and abundance of natural freshwaters, many of which are suitable for the establishment of this organism. The movement of anglers acts as a direct pathway to transfer this organism from an infested water to a suitable habitat elsewhere. As *Elodea nuttallii* has a high resilience to desiccation, 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 / LIKELY	HIGH	This pathway depends on the transfer of viable plant material surviving an overland / cross-channel journey in association with angling equipment from an infested water outside Ireland to an uninfested water in the country. In Northern Ireland, it is recorded in 29 x 10 km squares (National Biodiversity Data Centre 2009). In Britain's freshwaters, it is recorded in *circa* 1000 x 10km squares (Simpson and Duenas 2011). As there is a paucity of specific information available on the movement of anglers from infested areas abroad to Ireland, it is considered moderately likely that the organism can enter *via* this pathway, at least from Britain. However, this is more likely from Northern Ireland due to the regular cross-border movement of anglers from infested areas e.g. from Lough Erne to fish in Ireland (J. Caffrey pers. comm.).
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 *via* the horticultural and aquarium sectors. The movement of boats and anglers from infested areas outside the island of Ireland into the country may also facilitate entry as viable plant material can survive in a damp environment out of water for at least several days. The movement of the species from Northern Ireland, particularly Lough Erne, to the Republic of Ireland is far more probable.

Stage 2 - Detailed assessment: Section B – Establishment

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

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	YES	-	Refer to Question 8.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on its present widespread occurrence in Ireland, 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 abiotic conditions and the organism's current global distribution?	VERY LIKELY	VERY HIGH	Based on its present widespread occurrence in Ireland, 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 the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	VERY HIGH	Ireland 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).
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	VERY HIGH	Experience in Ireland to date demonstrates that *Elodea nuttallii* can establish large populations which can out-compete and extirpate native plant species (National Biodiversity Data Centre 2009, NIEA 2011).
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 adverse effect on its establishment.
2.07	How likely is it that establishment will occur despite existing management practices?	UNLIKELY	HIGH	In general, the public management of waterways is undertaken cognisant of ensuring biosecurity measures are in place to mitigate for the spread of aquatic invasive species. An increase in awareness of the threat from aquatic invasive species by some private entities has also reduced this risk.
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?	VERY LIKELY	MEDIUM	As only female plants are present in Ireland, 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 following two control methods. Light-excluding benthic barriers, such as jute matting, may effect control in sites where *Elodea nuttallii* colonisation is localised and the eradication of low density infestations can be achieved *via* manual removal (Vernon 2011; CAISIE 2013a). The eradication of extensive infestations in large, open waters is infeasible.
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	VERY HIGH	The ability of *Elodea nuttallii* to reproduce asexually from vegetative fragments, to out-compete native plant species and its high desiccation tolerance can facilitate its establishment.
2.11	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 *via* plant fragments attached to water fowl. Anthropogenic-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters.
2.12	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).
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 (Simpson 1984), there is no evidence to suggest low genetic diversity in the founder population will inhibit any future establishment. 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).

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
2.14	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	*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).
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MODERATE	HIGH	Refer to Question 2.11.
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MASSIVE	VERY HIGH	Anthropogenic-mediated transfer is the principal pathway to facilitate the establishment of the plant from colonised to uncolonised waters. The movement of boats and angling gear has a high potential to inadvertently spread *Elodea nuttallii* within and between watersheds.
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MAJOR	VERY HIGH	*Elodea nuttallii* is regionally distributed in Ireland and is widespread in many water systems (e.g. River Barrow; Shannon-Erne waterway [refer to Question 8]). It is also recorded in isolated ponds (National Biodiversity Centre 2013). Containment in colonised areas of large open water systems is unlikely. However, external spread can be mitigated through the implementation of routine biosecurity measures. Eradication in small isolated waters (e.g. ponds) is feasible.
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	11% - 33%	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)?	11% - 33%	MEDIUM	It is likely that the internal spread of *Elodea nuttallii* within contiguous or open water systems where it currently exists will continue. The enactment and enforcement of proposed restrictions on its sale and import and the further implementation of biosecurity practices by stakeholders may mitigate any spread to external uncolonised waters. Its potential for spread from small artificial waters where it is present is considered low as these are generally confined systems.

