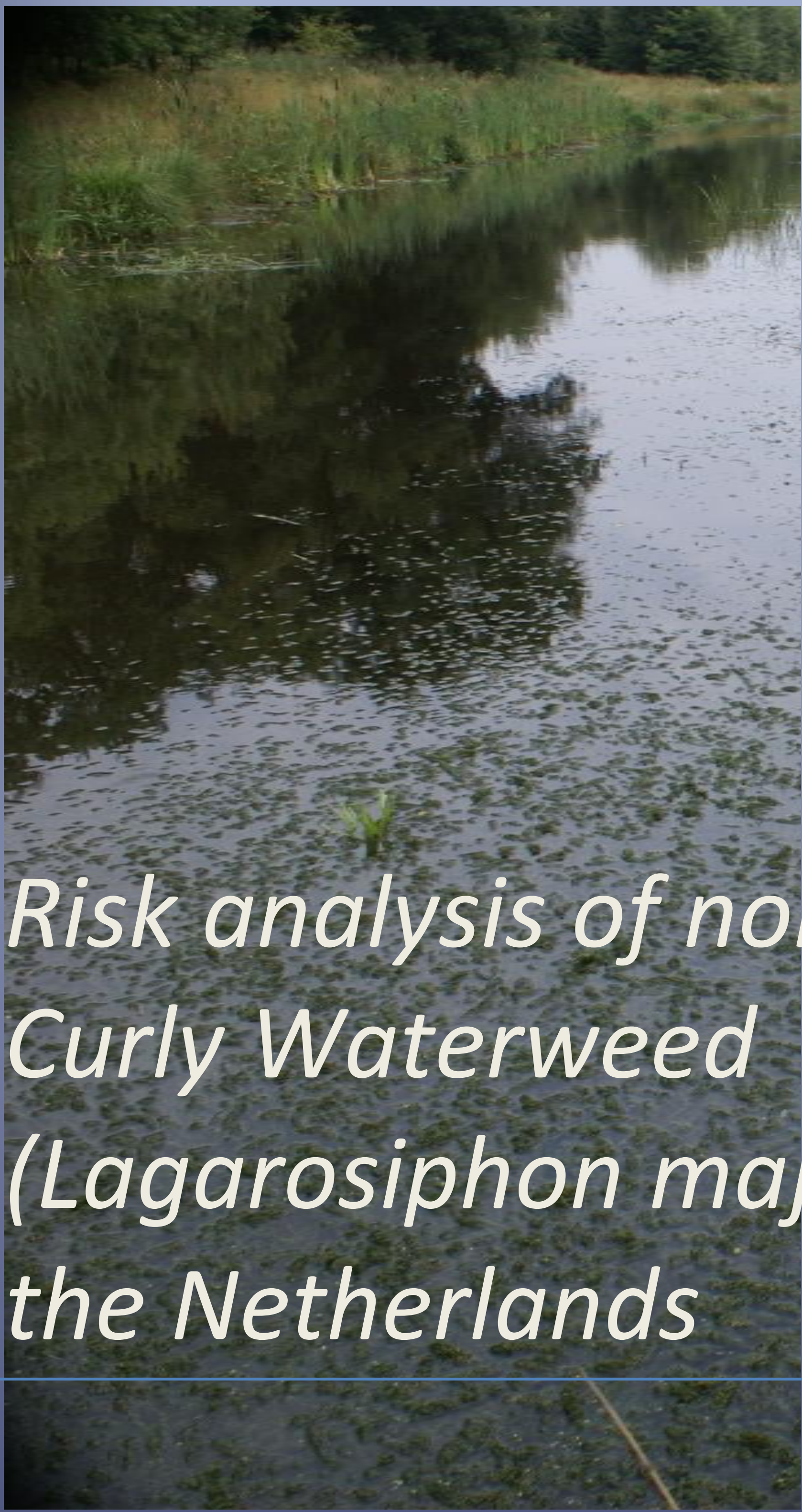

Risk analysis of non-native Curly Waterweed (Lagarosiphon major) in the Netherlands

By J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot, L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge & R.S.E.W. Leuven

Risk analysis of non-native Curly Waterweed (*Lagarosiphon major*) in the Netherlands

J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot,
L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge
& R.S.E.W. Leuven

draft report
22 August 2012

Radboud University Nijmegen,
Institute for Water and Wetland Research
Department of Environmental Sciences,
FLORON & Roelf Pot Research and Consultancy

Commissioned by
Invasive Alien Species Team
Netherlands Food and Consumer Product Safety Authority
Ministry of Economic Affairs, Agriculture and Innovation

Series of Reports on Environmental Science

The series of reports on Environmental Science are edited and published by the Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands (tel. secretariat: + 31 (0)24 365 32 81).

Reports Environmental Science nr. 418

Title:	Risk analysis of non-native Curly Waterweed (*Lagarosiphon major*) in the Netherlands
Authors:	J. Matthews, R. Beringen, F.P.L. Collas, K.R. Koopman, B. Odé, R. Pot, L.B. Sparrius, J.L.C.H. van Valkenburg, L.N.H. Verbrugge & R.S.E.W. Leuven
Cover photo:	Dense vegetation of Curly Waterweed (*Lagarosiphon major*) in a ditch near Ter Apel, the Netherlands (© Photo R. Pot)
Project manager:	Dr. R.S.E.W. Leuven, Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands, e-mail: r.leuven@science.ru.nl
Project number:	62001590
Client:	Netherlands Food and Consumer Product Safety Authority, P.O. Box 43006, 3540 AA Utrecht
Reference client:	TRC/NVWA/2012/2009, order nr. 60400891, formdesk nr. 19460, specification code 6300004
Orders:	Secretariat of the Department of Environmental Science, Faculty of Science, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands, e-mail: secres@science.ru.nl, mentioning Reports Environmental Science nr. 418
Key words:	Dispersion; ecological effects; invasive species; management options, public health, socio-economic impacts

Printed on environmentally friendly paper

Contents

Summary

Curly Waterweed (*Lagarosiphon major*) is an aquatic plant, non-native to the Netherlands. After first being observed in 2003 in the Soest administrative area, *L. major* has been recorded in the southern and northern provinces. Previously, there was a lack of knowledge regarding the pathways for introduction, vectors for spread, key factors for establishment and invasiveness, (potential) effects of *L. major* and management options in the Netherlands. This report is the synthesis of results obtained from a literature study, field observations and expert consultation that address this knowledge gap in the form of a knowledge document. The knowledge document was used to assess the ecological risk using the Belgian Invasive Species Environmental Impact Assessment (ISEIA) protocol. Socioeconomic and public health risks were assessed separately as these risk categories do not form part of the ISEIA protocol. Recommendations were then made regarding management options relevant to the situation found in the Netherlands.

