Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

VKM Report 2016:50

Assessment of the risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants

Opinion of the Panel on Alien Organisms and Trade in Endangered Species (CITES) of the Norwegian Scientific Committee for Food Safety

Report from the Norwegian Scientific Committee for Food Safety (VKM) 2016:50
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01.11.2016

ISBN: 00000-00000
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Suggested citation: VKM (2016). Assessment of the risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants. Scientific Opinion on the on Alien Organisms and Trade in Endangered species of the Norwegian Scientific Committee for Food Safety ISBN: 978-82-8259-240-6, Oslo, Norway.

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Authors preparing the draft opinion

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Assessed and approved

The opinion has been assessed and approved by Panel on Alien organisms and Trade in Endangered Species (CITES). Members of the panel are: Vigdis Vandvik (chair), Hugo de Boer, Jan Ove Gjershaug, Kjetil Hindar, Lawrence Kirkendall, Nina Elisabeth Nagy, Anders Nielsen, Eli K. Rueness, Odd Terje Sandlund, Kjersti Sjøtun, Hans K. Stenøien, Gaute Velle.

Acknowledgment

The Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) has appointed a working group consisting of both VKM members and external experts to answer the request from the Norwegian Food Safety Authority/Norwegian Environment Agency. Project leader from the VKM secretariat has been Maria Asmyhr. The members of the working group Hugo de Boer, Inga Kjersti Sjøtun, Hans K. Stenøien (Panel on Alien organisms and Trade in endangered species (CITES)), Iris Stiers (Vrije Universiteit Brussel) and Hanne Hegre Grundt (FlowerPower) are acknowledged for their valuable work on this opinion. The Panel on Alien organisms and Trade in endangered species (CITES) are acknowledged for comments and views on this opinion. VKM would like to thank the hearing experts Johan van Valkenburg (Q-bank) and Svein Fosså (Norges Zoohandleres Bransjeforening) for their contributions.

Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

The Norwegian Environment Agency (NEA) asked the Norwegian Scientific Committee for Food Safety (VKM) to assess the risks of negative impacts on biodiversity in Norway from the import and keeping of various species of freshwater plants for aquaria and garden ponds.

VKM was asked to assess: (I) species survival under Norwegian conditions, (II) possible impacts on ecosystems and other species, (III) possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites. In addition, VKM was asked to assess the likelihood of escape or release of the organisms. Possible precautionary measures, such as excluding import from certain areas or excluding certain sub-species or populations, should be included in the report.

The assessment adopted a fifty-year perspective and stated for each species whether it can survive below a cut-off temperature of 5° C. This is because current legislation includes an exemption for import permit requirements for species that cannot survive below this cut-off temperature.

The final report also included information on whether climate change could particularly affect the outlook for the assessed plant species beyond the specified period of 50 years. Finally, it considered whether the export of these species has any significant negative effects on biodiversity of the exporting country.

VKM appointed a working group consisting of members of the Panel on Alien Organisms and Trade in Endangered Species, the VKM Secretariat, an external botanist as well as an external expert on invasive aquatic plants to answer the request to answer the request. The Panel on Alien Organisms and Trade in Endangered Species has reviewed, revised, and finally approved the report prepared by the working group.

In order to address the assignment from NEA, all specified taxa were subjected to a preliminary screening followed by a risk assessment. In the preliminary screening, taxa were classified into three categories based on their area of occurrence and climatic preferences:

Category 1: taxa naturally occurring in tropical climates, **Category 2**: taxa naturally occurring in temperate and continental climates, **Category 3**: taxa occurring naturally in Norway. Taxa classified as **Category 1** were individually assessed for their ability to survive below 5°C. Taxa classified as **Category 2** were individually risk assessed using a modified two-stage Non-native Species Application-based Risk Analysis (NAPRA) Scheme. Taxa classified as **Category 3** were assessed as a group with regard to the risk that these species could transfer genetic material to locally adapted genotypes in native populations.

Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, were assessed for all species. None of the plant species in the Terms of Reference (ToR) are reported to have acted as vectors for harmful hitchhiker

organisms, including pathogens and parasites, and we therefore assessed that this risk to Norwegian biodiversity to be low.

The effects of climate change beyond a 50-year perspective are difficult to predict, but no immediate change in the risks associated with the ToR species were identified as a consequence of climate change beyond a 50-year perspective. Theoretically, there is a possibility that export of some of the evaluated plant species could have a negative impact on the biodiversity of the exporting country, however all the species used for aquarium and garden ponds are taken from cultivated populations and not from wild populations.

Responding to the ToR, VKM concludes that none of the Category 1 species can survive below 5° C . VKM concludes that all species in Categories 1 and 3 pose low risks to Norwegian biodiversity, in regard to species survival under Norwegian conditions, possible impacts on ecosystems and other species, and the possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites.

Some species in category 2 do not exhibit any characteristics related to invasiveness in their current areas of occurrence and they have a limited area of occurrence in Europe. VKM concludes that such species pose a low risk to Norwegian biodiversity in regard to points I,II and III above.

Further, VKM notes that those species of Category 3 that are on the Norwegian Red List could have a negative impact on Norwegian biodiversity in regard to point II; possible impacts on ecosystems and other species. Red listed species could potentially transfer novel genetic material to locally adapted genotypes. However, the probability of Red listed species of plants escaping from aquariums or garden ponds and subsequently encounter native populations is low, and therefore **VKM concludes** that these species pose a low risk to Norwegian biodiversity.

Finally, species in Category 2 for which a full modified NAPRA risk assessment was conducted, it is concluded that *Crassula helmsii* and *Myriophyllum heterophyllum* pose a high risk with, respectively, medium to high confidence, to Norwegian biodiversity with regard to points I, II and III. In addition, *Egeria densa*, *Hydrilla verticillata*, *Lagarosiphon major*, *Lemna gibba*, *Myriophyllum aquaticum*, *Najas minor*, and *Trapa natans* pose a moderate risk, with medium to high confidence depending on the species, to Norwegian biodiversity, with regard to points I, II and III . All other species are considered to pose a low risk, with low to high confidence depending on the species, to Norwegian biodiversity with regard to points I, II and III above.

Key words: VKM, environmental risk assessment, Norwegian Scientific Committee for Food Safety, *Myriophyllum heterophyllum*, *Crassula helmsii*, invasive alien species, alien organisms, entry, establishment, introduction, spread, impact, biodiversity, Norwegian Environment Agency, escape, release, precautionary measures, hitchhiker organisms, pathogens, parasites.

Sammendrag på norsk

Vitenskapskomiteen for mattrygghet har på oppdrag fra Miljødirektoratet utført en risikovurdering av uheldige følger på biologisk mangfold ved innførsel og hold av en rekke ferskvannsplanter til bruk i akvarium og hagedammer.

VKM ble bedt om å vurdere (I) plantenes evne til å overleve under norske forhold, (II) mulige negative effekter som privat innførsel av plantene vil kunne ha på norske økosystem og arter, (III) mulig risiko forbundet med introduksjon av skadelige blindpassasjerer, inkludert patogener og parasitter. I tillegg ble VKM bedt om å vurdere sannsynligheten for at innførsel kan medføre at ferskvannsplantene sprer seg utenfor akvarier eller hagedammer.