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
3.07	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 import and the implementation of routine biosecurity measures, further spread to uncolonised systems is considered likely (Refer to Question 3.06).
3.08	In this timeframe, what proportion of the endangered area (including any currently occupied areas) is likely to have been invaded by this organism?	11% - 33%	HIGH	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	68% - 90% of 10 km squares in Ireland are at risk of colonisation (refer to Question 3.01).
3.10	Estimate the overall potential for future spread for this organism in Ireland (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues .	RAPIDLY	HIGH	Where *Elodea nuttallii* is already present within a system, further internal spread will likely be rapid. 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 (excluding Ireland), including the cost of any current management?	MAJOR	HIGH	There is a paucity of information available on the economic loss caused by *Elodea nuttallii* within its global distribution (excluding Ireland). 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). 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).
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	MODERATE	HIGH	There is a paucity of specific information available on the economic loss caused by *Elodea nuttallii* to date in Ireland. Waterways Ireland control *Elodea nuttallii* in the Grand Canal and Barrow Navigation as part of their routine weed management to keep the waterway open for recreational boating. The plant is also a nuisance in Lough Derg where it grows prolifically in depths up to 3.2 m impeding boat traffic and angling in some sheltered areas of the lake. In addition, cut strands have accumulated on beaches and fouled bathing areas (Minchin 2007). In parts of Carrigadrohid Reservoir on the River Lee system, dense stands of the plant have rendered large areas of the lake unfishable (Caffrey *et al*. 2006; Caffrey and Coyne 2010; National Biodiversity Data Centre 2009).
4.03	How great is the economic cost of the organism likely to be in the future in Ireland? Exclude any costs associated with managing the organism from your answer.	MODERATE / MAJOR	MEDIUM	This is difficult to quantify (see Question 4.01 for an overview of economic impacts likely to occur should *Elodea nuttallii* spread further). The widespread establishment of *Elodea nuttallii* in Upper Lough Erne in Northern Ireland has already incurred significant control costs (refer to Question 4.02) and this programme of measures will continue to be necessary. Significant control costs may be incurred if infestations intensify elsewhere (e.g. Lough Derg, Grand Canal). 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). There may also be financial implications if conservations goals such as those specified in the EC Habitats Directive and the EU Water Framework Directive are under threat.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MODERATE	MEDIUM	This is difficult to quantify. In general, such costs have been incurred to establish the distribution and extent of infestation of the plant in Ireland as well as conceiving and implementing programmes of measures where necessary (e.g.in the Grand Canal). The costs through loss of angling and boating revenue in systems such as Carrigadrohid Reservoir and the Annalee System have probably been considerable, but have never been estimated.
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MODERATE / MAJOR	MEDIUM	This is difficult to quantify and depends on range expansions of the plant and future levels of infestation in colonised waters.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	VERY HIGH	*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). 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. In Japan, it has been reported that the biomass of native plants declined drastically after the invasion of *Elodea nuttallii* (Kadono 2004). *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*. Impacts have also been recorded on invertebrate communities (reviewed in Simpson and Duenas 2011). This species may also have a significant impact on protected sites.

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	MODERATE	HIGH	Where dense, light-excluding stands of *Elodea nuttallii* occur (e.g. Grand Canal, Carrigadrohid Reservoir, Annalee) native plant species have been displaced (CAISIE 2013b). The effects of this and other reported phenomenon (e.g. secondary eutrophication) on other biota have not been studied in detail to date.
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MAJOR	HIGH	If *Elodea nuttallii* establishes dense populations in as yet uncolonised freshwaters in Ireland or continues its expansion in colonised waters, detrimental impacts on biodiversity, as outlined in answer to Question 4.06, are probable. 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 under the EU Habitats Directive.
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 Ireland from the time of introduction to the present?	MODERATE / MAJOR	MEDIUM	There is a paucity of information available to elucidate the impact of *Elodea nuttallii* on ecosystem functioning in Ireland apart from its impact on native flora (refer to Question 4.07 for an outline on the alteration to habitat and impact to native plant species caused by *Elodea nuttallii* and Question 4.06 for general impacts). However, the impacts are considered to be significant. Where dense light-excluding stands of *Elodea nuttallii* have displaced native species (see Question 4.07) the ecosystem services impact may be on Regulation and Maintenance – 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). 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.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				(Ecosystem service terminology following CICES v4.3, Haines-Young. and Potschin, 2013). The presence of extensive and dense stands have the potential to cause or exacerbate flood events in affected lakes and rivers.
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 Ireland in the future?	MODERATE / MAJOR	MEDIUM	Failure to reduce the current level of infestation in Irish 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 observed already at infested sites in Ireland and elsewhere (refer to Questions 4.07 and 4.09 for more information). A range of studies are required to comprehensively address this subject.
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.	MINIMAL	HIGH	There has been no official decline in conservation status caused by *Elodea nuttallii* to date.
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MAJOR	VERY 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 Ireland. 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?	MINIMAL	HIGH	None reported.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	MINIMAL	HIGH	See Question 4.13.
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.

Stage 2 - Detailed assessment: Section D - Impact
This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	MINIMAL	VERY HIGH	
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	
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	*Elodea nuttallii* is not naturally controlled by any predator, parasite or pathogen in Ireland or Northern Ireland.
4.19	Indicate any parts of Ireland where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.		HIGH	Many freshwaters are vulnerable to colonisation by and suffer impacts from *Elodea nuttallii* in Ireland. 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.
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 from waters where *Elodea nuttallii* has already established in Ireland, and neighbouring countries *such as* Northern Ireland and Britain, clearly indicate that this invasive species has the potential to cause significant ecological, environmental and socio-economic impacts should it become further established in freshwaters here.

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	This non-native species continues to pose a major risk to native biodiversity, native ecosystems and conservation goals 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.

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	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 *et al*. 2008). 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) (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).
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		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. However, if the suitable range of *Elodea nuttallii* decreases there may be a concomitant reduction in impact potential.
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 and biodiversity in Ireland. Such research may strengthen confidence in the impact section (Stage 2, Section D) of the risk assessment.

References

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.

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.

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.

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.

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

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]

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.

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

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.

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.

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.

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

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.

National Biodiversity Data Centre (2009). Nuttall's Waterweed. http://apps.biodiversityireland.ie/InvasivesBrowser/speciesinfo.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).

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. (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 nutallii*. Food and Environment Research Agency, UK. https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=618 (accessed 17/01/2014).

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).

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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.