Four factors are considered as part of the ISEIA protocol: dispersion potential and invasiveness, colonisation of habitats with high conservation values, adverse impacts on native species and alteration of ecosystem functions.

- Dispersion potential and invasiveness: *L. major* has a strong reproductive potential, can disperse via hydrochory and the level of imports for use in the plant trade remain high. The dispersal of *L. major* away from its initial points of introduction in the Netherlands has been limited and its distribution is characterised by isolated populations. This may be due to isolation or low water flow of the colonized water bodies and a lack of secondary dispersal vectors.

- Colonisation of high conservation value habitats: *L. major* is found in and around urban areas and no records exist in high conservation value habitats (i.e. habitat types in accordance with EU Habitats Directive or Bird Directive) in the Netherlands. However, there is potential that a protected nature area and peat-land with similar characteristics to the H3150 EU Habitats Directive type around Soest may be colonised in the future.

- Adverse impacts to native species: While there are many examples of impacts of *L. major* on native species observed in other countries, until now no effects have been observed in the Netherlands. However, future changes to habitat resulting from e.g. climate change, may increase (potential) risks in the future.

- Alteration to ecosystem functions: There is limited evidence demonstrating negative impacts on the functioning of ecosystems in the Netherlands. However, in other countries where *L. major* has become more widely established, negative impacts on ecosystem functioning have been extensive. Future changes to habitat resulting from e.g. climate change, may result in a revision of this risk score in the future.

Using the ISEIA protocol for a risk assessment within the context of the Netherlands, *L. major* was rated as a medium risk species for ecological impacts.

Due to limited distribution of *L. major* in the Netherlands, the current socio-economic impact of the species is low. However, potential future changes as a result of a rise in water temperature due to climate change, may increase the suitability and area of *L. major* habitat leading to increased socio-economic impact.

There was no information found concerning the public health effects of *L. major* during the literature study or in communications with project partners.

Banning of sale of *L. major* via the plant trade and creating consumer awareness are the best options for preventing new introductions and controlling further spread. Once established, the management of plants is challenging. Managers may wish to consider observing the dispersal potential of individual populations of *L. major* prior to instigating active measures. If populations become problematic, isolation of plants may be considered as this will facilitate the elimination of the species. Costs and the risk of facilitating dispersal through fragmentation, together with the limited dispersal of *L. major* observed in the Netherlands to date, count against the early implementation of weed cutting as a control measure.

L. major is classified in the medium risk category using the ISEIA protocol, however, there is a large body of evidence from abroad that demonstrates the high level of impact that can occur on native species and ecosystem functions if *L. major* becomes more wide spread. If the current situation persists then it is recommended that *L. major* be classified as an appendix 2 species of the Dutch Water Plant Code of Conduct. This classification requires that plants are sold with information that informs buyers of their potential invasive nature and the circumstances within which the plant can safely be used. However, future habitat changes due to climate change may result in a wider distribution of *L. major* (depending on potential management interventions e.g. isolation of the species or weed cutting) and re-classification to a high risk category. If this were to occur then it is recommended that *L. major* be classified in appendix 1 of the Dutch Water Plant Code of Conduct. This classification recommends that plants are banned from sale to the public and are not used by companies involved in landscaping or horticulture.

1. Introduction

1.1 Background and problem statement

Curly Waterweed (*Lagarosiphon major*) is a member of a genus of plants that are all endemic to different parts of Southern Africa. *L. major* is a well-defined species and is the only species of the genus *Lagarosiphon* that has been cultivated and introduced elsewhere (Symoens & Triest, 1983). *L. major* was first recorded in the Netherlands in the municipality of Soest around 2003 (Van Valkenburg & Pot, 2008). Over the past decade, this plant species was also recorded at locations in the southern and northern provinces. At the start of this project, there was a lack of knowledge regarding the pathways for introduction, vectors for spread, key factors for dispersion and invasiveness, (potential) effects of *L. major* and management options in the Netherlands.

To support decision making with regard to the design of measures to prevent ecological, socio-economical and public health effects, the Invasive Alien Species Team of the Netherlands Food and Consumer Product Safety Authority (Ministry of Economic Affairs, Agriculture and Innovation) has asked to carry out a risk analysis of *L. major.* The present report assesses relevant available knowledge and data which is subsequently used to perform a risk analysis of this species.

1.2 Research goals

The major goals of this study are:

- To perform a risk analysis based on dispersion, invasiveness, (potential) impacts and management options of *L. major* in the Netherlands.

- To assess the dispersion, invasiveness and (potential) ecological, socio-economic and public health effects of *L. major* in the Netherlands

- To describe effective management options for control of spread, establishment and negative effects of *L. major*.

1.3 Outline and coherence of research

The present chapter describes the problem statement, goals and research questions in order undertake a risk analysis of *L. major* in the Netherlands. Chapter 2 gives the methodological framework of the project, describes the Belgian Invasive Species Environmental Impact Assessment (ISEIA) protocol and approaches to assess socio-economic risks and public health risks, and analyses management approaches applicable in the Netherlands. Chapter 3 describes the results of the risk assessment, summarizes the results of the literature study of socio-economic and public health risks and analyses risk management options. Chapter 4 discusses gaps in knowledge and uncertainties, other available risk analyses and explains differences between risk classifications. Chapter 5 draws conclusions and gives recommendations for further research. An appendix containing background information in the form of a knowledge document completes this report. The coherence between various research activities and outcomes of the study are visualised in a flow chart (Figure 1.1).