VKM ble bedt om å utføre vurderingene i et 50-års perspektiv. I vurderingen av hver enkelt art skulle det komme tydelig frem om arten kan overleve temperaturer under 5° C , siden forskrift om fremmede organismer gir fritak for organismer som krever temperaturer over 5° C for å overleve.

VKM ble også bedt om å vurdere om noen av planteartene kan være spesielt utsatt for klimaendringer utover 50-årsperspektivet, og om eksport av planteartene vil kunne ha uhelldige følger for biologisk mangfold i landet de eksporteres fra.

For å svare på bestillingen satte VKM sammen en prosjektgruppe bestående av medlemmer fra faggruppen for fremmede organismer og handel med truede arter og VKMs sekretariat, en ekstern botaniker og en ekstern ekspert på vannlevende fremmede planter. Faggruppen for fremmede organismer og handel med truede arter har gjennomgått og revidert utkastet fra arbeidsgruppen og godkjent rapporten.

For å besvare spørsmålene i bestillingen ble det utført en to-stegs screening av alle taxa. Basert på resultatet av den første screeningfasen ble alle taxa kategorisert i tre kategorier etter hva slags utbredelsesområde og klimapreferanser de har.

Kategori 1: Taxa som har sitt naturlige utbredelsesområde i tropiske områder, **kategori 2**: Taxa som finnes i temperert og kontinentalt klima, **kategori 3**: Taxa som har Norge som en del av sitt naturlige utbredelsesområde. For plantene i **kategori 1** ble det vurdert hvorvidt de kunne overleve i temperaturer under 5° C. For plantene i **kategori 2** ble det ved hjelp av en modifisert to-stegs NNSS risikovurderingsmal vurdert hvor sannsynlig det er at de vil kunne etablere seg i Norge (steg 1). I tilfeller hvor det var en reell sannsynlighet for at planten kan etablere seg i Norge, ble sannsynligheten for at den også kan spre seg i norsk natur vurdert, og hvilke konsekvenser det kan ha for norsk biologisk mangfold (steg 2). Plantene i **kategori 3** ble vurdert som én gruppe med hensyn til risiko for overføring av gener til etablerte populasjoner i Norge.

Videre vurderte VKM risikoen for at alle plantene som omfattes av oppdraget kan ha med seg skadelige blindpassasjerer, inkludert patogener og parasitter. Ingen av plantene som er

listet i oppdraget er tidligere blitt rapportert å være vektorer for skadelige blindpassasjerer, inkludert patogener og parasitter. Derfor ble risikoen for uheldige følger for biologisk mangfold i Norge som en følge av dette ansett som lav.

Det er vanskelig å forutse effekter av klimaendringer utover et 50-års perspektiv. Ingen av plantene som er vurdert i denne rapporten pekte seg ut som sannsynlige for å kunne ha uheldige følger utover et 50-års perspektiv. Det er teoretisk sett en potensiell risiko for at eksport av noen av planteartene vil kunne ha en uheldig effekt på biologisk mangfold i landet de eksporteres fra, men alle artene som selges til bruk i akvarier og hagedammerhandelen er kultiverte og ikke hentet i naturen.

VKM konkluderer med at ingen av artene i kategori 1 kan overleve under 5° C. VKM konkluderer at alle artene i kategori 1 og 3 utgjør lav risiko for biologisk mangfold. Det gjelder både evne til å overleve under norske forhold, mulige negative effekter på norske økosystem og arter, og mulig risiko for introduksjon av skadelige blindpassasjerer, patogener og parasitter. Artene i kategori 2 som ikke har egenskaper som gjør at de skiller seg ut som spesielt invaderende i sine naturlige utbredelsesområder og som har begrenset utbredelse i Europa, utgjør også lav risiko for biologisk mangfold i henhold til punktene I – III.

Videre konkluderer VKM at import av de rødlistede artene i kategori 3 vil kunne ha uheldige følger for biologisk mangfold i Norge, med tanke på punkt II; mulige negative effekter på norske økosystem og arter. De rødlistede artene kan potensielt overføre gener og dermed ødelegge lokalt tilpassede genotyper. VKM velger likevel å klassifisere disse artene som lav risiko, fordi det er svært lite sannsynlig at rømte planter vil komme i kontakt med slike rødlistede arter og dermed at slike genoverføringer vil forekomme.

For artene i kategori 2 som ble risikovurdert med den modifiserte NNSS risikovurderingsmalen, konkluderer VKM at *Crassula helmsii* og *Myriophyllum heterophyllum* utgjør en stor risiko mot biologisk mangfold i Norge i henhold til punktene I, II og III. Vurderingen har medium til høy sikkerhet. Artene *Egeria densa*, *Hydrilla verticillata*, *Lagarosiphon major*, *Lemna gibba*, *Myriophyllum aquaticum*, *Najas minor*, *Trapa natans* utgjør en moderat risiko i henhold til punktene I, II og III. Vurderingen har medium til høy sikkerhet, avhengig av hvilken art det handler om.

Abbreviations and glossary

Abbreviations

CBD: Convention on Biological Diversity

CITES: Convention on International Trade in Endangered Species of Flora and Fauna

DAISIE: Delivering Alien Invasive Species Inventories for Europe

EEA: European Environment Agency

EFSA: European Food Safety Authority

EN: IUCN Red List category Endangered

EPPO: European and Mediterranean Plant Protection Organization

GB-NNRA: Great Britain Non Native Species Risk Assessment

GB-NNSS: Great Britain Non Native Species Secretariat

IAP: Invasive aquatic plants

IAS: Invasive alien species

IPCC: Intergovernmental Panel on Climate Change

IUCN: International Union for the Conservation of Nature

IUCN red list: IUCN Red List of Threatened Species

NAPRA: Non-native species Application based Risk Analysis

NBIC: Norwegian Biodiversity Information Centre (Artsdatabanken)

NT: IUCN Red List category Near Threatened

NVWA: Netherlands Food and Consumer Product Safety Authority

NEA: Norwegian Environment Agency

NZB: Norges Zoohandleres Bransjeforening

Q-Bank: Comprehensive Databases on Quarantine Plant Pests and Diseases

RCP: Representative Concentration Pathways

ToR: Terms of Reference

VU: IUCN Red List category Vulnerable

Glossary

Alien organism (IUCN definition): a species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce

Biodiversity (CBD definition): The variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Invasive Alien Species (IUCN definition): Invasive alien species are animals, plants or other organisms introduced by man into places out of their natural range of distribution, where they become established and disperse, generating a negative impact on the local ecosystem and species.

Representative Concentration Pathways: Representative Concentration Pathways (RCPs) are four greenhouse gas concentration trajectories adopted by the IPCC for its fifth Assessment Report (IPCC, 2014). The pathways are used for climate modeling and research. They describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come.

Background as provided by the Norwegian Environment Agency

All import of freshwater organisms fall under the Regulation on Alien Species (forthwith "the Regulation"), pursuant to the Norwegian Nature Diversity Act. The regulation transfers the requirement under the Act relating to salmonids and freshwater fish of permission for import of freshwater organisms. Exemptions to current import permit requirements include organisms for use in aquaria. These exemptions are maintained under the new regulations however they are restricted to thermophilic organisms only:

"A permit is not required for import of freshwater organisms that can only survive at temperatures above 5 °C, and are being held exclusively for ornamental purposes in indoor aquaria arranged in a way that prevent the escape of the organism…"

In addition to the permit requirement for species that can survive at, or below 5° C, the Regulation requires import permits for a number of species listed in Annex III to the regulation. The species listed in Annex III were selected based on information from pet trade associations and assessments conducted by individual researchers and research institutions. However these assessments were carried out before the final draft of the Regulation was completed, thus the basis for these assessments has slightly changed.