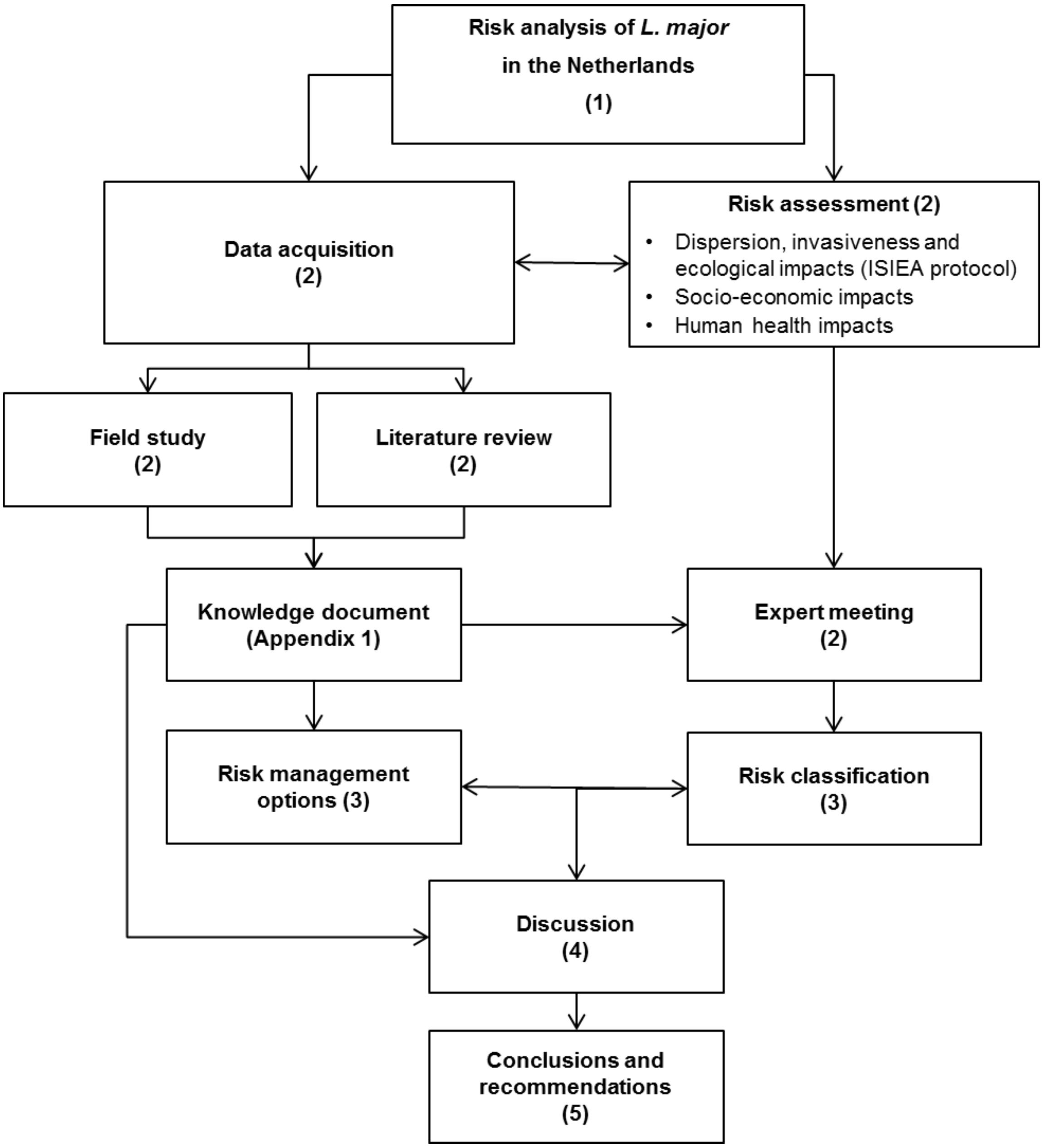

Figure 1.1: Flowchart visualising the coherence of various components of the risk analysis of Curly Waterweed (*Lagarosiphon major*) in the Netherlands. Chapter numbers are indicated in brackets.

2. **Methods**

2.1 Components of the risk analysis

The risk analysis of Curly Waterweed (*Lagarosiphon major*) in the Netherlands was comprised of an ecological risk assessment using the Belgian Invasive Species Environmental Impact Assessment (ISEIA), developed by the Belgian Biodiversity Platform (Branquart, 2007; ISEIA, 2009). Separate assessments of socio-economic, public health impacts and management options were made. Background information and data used for the risk analysis were summarised in the form of a separate knowledge document (Section 2.2).

2.2 Knowledge document

A literature search and data analysis describing the current body of knowledge with regard to taxonomy, habitat preference, dispersal mechanisms, current distribution, ecological and socio-economic impacts and management options for *L. major* were undertaken. The results of the literature search were presented in the form of a knowledge document (Matthews *et al*., 2012; Appendix 1) and distributed to an expert team in preparation for the risk assessment.

2.3 Risk assessment

2.3.1 Dispersion potential, invasiveness and ecological impacts

The ISEIA protocol assesses risks associated with dispersion potential, invasiveness and ecological impacts only (Branquart, 2007; ISEIA, 2009). The *L. major* risk assessment was carried out by an expert team. This team consisted of five individuals. One from the Netherlands Food and Consumer Product Safety Authority; one from the Dutch plant research and conservation organisation FLORON; one from the Roelf Pot Research and Consultancy firm and two from the Radboud University, Nijmegen. Each expert completed an assessment form independently, based on the contents of the knowledge documents. Following this preliminary individual assessment, the entire project team met, elucidated differences in risk scores, discussed diversity of risk scores and interpretations of key information. The results of these discussions were presented in an earlier draft of this report. Following the submission of this draft version to the expert team, further discussion led to agreement on consensus scores and the level of risks relating to the four sections contained within the ISEIA protocol (Table 2.1).

Table 2.1: Definitions of criteria for risk classifications per section used in the ecological risk assessment protocol (Branquart, 2007; ISEIA, 2009).

1. Dispersion potential or invasiveness risk	
Low	The species does not spread in the environment because of poor dispersal capacities and a low reproduction potential.
Medium	Except when assisted by man, the species doesn't colonize remote places. Natural dispersal rarely exceeds more than 1 km per year. However, the species can become locally invasive because of a strong reproduction potential.
High	The species is highly fecund, can easily disperse through active or passive means over distances > 1km / year and initiate new populations. Are to be considered here plant species that take advantage of anemochory, hydrochory and zoochory, insects like *Harmonia axyridis* or *Cemeraria ohridella* and all bird species.
2. Colonisation of high conservation habitats risk	
Low	Population of the non-native species are restricted to man-made habitats (low conservation value).
Medium	Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonise high conservation habitats.
High	The non-native species often colonises high conservation value habitats (i.e. most of the sites of a given habitat are likely to be readily colonised by the species when source populations are present in the vicinity) and makes therefore a potential threat for red-listed species.
3. Adverse impacts on native species risk	
Low	Data from invasion histories suggest that the negative impact on native populations is negligible.
Medium	The non-native is known to cause local changes (<80%) in population abundance, growth or distribution of one or several native species, especially amongst common and ruderal species. The effect is usually considered as reversible.
High	The development of the non-native species often causes local severe (>80%) population declines and the reduction of local species richness. At a regional scale, it can be considered as a factor for precipitating (rare) species decline. Those non-native species form long standing populations and their impacts on native biodiversity are considered as hardly reversible. Examples: strong interspecific competition in plant communities mediated by allelopathic chemicals, intra-guild predation leading to local extinction of native species, transmission of new lethal diseases to native species.
4. Alteration of ecosystem functions risk	
Low	The impact on ecosystem processes and structures is considered negligible.
Medium	The impact on ecosystem processes and structures is moderate and considered as easily reversible.
High	The impact on ecosystem processes and structures is strong and difficult to reverse. Examples: alterations of physico-chemical properties of water, facilitation of river bank erosion, prevention of natural regeneration of trees, destruction of river banks, reed beds and / or fish nursery areas and food web disruption.

The ISEIA protocol contains twelve criteria that match the last steps of the invasion process (i.e., the potential for spread establishment, adverse impacts on native species and ecosystems). These criteria are divided over the following four risk sections: (1) dispersion potential or invasiveness, (2) colonisation of high conservation habitats, (3) adverse impacts on native species, and (4) alteration of ecosystem functions. Section 3 contains sub-sections referring to (i) predation / herbivory, (ii) interference and exploitation competition, (iii) transmission of diseases to native species (parasites, pest organisms or pathogens) and (iv) genetic effects such as hybridisation and introgression with native species. Section 4 contains sub-sections referring to (i) modifications in nutrient cycling or resource pools, (ii) physical modifications to habitats (changes to hydrological regimes, increase in water turbidity, light interception, alteration of river banks, destruction of fish nursery areas, etc.), (iii) modifications to natural successions and (iv) disruption to food-webs, i.e. a modification to lower trophic levels through herbivory or predation (top-down regulation) leading to ecosystem imbalance.

Each criterion of the ISEIA protocol was scored. Scores range from 1 (low risk) to 2 (medium risk) and 3 (high risk). Definitions for low, medium and high risk, according to the four sections of the ISEIA protocol are given in table 2.1. If knowledge obtained from the literature review was insufficient, then the assessment was based on expert judgement and field observation leading to a score of 1 (unlikely) or 2 (likely). If no answer could be given to a particular question (no information) then no score was given (DD - deficient data). Finally, the highest score within each section was used to calculate the total score for the species.

Consensus on the risk score of each section was reached using a hierarchical method where evidence from within the Netherlands was given priority over evidence derived from impacts occurring outside the Netherlands. It was also considered that the suitability of habitats in the Netherlands may change due to e.g. water temperature rise due to climate change. Moreover, consideration was given to the future application or non-application of management measures that will affect the invasiveness and impacts of this invasive plant in the Netherlands.

Subsequently, the Belgian Forum Invasive Species (BFIS) list system for preventive and management actions was used to categorise the species of concern (Branquart, 2007; ISEIA, 2009). This list system was designed as a two dimensional ordination (Environmental impact * Invasion stage; Figure 2.1). It is based on guidelines proposed by the Convention on Biological Diversity (CBD decision VI/7) and the European Union strategy on invasive non-native species. Environmental impact of the species was classified based on the total risk score (global environmental risk) which is converted to a letter / list: score 4-8 (C), 9-10 (B - watch list) and 11-12 (A - black list). This letter is then combined with a number representing invasion stage: (0) absent, (1) isolated populations, (2) restricted range, and (3) widespread.

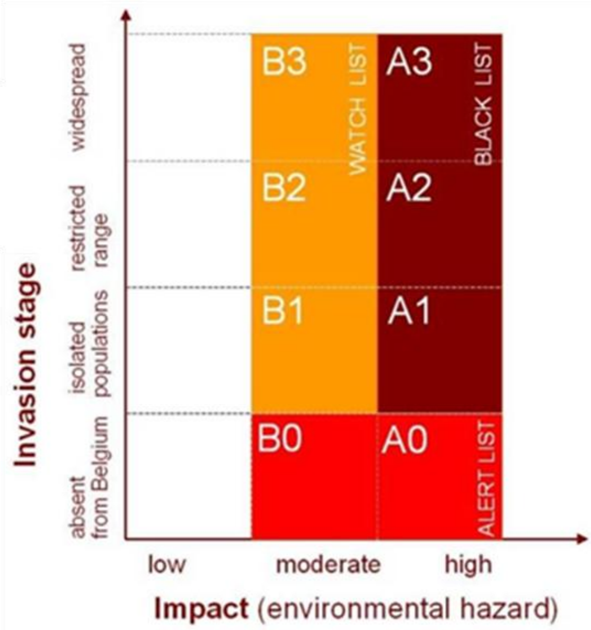

Figure 2.1: BFIS list system to identify species of most concern for preventive and mitigation action (Branquart, 2007; ISEIA, 2009).

2.3.2 Socio-economic and public health impacts

Potential socio-economic and public health impacts did not form a part in the risk analysis according to the ISEIA protocol. However, these potential risks should be considered in an integrated risk analysis. Socio-economic risks were examined as part of the literature study (Matthews *et al*., 2012) and in discussions with project partners. Socio-economic risks occurring at present or in the future dependent on alterations in habitat suitability and management interventions were considered.

2.4 Risk management options

Management options were examined as part of the literature study and extensively described in the knowledge document (Appendix 1) and in discussions with project partners. A description of effective management options is given. These are specifically relevant to, and therefore recommended for, the Netherlands. Recommendations are given in the context of the Dutch Water Plant Code of Conduct which provides voluntary guidelines that recommends limitations on the sale on non-native plants in the Netherlands depending on their potential impacts (Netherlands Food and Consumer Product Safety Authority, 2010).

3. Risk analysis

3.1 Risk classification using the ISEIA protocol

3.1.1 Expert consensus scores

The risk classifications attributed to Curly Waterweed (*Lagarosiphon major*) for each section of the ISEIA protocol were medium or high. The total risk score attributed to this species was 9 out of a maximum risk score of 12. This results in an overall classification of medium risk for this species.

Table 3.1: Consensus scores and risk classifications for Curly Waterweed (*Lagarosiphon major*).

ISEIA Sections	Risk classification	Consensus score
Dispersion potential or invasiveness	high risk	3
Colonization of high value conservation habitats	medium risk	2
Adverse impacts on native species	medium risk	2
Alteration of ecosystem functions	medium risk	2
Global environmental risk	**B - list category**	**9**

3.1.2 Dispersion potential or invasiveness

Classification: **High risk**. *L. major* exhibits a strong reproduction potential and is able to reproduce vegetatively through fragmentation. Dispersal over a distance of greater than 1 kilometre per year may occur due to fragmentation and hydrochory. Moreover, *L. major* disperses via a variety of human vectors. The importance of human vectors in the dispersal of this plant outside its native range is demonstrated by scattered distribution patterns that correlate with concentrations of human activity e.g. access points for vehicles and boats on lake shores. Moreover, there continues to be a strong market for *L. major* in the Netherlands demonstrated by the high number of plant imports and the availability of plants for sale online. The dispersal of *L. major* away from initial points of introduction in the Netherlands has been limited. Since 2003, 31 kilometre squares that contained *L. major* have been recorded. The majority of records are distant and isolated from each other, indicating multiple introductions. *L. major* is found in and around urban areas where it is likely that human introductions through the disposal of plants to the inland network of water bodies occur. Reasons for the observed limited dispersal after initial introduction maybe low water velocity or a lack of dispersal vectors at the colonised locations. There are a few examples where locations are remotely interconnected by rivers and canals, such as in the provinces of Drenthe and Groningen, where vegetative dispersal or dispersal facilitated by vectors may have occurred.