Therefore, as a basis for import permit applications and to evaluate how species should be regulated under the Regulation on Alien Species, the Norwegian Environment Agency requires updated risk assessments of negative impacts on biodiversity stemming from the import and keeping of the aquatic plants listed in Annex III. The assessment is limited to plant species for use in aquaria and garden ponds.

Terms of reference as provided by the Norwegian Environment Agency

The Norwegian Environment Agency requests the Norwegian Scientific Committee for Food Safety (VKM) to undertake an assessment of the risks of negative impacts on biodiversity in Norway stemming from the import and keeping of species of freshwater plants for aquaria and garden ponds listed in Annex I to this assignment.

The Norwegian Nature Diversity Act (https://lovdata.no/dokument/NL/lov/2009-06-19-100) defines biological diversity as the variability among ecosystems and species, intraspecies genetic variation and the ecological relationships between ecosystem components.

Issues to be included in the assessment of the risks of negative impacts on biodiversity are:

I. Species survivability under Norwegian conditions
II. Possible negative impacts on ecosystems and other species
III. Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites

The Norwegian Biodiversity Information Centre's methodology for assessing environmental risks resulting from alien organisms cover most of the issues stated above and may be used as a starting point for the evaluation. In addition, the likelihood of escape or release of the organisms should be included in the risk assessment. Possible precautionary measures, such as excluding import from certain areas or excluding certain sub-species or populations, should be included in the report.

The time frame for the risk assessment of adverse impacts on biodiversity should be 50 years or 5 generations for organisms with a generation time of more than 10 years.

Given there is a cut-off temperature of 5° C for an exemption under the import permit requirements, it must be stated for each risk assessment whether the species can survive below this temperature.

A grouped risk assessment may be conducted where whole families or genera are listed in the Annex III, given that the risks are (likely) similar among all species.

Species that have previously been assessed by the Norwegian Biodiversity Information Centre need not be included in the assignment.

In cases where a plant species being assessed is likely to affect ecosystem services and/or may be particularly affected by climate change beyond the specified time frame, this should be stated in the report. Furthermore, any known negative effects on the biodiversity of the exporting country resulting from the harvest of a species being assessed should be stated in the report. The above factors should, however, not be included as a part of the actual risk assessment.

The risk assessment report should be written in English with a Norwegian summary. The report should be finalized before October 2016. For more details on the assignment, we refer to the written agreement on cooperation between the Norwegian Environment Agency and VKM, and between VKM and the Norwegian Biodiversity Information Centre.

1 Introduction

1.1 Invasive alien species

Globalization facilitates the spread of invasive alien species (IAS) as international commerce develops new trade routes, markets, and products (Fig 1.1-1)(Luque et al., 2014; Meyerson and Mooney, 2007; Westphal et al., 2008). Globalization removes or lowers biogeographic barriers and historic boundaries that have isolated biotas throughout evolutionary time, and significant alterations of physical (especially climatic), as well as biotic, environments are currently happening at a speed rarely, if ever, previously encountered in geological history (Mooney and Cleland, 2001; Rockström et al., 2009; Steffen et al., 2015).

Changes in biotic environments caused by alien species are pronounced across the globe, and alien species that become invasive threaten ecosystems, habitats and native species alike (Bax et al., 2003; Lowe et al., 2000; Pejchar and Mooney, 2009; Richardson and Rejmánek, 2011). Invasive alien species (IAS), together with habitat destruction, are regarded as major causes of species endangerment and extinctions (Gurevitch and Padilla, 2004; Mooney, 2005; Wilcove et al., 1998). Alien species have profound economic and ecological effects, and are likely to impact on future evolutionary trajectories in invaded areas (Early et al., 2016; Mooney and Cleland, 2001).

Invasions by alien organisms causes more than US$ 300 billion per year in damage and control costs in the United States, Europe, Australia, India, Brazil and South Africa (Pimentel, 2011). In New Zealand, there are now as many established alien species as native species (Mooney and Cleland, 2001). A significant proportion of these are aquatic organisms (NIWA, 2002), and many, especially among terrestrial and aquatic plants, were initially introduced for ornamental purposes (Howell, 2008).

Aquatic and semi-aquatic plants have a higher probability of becoming invasive than do species from terrestrial plant families (Daehler, 1998) and thus form a significant proportion of potentially invasive species (Andreu and Vilà, 2010). Plant traits positively correlated with invasiveness are reviewed by Kolar and Lodge (2001) and include vegetative reproduction (Reichard and Hamilton, 1997; Richardson et al., 1990), abiotic dispersal (Reichard and Hamilton, 1997; Richardson et al., 1990), extended flowering period length (Goodwin et al., 1999) and history of invasiveness within genus or family (Pyšek, 1998; Reichard and Hamilton, 1997; Scott and Panetta, 1993). In aquatic plants, the ability to become invasive has arisen independently and is not due to shared phylogeny (Daehler, 1998). Daehler (1998) suggests that freshwater habitats can be broadly divided into man-made habitats like reservoirs and irrigation channels, and natural habitats like lakes, rivers, streams and wetlands. The man-made aquatic habitats are generally relatively recently formed, species-poor, and disturbed, all of which may facilitate invasion (Ashton and Mitchell, 1989). Most natural aquatic habitats also have altered nutrient regimes due to increased terrestrial run-off from human disturbance arising from agriculture and deforestation (Anderson, 1995).

Thus, severe modification of most freshwater habitats by humans may have increased the susceptibility of freshwater habitats to invasion (Daehler, 1998).

Freshwater aquatic plants often have broad distribution ranges. Nevertheless, they are not ubiquitous, and there are currently more than 400 alien aquatic and semi-aquatic plant species traded for use in aquaria and garden ponds in Europe. Most of these are considered to be potential invaders to European freshwater habitats (Hussner, 2012). Several studies have linked species introductions with international trade routes, and there is evidence of links between volume of trade and general invasion risk (Perrings et al., 2005). Hussner et al. (2010) for instance, found a significant positive association between the reported number of aquatic IAS and human population density in German federal states. This finding they explained by the absolute number of plant keepers and thus that the potential vectors for plant introductions increases as a function of human population size (Hussner, 2012). Plants that are widely available have a higher risk of being accidentally or deliberately released into the wild, and sales volumes of individual taxa have therefore been used as a proxy for propagule pressure in risk assessments of invasive alien aquatic plants (Azan et al., 2015).

In Europe, major sources of introduction of freshwater alien species are aquaculture, the pet/aquarium trade, and stocking activities (Nunes et al., 2015). Pathways of aquatic IAS introductions do not usually involve deliberate release, but more often accidental escape or through stowaways attached to river or canal traffic (Hulme et al., 2008). Globally, the costs resulting from the environmental, social, health, and economic impacts of invasive aquatic plants (IAPs) are significant; for example, the United States has invested in excess of US$800 million annually to control *Myriophyllum spicatum* L., *Lythrum salicaria* L. and *Trapa natans* L. (Pimentel et al., 2005). In Europe, it has been argued that problems associated with invasive alien aquatic plant species like *Eichhornia crassipes*, *Elodea* spp., and *Myriophyllum aquaticum* are increasing (Hussner, 2012; Sheppard et al., 2006). Problems caused by such species include the threat to native biodiversity, as well as deterioration of provisioning services, through, for example, hindrance of water flow and restrictions for recreational use.

Climate change is expected to increase the problems associated with invasive species by increasing their probability of establishment and spread (reviewed in Hellmann et al., 2008). Warmer water temperatures, shorter duration of ice cover, and briefer frost and low winter temperature periods, may soon change environmental conditions in such a way that IAS could spread beyond their current invasive distribution limits and allow other species to spread beyond their natural distribution limits and become IAS (IPCC, 2014; Rahel and Olden, 2008). Climate change is not expected to have mitigating effects on current IAS as currently many thrive under broad environmental conditions (Qian and Ricklefs 2006; cited in Hellmann et al., 2008).

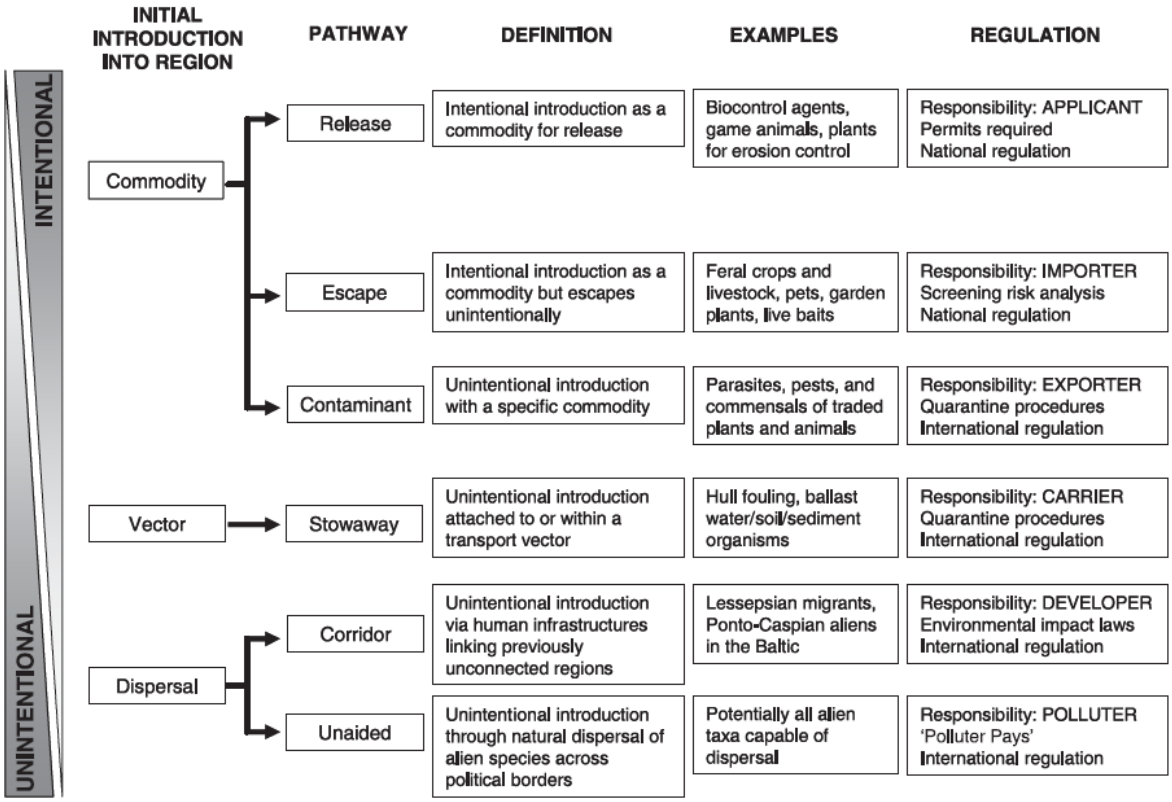

Fig 1.1-1 A simplified framework to categorize pathways of initial introduction of alien species into a new region as presented in Figure 2 in Hulme et al. (2008). Reproduced with permission from John Wiley & Sons, Inc.

1.2 Escape and spread of aquarium and garden pond plants

Aquaria and garden pond tanks are, in principle, closed systems and living organisms should not be able to disperse from these to natural ecosystems. In practice, however, species are able to spread, mostly because of intentional dumping of unwanted organisms, but also through escape from tanks (e.g. during storms; Severinghaus and Chi, 1999; Padilla and Williams, 2004). In general, aquatic plants often propagate by vegetative reproduction, and once established in suitable habitats they can readily propagate further (Kadono, 2004). Unfortunately, those biological traits that make species attractive for use in aquaria and garden ponds, like rapid growth, stress tolerance, and ease of reproduction, are the same traits that enable the species to become invasive. As expected, traded plants that are relatively cold tolerant, able to propagate from fragments, and capable of reproduction through different modes, are of particular concern with respect to potential for invasiveness (Azan et al., 2015).

The Norwegian aquarium trade has an annual turnover of more than NOK 2 billion; more than 2,000 people are employed in the industry, and it provides plants, animals, products, and

information to at least 758,000 Norwegian households that keep aquaria and ponds (S. Fosså, pers. comm. 2016). An overview of sales volumes for common plants used in aquaria and ponds are presented in Fig. 1.2-1. As noted by representatives of the business, (S. Fosså, pers. comm. 2016), this can be a positive activity for children and adults, both for recreation and for stimulating the development of an overall interest in biology, nature, and conservation. In Norway, the Norges Zoohandleres Bransjeforening (NZB) is the trade organization of pet shops, and an effective partner for collaboration on monitoring and restricting trade in aquatic IAS. Nevertheless, a significant proportion of the trade in plants for aquaria and garden ponds is conducted via the Internet, and is effectively beyond the control of NZB (S. Fosså, pers. comm. 2016). Targeting information to end-users about the potential risks of IAS to biodiversity and ecosystems can be facilitated through collaboration with trade organizations (in Norway, organizations like NZB) and this seems pivotal for mitigating the risk of establishment and spread of IAS from this trade. Nevertheless, escapees from aquaria and ponds, through accidental or intentional release, are a significant source of aquatic invasive alien species (Hulme et al., 2008) and this illustrates the need for monitoring and regulating this pathway. Yet, regulating post-marketing use, trade and disposal of these organisms is inpracticable.

A more rigorous option for limiting further introduction of IAP species is to prevent the import and sale of potential IAP through legislation (Hussner, 2012). On 13 July 2016, the EU Commission on implementing EU regulation No 1143/2014 the prevention and management of the introduction and spread of IAS, adopted a list of IAS of Union concern, pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council (EU regulation 2016/1141). The 37 IAS on this list require action across the EU, and species on the list are subject to a set of restrictions and measures including restrictions on keeping, importing, selling, breeding and growing. Member States will also be required to take measures for early detection and rapid eradication of any new establishing population, while established populations have to be eradicated, contained or controlled. Currently, the list contains 7 freshwater plants: *Cabomba caroliniana* Gray, *Eichhornia crassipes* (Martius) Solms, *Hydrocotyle ranunculoides* L.f., *Lagarosiphon major* (Ridley) Moss, *Ludwigia grandiflora* (Michx.) Greuter & Burdet, *Ludwigia peploides* (Kunth) P.H. Raven, and *Myriophyllum aquaticum* (Vell.) Verdc.