3.1.3 Colonisation of high conservation habitats

Classification: **Medium risk**. *L. major* is found in and around urban areas and to date, no records exist in high conservation habitats in the Netherlands. However, a potential EU Habitats Directive type in which *L. major* may appear is H3150 (Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation). This habitat type features species like *Stratiotes aloides*, *Utricularia vulgaris* and *Hydrocharis morsus-ranae*. *L. major* can occur together with these species. A population of *L. major* is present in Soest, close to areas of peat-land containing plant species that are representative of a H3150 habitat type and the protected Soesterveen nature area. These areas are hydrologically connected to the water body containing *L. major* but have not been colonised. Regular management of the waterbody containing *L. major* occurs, which may encourage its dispersal. Therefore, it cannot be ruled out that the peat-land and protected areas around Soest may be colonised by *L. major* in the future.

3.1.4 Adverse impacts on native species

Classification: **Medium risk**. Impact criteria relating to predation and herbivory are not relevant for *L. major*. The result of the literature search revealed no information relating to the transmission of parasites and diseases. Moreover, impact criteria related genetic effects are not relevant for the Netherlands. Hybridisation or introgression with natives will not occur because closely related species are absent. Therefore, the risk classification is based on the competition sub-section. The major adverse impacts of *L. major* are related to interference and exploitation competition. Evidence relating to these impacts comes from foreign sources, however, it was considered that similar impacts could occur in the Netherlands if *L. major* was to become more widespread here. In Lough Corrib, Ireland and Lake Taupo, New Zealand a number of native species were lost following *L. major* invasion (Caffrey & Acavedo, 2007; Howard-Williams & Davies, 1988). Moreover, large weed beds of *L. major* attracted herbivorous birds and detritivores such as swans and crayfish which also adversely affect the native flora (Howard-Williams & Davies, 1988). In other locations, however, *L. major* has proven to be less aggressive. In some areas of New Zealand *L. major* has been displaced by other species and may co-exist with native species (McGregor & Gourlay, 2002). Heavy infestations confer no oxygen benefit on fish and other animals (Ramey, 2001). Herbivorous fish species may find *L. major* less palatable then native species. *L. major* was found to be least palatable to the Grass carp (*Ctenopharyngodon idella*) when compared to a group of 9 other species of waterweed (Edwards, 1974). Changes in habitat structure resulting from the dense canopy produced by *L. major* may impact indigenous fish species. Salmonids have a preference for open water conditions while the cyprinids, perch and pike commonly seek the cover provided by dense weed beds (Caffrey & Acavedo, 2007). Finally, significant changes in abundance and species composition within the macroinvertebrate community have been observed following invasion by *L. major* (Kelly & Hawes, 2005; Caffrey & Acavedo, 2007). However, other researchers have found no difference in the preference of macroinvertebrate groups between native macrophytes and *L. major* (Biggs & Malthus, 1982).To date, these type of effects have not been observed in the Netherlands. Field experimentation has demonstrated that *L. major* is less competitive when grown under conditions found in the Netherlands than evidence from other countries suggests.

The minimum temperature limit for survival of *L. major* is 10 ^{o}C. In the Netherlands surface water layer temperatures frequently fall below this level for an extended period in winter. However, deeper warmer refuges may exist and the plant has been shown to sink in winter to avoid colder surface water (Centre for Ecology and Hydrology, 2004). Competitiveness may be reduced in very shallow water (maximum depth 30 cm) where freezing of the entire water compartment and top layer of the sediment occurs. Here, plants may suffer damage as they cannot sink away from the surface. The time of year at which plant growth is triggered will differ per location dependent on temperature. In other more southerly locations, where the climate is warmer, growth will occur all year round (R. Pot, unpublished results). Limited growth due to low temperature will also impact competitiveness.

Reduced competitiveness and the lack of observations of impacts suggests a current low risk to native flora and fauna in the Netherlands. However, taking into account the high negative impact of *L. major* on native species seen in other countries in temperate regions, potential risks cannot be excluded in the Netherlands, resulting in a medium risk classification in this category.

Future increases in temperatures due to climate change and omitting measures to prevent human introduction may lead to an increase in the distribution and competitiveness of *L. major* in the Netherlands, also resulting in a greater impact on native species and an increase in the risk score.

3.1.5 Alteration of ecosystem functions

Classification: **Medium risk**. The risk classification is based on all four sub-sections contained within this section. Evidence of altered ecosystem functioning observed within the Netherlands is limited. Most of the evidence presented here is from foreign studies, however, it was considered that similar impacts could occur in the Netherlands if *L. major* was to become more widespread. A major impact of *L. major* on ecosystem functioning is light interception. Where mature surface-reaching stands have become established, the canopy is able to shade out, and competitively exclude, even tall submerged species (Figure 3.1). Changes in nutrient cycling, resource use and habitat structure in the presence of *L. major* result in increased dissolved reactive phosphorous and dissolved inorganic nitrogen and result in changes in temperature and dissolved oxygen level (Schwarz & Howard-Williams, 1993; Department of Primary Industries, 2011). Food webs involving fish species may be effected directly due to the change of species food source availability following *L. major* invasion (Edwards, 1974) and changes in the macroinvertebrate community (Kelly & Hawes, 2005; Caffrey & Acavedo, 2007). If the growth form of *L. major* is different from that of the aquatic plants that it replaces then changes in natural succession may occur.

However, many of the negative effects listed in the literature may be viewed as positive effects in the Netherlands. For example, increase in plant biomass and changes in nutrient cycling usually lead to a higher water transparency and more complex invertebrate food web systems (Jeppesen *et al.*, 1998). This is regarded as an improvement in water quality according to the water quality assessment of the EC Water Framework Directive (Van der Molen & Pot, 2007).

The lack of observed impacts to ecosystem functioning in the Netherlands suggests a current low risk in this category. However, the observed high impact on ecosystem functioning in other countries in temperate regions resulted in the experts involved coming to a consensus that the potential risk of the species is medium.

Figure 3.1: Dense vegetation of Curly Waterweed (*Lagarosiphon major*) in a ditch near Ter Apel, the Netherlands (© Photo R. Pot).

Future increasing water temperatures due to climate change may have an impact on ecosystem functions e.g. modification of natural resources and disruption to food-webs that may lead to an increase in the risk score in the future.

3.1.6 Species classification

The species classification corresponds to the global environmental risk score of the ISEIA (Table 3.1) combined with the current distribution of the non-native species within the country in question. The species classification for *L. major* is B1 (Figure 3.2). This indicates a non-native species with isolated populations and moderate environmental hazard (i.e. ecological risk) that should be placed on a watch list.