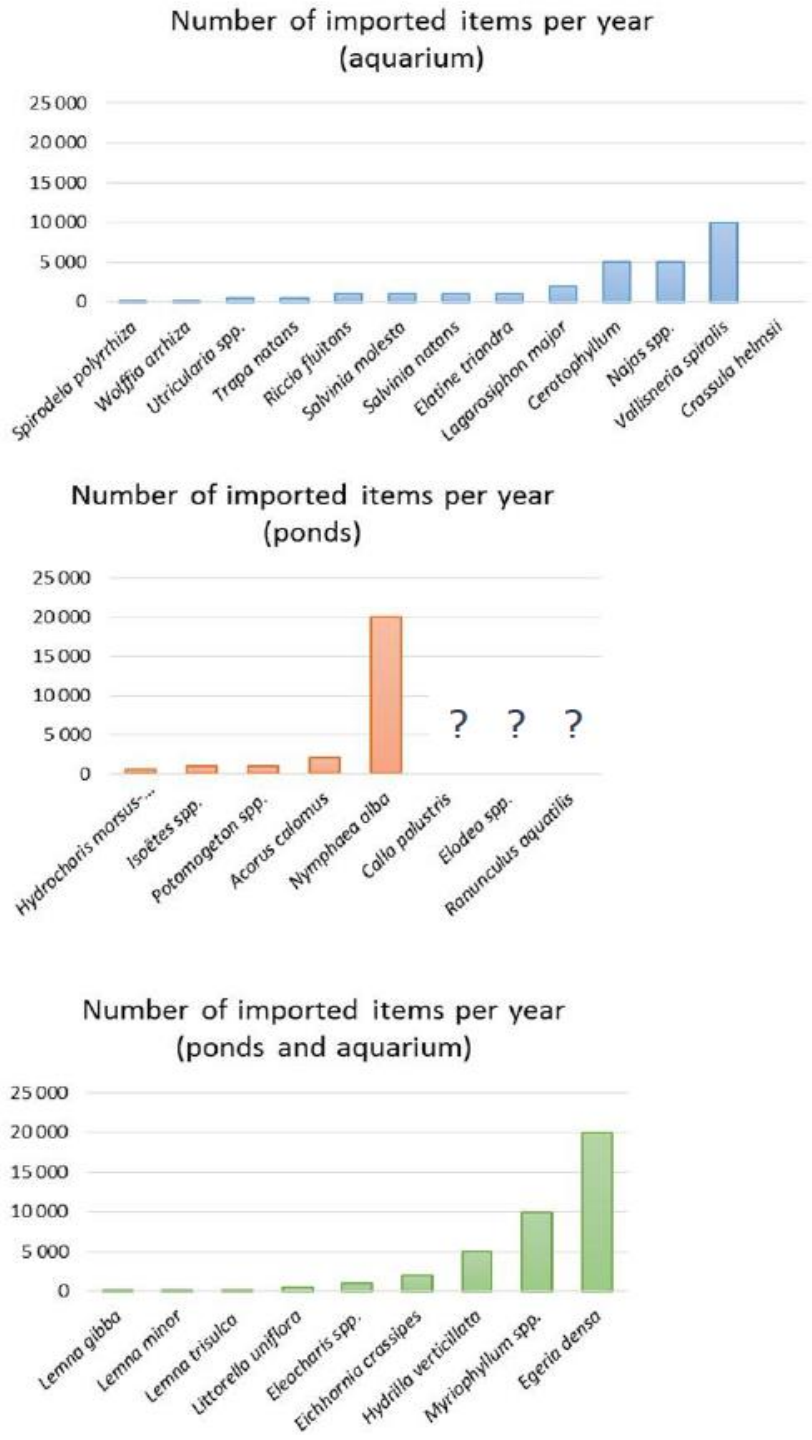

Fig. 1.2-1 Relative sales volumes for plants imported to Norway and commonly used in aquaria and ponds (after Fosså, pers comm.). Top: species used only in aquaria; centre: species used primarily in garden ponds; bottom: species used frequently in both aquaria and ponds. Approximate sales volumes (number of imported shipments) are depicted on the Y-axes. Information is lacking for a few species to the right in the figures and indicated by question marks (?).

1.3 Presentation of the taxa for risk assessment

Annex 1 to the Terms of Reference (ToR) contains a range of aquarium and garden pond species to be assessed in this commision. The Annex covers from many groups of plants, including one liverwort species (Marchantiophyta, Marchantiales, Ricciaceae, *Riccia fluitans* L.), two species of ferns (Pteridophyta, Salviniales, Salviniaceae, *Salvinia* 2 species), the quillwort genus (Lycopodiophyta, Isoetales, Isoetaceae, *Isoetes*), and 19 species and 9 genera in the angiosperm families, Acoraceae, Araceae, Ceratophyllaceae, Crassulaceae, Cyperaceae, Elatinaceae, Haloragidaceae, Hydrocharitaceae, Lentibulariaceae, Lythraceae, Nymphaeaceae, Plantaginaceae, Pontederiaceae, Potamogetonaceae, and Ranunculaceae.

A total of 44 of these taxa occur as native species in Norway, 29 are common taxa and 15 are included on the Norwegian Red List (Henriksen and Hilmo, 2015). None of the species are currently on the Norwegian Black-List of alien species (Gederaas et al., 2012).

The remaining taxa in the commission are not native in Norway but occur naturally in tropical, temperate, or continental climates.

2 Methodology and data

2.1 Climate classification

A key criterion for both the NEA and the risk assessment is survival at temperatures below 5° C, given that it is a cut-off temperature and plants that cannot surive below this temperature are exempt from import permit requirements. The 5° C threshold is also key to species survival under Norwegian conditions, which is manageable to assess for tropical species and species occurring in Norway, but harder for taxa occurring in temperate and continental climate zones. The Köppen-Geiger climate classification (Geiger, 1954; Geiger, 1961), defines tropical climates as being characterized by constant high temperatures (at sea level and low elevations) with an average temperatures of 18° C or higher during all months of the year; temperate climates as being characterized by having an average monthly temperature above 10° C in their warmest months (April to September in northern hemisphere), and an average monthly temperature above −3° C in their coldest months; and continental climates as having an average temperature above 10 °C in their warmest months, and an average temperature in their coldest months below −3° C.

2.2 Screening methodology for evaluation

Based on the Norwegian Red List (Henriksen and Hilmo, 2015), the Norwegian Black List (Gederaas et al., 2012), and EPPO and Netherlands Food and Consumer Product Safety

Authority (NVWA) assessments of aquatic IAS (EPPO, 2015; Koopman et al., 2014; Matthews et al., 2012a; Matthews et al., 2012b; Matthews et al., 2013), a specific screening approach was adopted (Fig 2.2-1). The screening consisted of an initial screening of all taxa in Annex 1 of the NEA ToR in order to group the taxa into distribution categories, followed by risk assessments of all taxa based on the distribution categories. It is important to note that we often had very little or no information on whether the plants included in Annex 1 (appendix 1 to this report) were used for aquariums only, or whether they were commonly used for both aquariums and garden pond. We assume that there is a higher probability that plants could escape from an outdoor garden pond than from a closed indoor aquarium. Therefore, in this report the assessment of all taxa is based on the assumption that they are used for both aquarium and garden ponds.

2.2.1 Preliminary screening

In this stage of the screening all taxa, all taxa were scored for past and current natural and alien distribution, IAS information, and existing species risk assessments. This screening was based on information from scientific studies as well as non-peer reviewed scientific publications obtained from public and closed databases (cf. 2.5 Sources of Information).

Based on these data, the taxa were grouped into three distribution categories, two of which are based on the Köppen-Geiger climate (Geiger, 1954; Geiger, 1961), and the third on whether the species is native to Norway. The following actions were undertaken:

- **Category 1**: Taxa occurring in tropical climates. Taxa were individually assessed for their ability to survive below 5° C; in which case they were transferred to Category 2.
- **Category 2**: Taxa occurring in temperate and continental climates. Taxa were individually assessed using a modified version of the NAPRA Risk Assessment Scheme;
- **Category 3**: Taxa with native occurence in Norway. Taxa were assessed as a group to determine the risk of genetic introgression into native populations.

Taxa in **Category 1** are thermophilic species that in Norway are only expected to survive inside or outside in heated ponds or effluents, or under extreme climatic change (representative concentration pathways (RCP) > 8.5). A key criterion to both the NEA and the risk assessment is survival below 5° C, which is treated as a cut-off temperature where organisms that are unable to survive below this temperature are exempt from import permit requirements. The 5° C threshold is also considered key to species survival under Norwegian conditions now and in a 50-year perspective. The individual assessments of the Category 1 taxa focused on their natural and alien distributions, and the climate zones in these areas. Species that were not deemed capable of surviving below 5° C remained in category 1 and assessed as having a low risk, whereas those capable of surviving below 5° C were moved to Category 2.

Taxa in **Category 2** occur naturally in temperate and continental climates (Köppen-Geiger climate classification). Key for the assessment of these taxa is first their survival below 5° C, as well as their ability and likelihood of entry (and escape), establishment, spread and impact in Norway. In order to evaluate these factors, all taxa were assessed using a modified NAPRA Risk Assessment Scheme for non-native species (cf. 2.2 Modified NAPRA Risk Assessment Scheme for non-native species).

The scheme was modified to address the NEA ToR, with the focus shifted towards Norway, and with questions beyond the scope of the ToR (e.g., economic impacts) omitted. The modified NAPRA Scheme consisted of two sections, Section A and Section B. Questions in Section A of the assessment scheme focus on the taxonomic identity of the species, the existence of earlier risk assessments and their current validity, the native distribution of the organism, the global and European distributions of the organism, and the documented invasiveness of the species. Based on the data obtained from the Section A assessments, taxa were either assessed as posing a low risk to Norwegian biodiversity or further subjected to a full risk assessment using section B of the modified NAPRA Scheme. Species that fulfilled the following criteria based on the section A modified NAPRA Scheme were assessed as posing a low risk to Norwegian biodiversity: Taxa that do not have any characteristics of invasiveness where they occur, have limited distributions in Europe, or are among the alien species in Europe have only non-established populations, e.g. ephemeral and occasional occurrences that are not (yet) established. All taxa in category 2 that were not excluded on the basis of these criteria listed above were subjected to a full risk assessment.

Taxa in **Category 3** are native to Norway and can obviously survive under Norwegian conditions. If escaped plants come into contact with native plants then the possibility arises that they will be able to reproduce with native plants or spread vegetatively through local populations. As part of the assessment, the likelihood of escaped plants meeting native populations was assessed for both common and Red-Listed species. In addition, the subsequent impact of introgression of novel genetic material on native populations and the risk for loss of genotypes adapted to local environments was assessed.

2.2.2 Introduction of harmful hitchhiker organisms, including pathogens and parasites

Assessment of the possible negative impacts on ecosystems and other species is related to the species survival under Norwegian conditions. However, the possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, is largely independent from survival of the Annex species, as the potential hitchhikers have their own survival characteristics and criteria, and possible negative impacts on ecosystems. The potential for risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, were assessed for all species. As part of the assessment, all taxa in the ToR were investigated for their role as vectors of harmful hitchhiker organisms, including pathogens and parasites (cf. section 2.5).

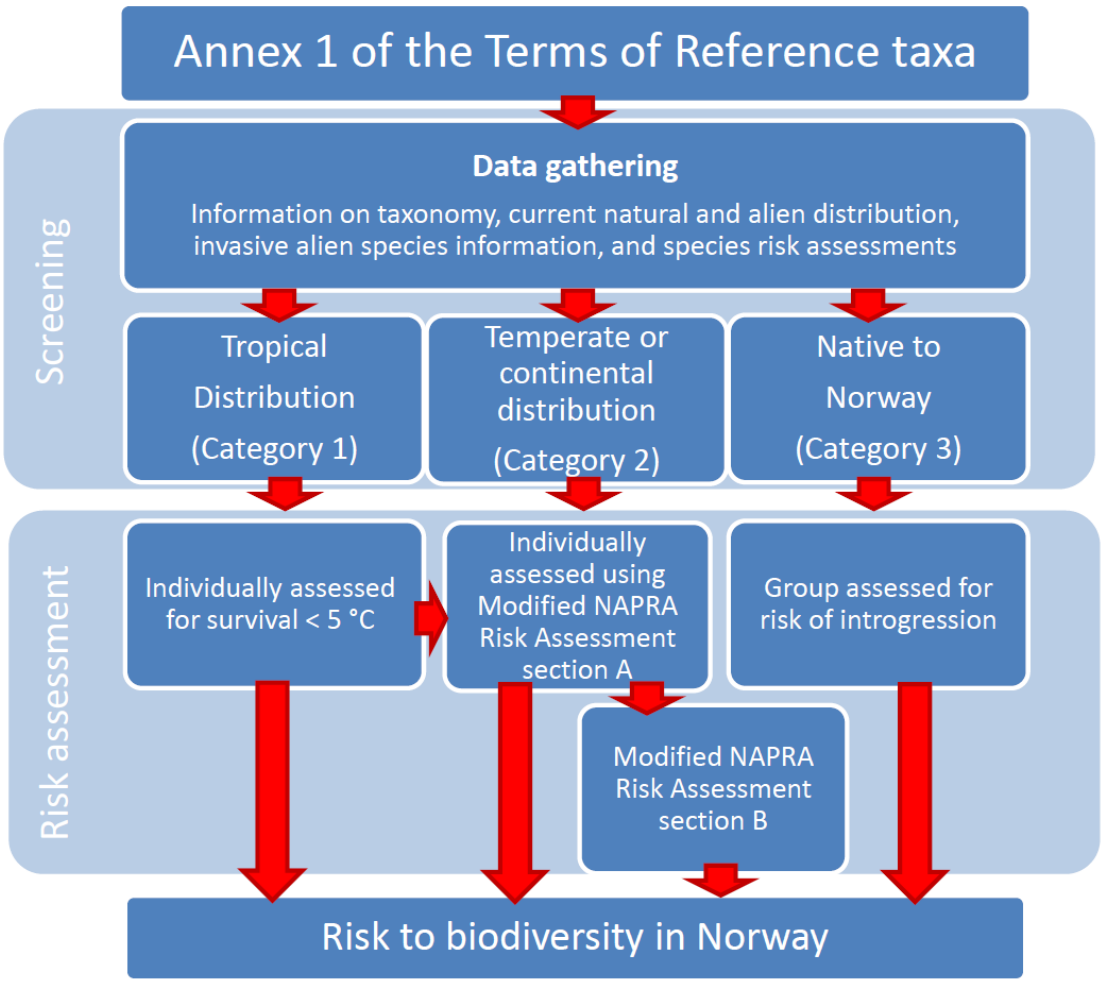

Fig 2.2-1 Decision-making flowchart for risk assessments of taxa in Annex 1 of the ToR.