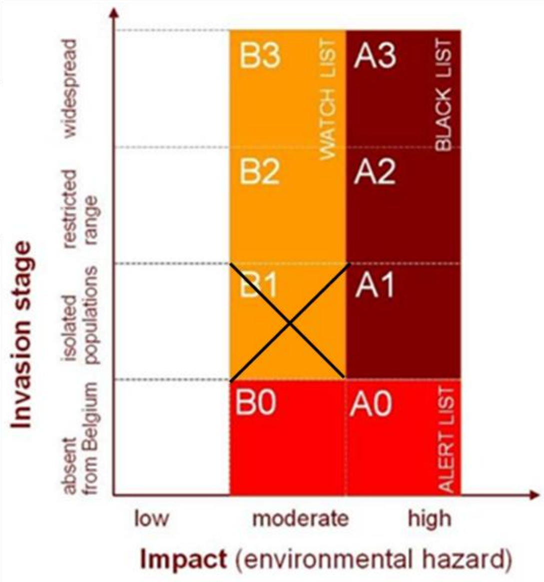

Figure 3.2: Curly Waterweed (*Lagarosiphon major*) classification according to the BFIS list system.

However, habitat alteration resulting from climate change may result in a future re-grading of risk. Future increases in the area suitable for the colonisation of *L. major* due to increased water temperature may occur. Moreover, if male plants are imported in conjunction with the current importation of female plants, then *L. major* may increase its dispersal and colonisation potential through the formation of seeds and associated increase in genetic vigour. In the absence of management intervention, these developments may result in wider distributions of *L. major* dependent on the availability of dispersal vectors. Colonisation of high conservation value habitats could potentially occur if they were accessed by vectors such as pleasure boats or anglers. Wider distributions of *L. major* will likely result in high impacts on native species and wide alterations to ecosystem functions. This would lead to a reclassification to high risk according to the ISEIA protocol (Table 3.2). In this theoretical scenario the distribution of *L. major* would increase to at least a restricted range resulting in at least an A2 classification.

Table 3.2: Curly Waterweed (*Lagarosiphon major*) theoretical classification according to potential future habitat scenario.

ISEIA Sections	Risk classification	Consensus score
Dispersion potential or invasiveness	high risk	3
Colonization of high value conservation habitats	medium risk	2
Adverse impacts on native species	high risk	3
Alteration of ecosystem functions	high risk	3
Global environmental risk	**A - list category**	**11**

3.2 Socio-economic impacts

Due to limited distribution of *L. major* in the Netherlands, the current socio-economic impact of the species is expected to be low. However, provincial water-boards are having to manage local populations of *L. major* due to water-flow obstruction at some locations. Potential future changes as a result of e.g. a rise in water temperature due to climate change, may increase the suitability and area of *L. major* habitat. Socio-economic impacts that have occurred in other countries are considered as it is possible that these impacts may occur in the Netherlands in the future.

In its South African native range as well as in introduced areas, prolific growth of *L. major* can interfere with commercial navigation and water-based recreation (Centre for Ecology and Hydrology, 2004; Caffrey & Acavedo, 2007). Swimming maybe impossible in areas of dense weed growth and the snarling of weeds in outboard motors may put recreational boaters at risk (Caffrey & Acavedo, 2007). Storms can tear the weed loose and deposit large masses of rotting vegetation on beaches, spoiling their amenity value; and effect power stations (Brown, 1975; Rowe and Hill, 1989). Large beds of *L. major* may increase the risk of flow impedance as the discharge capacity of an invaded water body is reduced (Department of Primary Industries, 2011). Extensive growth can block the turbine screens of hydro-electric power stations in quantities too great for the cleaning machinery to clear, causing temporary shutdowns, economic losses and power shortages (Chapman *et al.*, 1974).

In the United Kingdom, controlling *L. major* by mechanical means was estimated to cost 1,250 Euros per hectare per year assuming that each 10 km square contains at least 1 hectare of plants (GB Non-Native Species Secretariat, 2011).

3.3 Public health effects

During the literature study or in communications with project partners there was no information found concerning the public health effects of *L. major.*

3.4 Risk management options

3.4.1 Prevention

The main distribution channel or vector is trade of plants for aquaria and garden pools. One possible solution is to trade in a native plant or a non-native one with a low potential impact that replaces *L. major*. The best alternative native species is *Ceratophyllum demersum*. Another alternative for Curly Waterweed *(Lagarosiphon major)* for trade may be *Elodea nuttallii*. This is also a non-native species, but it has established and has already become very common in the Netherlands. Therefore, any new introductions of *E. nuttallii* are expected to have no additional effects. Currently, in the Netherlands, a campaign is underway that aims to prevent further introductions and spread by making consumers and employees from garden centres and plant nurseries more aware of the problems with non-native species. The name of this campaign is ‘Geen exoot in de sloot’. Its effectiveness is currently being examined (Verbrugge *et al.*, 2010).

Public awareness is an important component in a strategy aimed at controlling or removing an invasive species from a catchment area. This is especially important in the Netherlands due to the high level of imports and trade of *L. major* associated with the fact that people are the major vector for dispersal of this species. Awareness leaflets, press releases, calendars, lakeside notifications and an information website, warning of the environmental, economic and social hazards posed by this plant will contribute to public awareness (Caffrey & O'Callaghan, 2007).

Education of anglers and boaters may be especially useful as they can assist in reporting sightings of the plant. Moreover, instruction on the decontamination of boating and angling equipment is necessary to prevent dispersal of *L. major*. A guide for the identification of aquatic invasive species, describing associated impacts and strategies for prevention of spread was produced in the Netherlands in conjunction with the 'Code of conduct on aquatic plants' (Van Valkenburg, 2011). Its aim is to create awareness and assist in the monitoring of non-native aquatic plants.

3.4.2 Elimination

Once populations of the plants have established, eradication is very difficult. The best option is to isolate the local populations and intervene as little as possible. At the very least a natural lowering of fitness and abundance may be expected, as was previously observed in Ter Apel, the Netherlands. Here, manual removal of plants to prevent blocking discharge flow occurred only in the first year of appearance in 2008 (Figure 3.1). The plants did not recover to the same density in following years.

3.4.3 Control

If active control of *L. major* is required, as in Emmer-Erfscheidenveen, the Netherlands, removal using weed cutting machinery is recommended e.g. mowing baskets or weed cutting boats, and the prevention of fragment spread (Figure 3.1).

Figure 3.1: A weed cutting boat with adjustable mowing gear used for aquatic weed control in the Netherlands (© Photo R. Pot).