2.3 Risk Assessment Scheme for non-native species

In this risk assessment, a modified version of the NAPRA Scheme was used. The NAPRA Scheme is the template for risk assessors commissioned by the Non-native Species Secretariat (NNSS) for Great Britain (GB-NNSS). It has been developed from a scheme used by the European and Mediterranean Plant Protection Organisation (EPPO) and is a further development of the UK Non-Native Species Risk Assessment Scheme template from 2005. It provides detailed instructions for the following stages of risk assessment for non-native species: initiation, entry, establishment, and impact. It provides a consistent scheme, based on a sequence of questions to assess and document the risk. Both expert judgement and objective information can be used, but all responses should be documented (http://napra.eppo.org).

The NAPRA Scheme complies with the Convention on Biological Diversity (CBD) and reflects standards used by other forms, such as the Intergovernmental Panel on Climate Change (IPCC), EPPO, and the European Food Safety Authority (EFSA). For this risk assessment, the Scheme was modified to focus on Norway only, and questions related to economic impact were omitted. The NEA ToR requests only an assessment of the risks of negative impacts on biodiversity in Norway, resulting from the import and keeping of species of freshwater plants for aquaria and garden ponds. The GB-NNSS granted permission for modification of the NAPRA Scheme as described above.

The NAPRA Scheme is a qualitative risk assessment method that comprises a range of questions covering all aspects requested in the ToR. The assessment consists of two sections, Section A and Section B. Each section A assessment was carried out by a single expert. Section B assessments were carried out by two experts working intogether. The first expert made an initial risk assessment and the second expert subsequently reviewed and adjusted the risk assessment. Section B risk assessments comprise a detailed assessment, with questions covering the organism's probability of entry and pathways of entry, establishment and spread, and the potential impact that the organism may have on biodiversity. For each question, the assessor is asked to rank the confidence of their response and add additional comments. To ensure standardised use of terminology in the assessments, the terminologies presented in section 2.2.2 were used as guidelines for answering the assessment questions. Each section of the risk assessment, entry, establishment, spread, and impact, culminate in separate conclusions at the end of the assessment scheme. A summary conclusion, taking into account all sections, is presented at the end of the assessment. Species are assessed as having low, moderate or high risk, with low, moderate, high or very high confidence (cf. 2.2.2 Ratings and descriptors).

2.3.1 Modified NAPRA Risk Assessment Scheme for non-native species

The original version of the GB-NAPRA template can be found in Appendix 1. The modified version of the Scheme that was used for the analyses in the current report is provided below. **NB** Fields marked with 'Subnote: Background information' include information that was part of the screening process, but has not been used in any of the assessment results and conclusions.

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME
Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants.
Adapted by the Norwegian Scientific Committee for Food Safety (VKM).

Name of organism:
Author:
Risk Assessment Area: Norway

Introduction to genus/species:

Draft:

Note:

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**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?		
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)		
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?		
6. What is the global distribution of the organism?		
7. What is the distribution of the organism in Europe?		
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?		
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. This is not to be confused with spread, the movement of an organism within Norway. • For organisms that are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	none very few few moderate number many very many	low medium high very high	
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	[insert text]		
1.3. 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? Subnote: In your comment discuss the likelihood that the organism will get onto the pathway in the first place.	very unlikely unlikely moderately unlikely likely very likely	low medium high very high	
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via an Internet purchase, or due to misidentification	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	very unlikely unlikely moderately likely likely	low medium high very high	

	very likely		

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms that are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarities between climatic conditions here and the organism's current distribution?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	very isolated isolated moderately widespread widespread ubiquitous	low medium high very high	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.12. How likely are the biological characteristics of the organism (e.g., capacity of spread, adaptability, genetic variation) to facilitate its establishment?	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Norway? (If possible, specify the instances in the comments box.)	very unlikely unlikely moderately likely likely very likely	low medium high very high	

1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: The red-eared terrapin, a species that cannot re-produce in GB but is established because of continual releases, is an example of a transient species.	very unlikely unlikely moderately likely likely very likely	low medium high very high	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	very unlikely unlikely moderately likely likely very likely	low medium high very high	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minimal minor moderate major massive	low medium high very high	
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minimal minor moderate major massive	low medium high very high	
2.3. How difficult would it be to contain the organism within Norway? Subnote: Consider whether the plant is kept as an aquarium plant or as a garden pond plant.	very easy easy with some difficulty difficult very difficult	low medium high very high	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	[insert text]	low medium high very high	
2.5. Estimate the overall speed of future spread of this organism in Norway, should it become established (using the comment box to indicate any key issues).	very slowly slowly moderately fast rapidly very rapidly	low medium high very high	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments field of the disease question. •			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation)? (Include any past impact in your response)	minimal minor moderate major massive	low medium high very high	
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism? (Include any past impact in your response)	minimal minor moderate major massive	low medium high very high	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal minor moderate major massive	low medium high very high	
2.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. pathogens)?	minimal minor moderate major massive	low medium high very high	
2.17. How important might other impacts be (including positive impacts) not already covered by previous questions and resulting from introduction of the organism? (Specify in the comment box)	NA minimal minor moderate major massive	low medium high very high	
2.18. 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 Norway?	minimal minor moderate major massive	low medium high very high	
2.20. Estimate the overall impact of the species in Norway (use the comment box to indicate any key issues).	minimal minor moderate major massive	low medium high very high	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very unlikely unlikely moderately likely likely very likely	low medium high very high	
Summarise Establishment	very unlikely unlikely moderately likely likely very likely	low medium high very high	
Summarise Spread	very slowly slowly moderately fast rapidly very rapidly	low medium high very high	
Summarise Impact	minimal minor moderate major massive	low medium high very high	
Conclusion of the risk assessment	low moderate high	low medium high very high	

REFERENCES:

[End of form]

2.3.2 Ratings and descriptors

The ratings used in the section B assessments are described in the tables below. There is one table for each section, entry, establishment, spread, and impact, as well as for confidence. The descriptors were used to ensure that ratings meant the same to different authors, and thus to standardize the assessments. Tables are adapted from EFSA (EFSA, 2015).