However, mechanical methods may result in the breakup of plant stems resulting in the dispersal of plants to new areas (Bowmer *et al.*, 1995). The dispersal of plant fragments and subsequent vegetative reproduction has been observed following mechanical harvesting in the Netherlands (R. Pot, unpublished results). Plants spread to connected water bodies after cutting at Emmer-Erfscheidenveen. When management methods were not introduced, the plants did not spread at most of the known sites in the Netherlands. Therefore, the best method to prevent spread of the species is to show reticence when considering the implementation of management.

4. Discussion

4.1 Gaps in knowledge and uncertainties

A lack of information in the literature on the (potential) impact of Curly Waterweed (*Lagarosiphon major*) in the Netherlands has resulted in a reliance on expert knowledge and field observations to judge the level of certain impacts. This lack of information may be a reflection of the limited distribution of *L. major* in the Netherlands at the present time.

The high risk associated with *L. major* to native species and ecosystem functions in other countries maybe a function of a greater habitat suitability and resultant high level of invasiveness in those countries.

Future changes such as increases in water temperature associated with climate change may result in an increase in the distribution of *L. major* in the Dutch freshwater network as well as in isolated water bodies. Therefore, the risk of impacts may have to be reassessed in future in view of greater potential impacts.

The ISEIA protocol is limited to an assessment of invasiveness and ecological impacts. No assessment of socio-economic impacts or impacts to human health are considered and are not considered in the calculation of global environmental risk score. Socio-economic impacts or impacts to human health were therefore considered separately.

Risk criteria in the ISEIA protocol were sometimes restrictive, as there was an absence of quantitative data that allowed the criteria to be assessed e.g. 1 km per year dispersal criterion for the ‘dispersion or invasiveness’ section.

4.2 Comparison of available risk classifications

The ISIEA protocol has been used to assess the risk of *L. major* in Belgium. *L. major* was classified as high risk in all four ISEIA categories.

A number of other assessments have been used in other countries and have consistently scored *L. major* as a high risk invasive species. In the United Kingdom, application of the UK Risk Assessment Scheme resulted in *L. major* being given a high risk rating (GB Non-Native Species Secretariat, 2011). In Ireland *L. major* is defined as high risk, scoring 20 in the IS Ireland risk assessment (Irish National Invasive Database, 2007). In Spain, *L. major* scored 18 on a scale ranging from -14 to 30 on the Weed Risk Assessment protocol (WRA). Species scoring over 6 in the WRA are rejected for introduction due to their potential impacts (Andreu & Vilà, 2010). Finally, in Australia, the Victorian Weed Risk Assessment (WRA), while not giving an overall score, categorised *L. major* as high risk for adverse impacts to water quality and native plant species resulting from structural habitat change (Department of Primary Industries, 2011).

The medium risk score obtained from this assessment is therefore at odds with assessments carried out in other countries. The main reason for this is that high impacts have not been observed in the Netherlands, even though the species has been present since 2003. However, monitoring of *L. major* should continue due to (potential) future increases in population which may result in higher levels of impact.

4.3 Risk management

Banning of sale of invasive plants via the plant trade and creation public awareness of consumers continue to be the most potentially effective methods of controlling introduction and the spread of invasive plant species. Once *L. major* is released to the environment, control and elimination becomes more difficult.

Management by mechanical means has been recommended as management measure for control and possible elimination of the species. However, managers may first wish to consider observing the dispersal potential of individual populations of *L. major* prior to instigating active measures. If populations become problematic, isolation may be considered as this will facilitate the elimination of the species. The costs and risk of a facilitation of dispersal together with the limited dispersal of *L. major* observed in the Netherlands since 2003, count against the early implementation of weed cutting as a control measure.

L. major is classified in the medium risk category of the ISEIA protocol. Moreover, there is a large body of evidence from abroad that demonstrates the high level of impact that can occur on native species and ecosystem functions if *L. major* becomes more wide spread. Therefore, it is currently recommended that *L. major* be classified as appendix 2 species in the Dutch Water Plant Code of Conduct. This classification requires that plants are sold with information that informs buyers of their potential invasive nature and the circumstances within which the plant can safely be used (Netherlands Food and Consumer Product Safety Authority, 2010).

Future habitat changes due to climate change and continuous introductions may result in a wider distribution of *L. major* (depending on potential management interventions). If this were to occur then it is recommended that *L. major* be classified as appendix 1 species of the Dutch Water Plant Code of Conduct. This classification recommends that plants are banned from sale to the public and are not used companies involved in landscaping or horticulture.

5. Conclusions and recommendations

The main conclusions and recommendations of the Risk analysis of non-native Curly Waterweed (*Lagarosiphon major*) in the Netherlands are as follows:

- *L. major* is found in and around urban areas and no records exist in high conservation value habitats in the Netherlands.

- The dispersal of *L. major* away from its initial points of introduction in the Netherlands has been limited and its distribution is characterised by isolated populations. This may be due a lack of (secondary) dispersal vectors. Moreover, colonised sites are predominantly located in water bodies that are isolated or show low water flow. However, *L. major* has a strong reproductive potential and the level of imports for use in the plant trade remain high.

- While there are many examples of impacts on native species observed in other countries, no effects have been observed in the Netherlands. Future changes to habitat resulting from e.g. climate change, may result in a revision of this risk score in the future.

- There is limited evidence demonstrating negative impacts on the functioning of ecosystems in the Netherlands. However, in other countries where *L. major* has become more widely established, negative impacts on ecosystem functioning has been extensive. Future changes to habitat resulting from e.g. climate change, may result in a revision of this risk score in the future.

- Due to limited distribution of *L. major* in the Netherlands, the current socio-economic impact of the species is expected to be minimal. However, potential future changes as a result of e.g. a rise in water temperature due to climate change, may increase the suitability and area of *L. major* habitat.

- There was no information found concerning the public health effects of *L. major* during the literature study or in communications with project partners.

- *L. major* was rated as a medium risk species for ecological impacts according to the ISEIA protocol. Its current limited distribution in the Netherlands, combined with this medium risk score, results in a B1 classification in the BFIS list system. Future changes in habitat characteristics due to climate change may result in greater (ecological) impacts as a result of increases in *L. major* distribution and a reclassification to A2 in the BFIS list system.

- Managers may first wish to consider observing the dispersal potential of individual populations of *L. major* prior to instigating active measures. Costs and the risk of a facilitation of dispersal together with the limited dispersal of *L. major* observed in the Netherlands since 2003, count against the early implementation of weed cutting as a control measure.

- If populations become problematic, isolation may be considered as this will facilitate the elimination of the species. If active management will be required (e.g. in case of obstruction of water discharge in drainage ditches), mechanical means have been recommended for control and possible elimination of *L. major*.

- Based on current dispersion and potential invasiveness and risk it is recommended that *L. major* be classified as appendix 2 species of the Dutch Water Plant Code of Conduct. This classification requires that plants are sold with information that informs buyers of their potential invasive nature and the circumstances within which the plant can safely be used.

6. Acknowledgements

We thank the Netherlands Food and Consumer Product Safety Authority (NVWA) of the Dutch Ministry of Economic Affairs, Agriculture and Innovation) for financial support of this study and all volunteers and organisations that contributed to the knowledge report on *L. major*. Dr. Trix Rietveld-Piepers of the NVWA delivered constructive comments on an earlier draft of this report.

7. References

Andreu, J. & Vilà, M., 2010. Risk analysis of potential invasive plants in Spain. *Journal of Nature Conservation* 18: 34-44.

Biggs, B.J.F. & Malthus, T.J., 1982. Macroinvertebrates associated with various aquatic macrophytes in the backwaters and lakes of the upper Clutha Valley, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 16: 81-88.

Branquart, E., (ed.), 2007. Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. Belgian Biodiversity Platform, Belgium.

Brown, J.M.A., 1975. Ecology of macrophytes, *in:* Jolly, V.H., Brown, J.M.A., (eds.), New Zealand Lakes, Auckland University Press, New Zealand *cited in:* McGregor, P.G. & Gourlay, H., 2002. *Assessing the prospects for biological control of lagarosiphon (Lagarosiphon major (Hydrocharitaceae))*. Department of Conservation, New Zealand.

Caffrey, J. & Acevedo, S., 2007. Status and Mangement of *Lagarosiphon major* in Lough Corrib 2007. Central Fisheries Board, Ireland.

Caffrey, J.M. & O'Callaghan, D. 2007. A Guide to the Identification of Aquatic Invasive Species in Ireland. Central Fisheries Board, Swords, Dublin *cited in:* Caffrey, J. & Acavedo, S. 2007. Status and Management of *Lagarosiphon major* in Lough Corrib 2007. Central Fisheries Board, Ireland.

Centre for Ecology and Hydrology, 2004. Information Sheet. *Lagarosiphon major.* Centre for Ecology and Hydrology, Wallingford, England.

Chapman, V.J., Brown, J.M.A., Hill, C.F. & Carr, J.L., 1974. Biology of Excessive Weed Growth in the Hydro- Electric Lakes of the Waikato River, New Zealand. *Hydrobiologia* 44: 349-363.

Department of Primary Industries, 2011. *Impact Assessment Record – Lagarosiphon*. http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_Lagarosiphon, last accessed 10-07-2012.

Edwards, D.J. 1974. Weed preference and growth of young grass carp in New Zealand. *New Zealand Journal of Marine and Freshwater Research* 8: 341-350.

GB Non-Native Species Secretariat, 2011. *GB non-native risk assessment scheme: Lagarosiphon major*. Food and Environment Research Agency, UK. https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51, last accessed 10-07-2012.

Howard-Williams, C. & Davies, J., 1988. The invasion of lake Taupo by the submerged water weed *Lagarosiphon major* and its impact on the native flora. *New Zealand Journal of Ecology* 11: 13-19.

Irish National Invasive Database, 2007. Http://invasives.biodiversityireland.ie/, last accessed 21-08-2012.

ISEIA, 2009. Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. Version 2.6. Http://ias.biodiversity.be/documents/ISEIA_protocol.pdf, last accessed 14-06-2012.

Jeppesen, E., Sondergaard, M., Sondergaard, M. & Christoffersen, K., (eds), 1998. The structuring role of submerged macrophytes in lakes. Ecological Studies, 131; Springer, New York.

Kelly, D.J. & Hawes, I., 2005. Effects of invasive macrophytes on littoral-zone productivity and foodweb dynamics in a New Zealand high-country lake. *Journal of the North American Benthological Society* 24: 300-320.

McGregor, P.G. & Gourlay, H., 2002. *Assessing the prospects for biological control of lagarosiphon (Lagarosiphon major (Hydrocharitaceae))*. Department of Conservation, New Zealand.

Matthews, J., Beringen, R., Collas, F.P.L., Koopman, K.R., Odé, B., Pot, R., Sparrius, L.B., van Valkenburg J.L.C.H., Verbrugge, L.N.H. & Leuven R.S.E.W. 2012. Knowledge document for risk analysis of the non-native Curly waterweed (*Lagarosiphon major*) in the Netherlands. Reports Environmental Science nr. 414, Radboud University, Nijmegen, the Netherlands.

Molen, D.T.v.d., Pot, R., (eds), 2007. Referenties en maatlatten voor natuurlijke wateren voor de Kaderrichtlijn Water. Stowa, Rijkswaterstaat - Waterdienst, Utrecht.

Netherlands Food and Consumer Product Safety Authority , 2010. Code of conduct Waterplanten. Http://www.vwa.nl/onderwerpen/gevaren/dossier/invasieve-waterplanten/code of conduct-waterplanten, last accessed 17-08-2012.

Ramey, V., 2001. *Lagarosiphon major.* Centre for Aquatic and Invasive Plants, University of Florida, http://aquat1.ifas.ufl.edu/seagrant/lagmaj2.html *cited in:* Department of primary Industries, 2011. *Impact Assessment Record – Lagarosiphon.*

http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/impact_Lagarosiphon, last accessed 10-07-2012.
Rowe, D.K. & Hill, R.L., 1989. *Aquatic macrophytes, water weeds*. Technical communication, CAB International Institute of Biological Control 10: 331-337 *cited in:* McGregor, P.G. & Gourlay, H., 2002. *Assessing the prospects for biological control of lagarosiphon (Lagarosiphon major (Hydrocharitaceae))*. Department of Conservation, New Zealand.
Schwarz, A.M. & Howard-Williams, C., 1993. Aquatic weed-bed structure and photosynthesis in two New Zealand lakes. *Aquatic Botany* 46: 263-281.
Symoens, J.J. & Triest, L., 1983. Monograph of the African genus *Lagarosiphon* harvey, (Hydrocharitaceae). *Bulletin du Jardin Botanique National de Belgique* 53: 441-488.
Van Valkenburg, J.L.C.H., (ed.), 2011. *Invasieve waterplanten in Nederland*. nVWA, Wageningen; Bureau Waardenburg, Culemborg; Communicatiebureau de Lynx, Wageningen.
Van Valkenburg, J., & Pot, R., 2008. *Lagarosiphon major* (Verspreidbladige waterpest) nu ook gevestigd in de Groene Ruimte in Nederland. *Gorteria* 33: 89-92.
Verbrugge, L.N.H., Van den Born, R.J.G. & Leuven, R.S.E.W., 2011. Evaluatie convenant waterplanten: startmeting. Reports Environmental Science no 383. Department of Environmental Science, Faculty of Science, Radboud University Nijmegen, The Netherlands.

Appendices

Appendix 1. Knowledge document used for the risk analysis