Table 2.1.2-1 Rating of probability of entry

Rating	Descriptors
Very unlikely	The likelihood of entry is assessed as being very low because the species: • is rare in its native area; • is not currently traded anywhere
Unlikely	The likelihood of entry is assessed as being low because the species: • is rare in its native area; • is not currently traded in Norway
Moderately likely	The likelihood of entry is assessed as being moderate because the species: • is common in its native area; • is currently traded in small quantities in Norway
Likely	The likelihood of entry is assessed as being high because the species: • is common in its native area; • is currently commonly traded in Norway
Very likely	The likelihood of entry is assessed as being very high because the species: • is common in its native area; • is currently very commonly traded in Norway

Table 2.1.2-2 Rating of the probability of establishment

Rating	Descriptors
Very unlikely	The likelihood of establishment is assessed as being very low because: • environmental and current and future climatic conditions are unsuitable for establishment; • the occurrence of other considerable barriers to establishment
Unlikely	The likelihood of establishment is assessed as being low because: • environmental and current and future climatic conditions are unsuitable for establishment in less than 5 % of Norway; • the occurrence of other barriers to establishment
Moderately likely	The likelihood of establishment is assessed as being moderate because: • environmental and current and future climatic conditions are suitable in less than 10% of Norway; • no barriers to establishment occur
Likely	The likelihood of establishment is assessed as being high because: • environmental and current and future climatic conditions are suitable in less than 20% of Norway; • no barriers to establishment occur; • **Alternatively**, the species is already established in some areas of Norway
Very likely	The likelihood of establishment is assessed as being very high because: • environmental and current and future climatic conditions are suitable in more than 20% of Norway; • no barriers to establishment occur; • **Alternatively**, the species is already established in Norway

Table 2.1.2-3 Rating of the speed of spread

Rating	Descriptors
Very slowly	The speed of spread is assessed as being very slowly because: • the species has limited spreading capabilities; • highly effective barriers to spread exist (e.g. patchy distribution of suitable habitats); • suitable habitats are not present or very rarely present in the area of possible spread
slowly	The speed of spread is assessed as being slowly because: • the species has limited spreading capabilities; • effective barriers to spread exist; • suitable habitats are occasionally present
Moderately fast	The speed of spread is assessed as being moderately fast because: • the species has limited spreading capabilities; • partly effective barriers to spread exist; • suitable habitats occur widely in a few parts of the risk assessment area
Rapidly	The speed of spread is assessed as being rapidly because: • the species has effective ways to spread; • no effective barriers to spread exist; • suitable habitats occur widely in some parts of the risk assessment area
Very Rapidly	The speed of spread is assessed as being very rapidly because: • the species has effective ways to spread; • no effective barriers to spread exist; • suitable habitats are abundant in the whole risk assessment area

Table 2.1.2-4 Rating of the assessment of impact

Rating	Descriptors
Minimal	No impact on local biodiversity
Minor	Potential impacts on local biodiversity are within normal and expected fluctuations
Moderate	Impact may cause moderate reductions in native populations
Major	Impact may cause considerable reductions in local populations with consequences for local biodiversity and ecosystem functions and services
Massive	Impact may cause severe reductions in local biodiversity (local extinctions), with severe consequences for ecosystem functions and services

Table 2.1.2-5 Ratings used for describing the level of **confidence**

Rating	Descriptors
Low	Information on the species distribution, ecological requirements, and climate tolerance is largely lacking. Subjective judgement may be introduced without supporting evidence. Unpublished data are frequently used.
Medium	Information on the species distribution, ecological requirements, and climate tolerance is partly available. Subjective judgements are introduced with supporting evidence. Unpublished data are sometimes used.
High	Information on the species distribution, ecological requirements, and climate tolerance is mostly available. Subjective judgements are not introduced. Unpublished data are occasionally used.
Very High	Information on the species distribution, ecological requirements, and climate tolerance is available. Subjective judgements are not introduced. Unpublished data are not used.

2.4 Climate change from a 50-year perspective

In this assessment greenhouse gas Representative Concentration Pathways (RCPs) as adapted by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) (IPCC, 2014) were used to evaluate the risks associated with climate change.

The globally averaged combined land and ocean surface temperature shows a warming of 0.85° C (0.65 to 1.06) over the period 1880 to 2012, for which multiple independently produced datasets exist (IPCC, 2013). The rate of the warming has accelerated towards the present. Future climate change is expected to vary heterogeneously between- and within regions, and according to season. Currently, the warmest annual mean temperature in Norway is found in coastal southern Norway at 8° C (period 1971-2000). The warmest summer temperatures are in the southern part of Østlandet and the coastal areas of Sørlandet, with an average of about 17° C. Given the mid-range CO_2 emission scenario RCP4.5, these warm areas can expect an annual temperature increase of 2° C by the year 2066, with the highest increase (2.4° C) occurring during the winters (Table 2.3-1). The increase in temperature is more pronounced in emission scenario RCP8.5 (Table 2.3-1). The number of growing season days will also increase under both climate scenarios (Table 2.3-1).

Table 2.3-1 Modelled climate change (increase in temperature, precipitation and growing season days) from the period 1971-2000 and towards year 2066 under the CO2 emission scenarios RCP4.5 (emission peak 2040-2050, then decline) and RCP 8.5 (business as usual). These two scenarios are recommended by the IPCC. The projections are based on an ensemble of ten different climate models. Source, including uncertainties in the projections: klimaservicesenter.no

	Annual ° C	**Summer ° C**	**Winter ° C**	**Annual ppt %**	**Winter ppt %**	**Summer ppt %**	**Growing season days**
Norway RCP 4.5	2.2	2.0	2.5	6.7	5.6	10.5	0-60
Southern/Eastern Norway RCP 4.5	2.0	1.9	2.4	2.4/6.0	6.7/17.2	1.6/2.3	0-60*
Norway RCP 8.5	3.3	2.9	3.5	10.7	7.1	12.5	0-60
South-eastern Norway RCP 8.5	3.0	2.6	3.2	6.6/10.2	6.7/17.2	1.5/2.3	30-60

Summer= June, July, August; winter= December, January, February. Ppt, precipitation. *Small areas in southernmost Norway may experience up to 60 days increase.

Given a realistic temperature increase of 2° C, the average annual temperature will reach a maximum of 10° C in Norway in 2066. Winters may still be a bottleneck for the survival of non-native species originating from warmer climates. The mean temperatures of coastal southern Norway will increase to about 4.5° C during winters. However, one can expect that periods with sub-zero temperatures will be even shorter in 2066 than suggested by the modelled increase in winter temperatures. This is because the daily minimum temperatures are increasing about twice as fast as the maximum daily temperatures (IPCC, 2013).

The mid-range CO_2 emission scenario RCP4.5 is used for the risk assessments in this report. In that model the mean temperatures of coastal southern Norway will increase to about 4.5° C during winters, but this is still below the 5° C survivability cut-off temperature below which legislation includes an exemption for import permit requirements.

2.5 Effects of climate beyond a 50-year perspective and the potential negative impacts on biodiversity of the exporting country

The ToR specified that cases of plant species particularly affected by climate change beyond the specified time frame should be stated in the report. Furthermore, the ToR specified that any known negative effects on the biodiversity of the exporting country resulting from the harvest of a species should also be stated in the report. Effects of climate beyond a 50-year perspective and the potential negative impacts on biodiversity of the exporting country were assessed in parallel for all species. In this assessment the greenhouse gas Representative Concentration Pathway 4.5 (RCP4.5) as adapted by the IPCC AR5 (IPCC, 2014) was used to evaluate the risks associated with climate change beyond a 50-year perspective. The cascading effects of climate change at RCP4.5 beyond a 50-year perspective are difficult to predict, and this limits confidence of assessments in that time frame. The potential of negative impacts on biodiversity in the exporting country for aquatic plants in the aquarium and pond trade were evaluated for all taxa by compiling information on the origin of currently traded material, and whether the individual species are obtained from cultivation or from wild-harvest.

2.6 Sources of information

The number of taxa in the NEA ToR includes 22 species and 10 genera of plants. This includes liverworts (Marchantiophyta), ferns (Pteridophyta), quillworts (Lycopodiophyta), and several angiosperm families. For most single species there is ample information available on their biology and ecology, but there is much less information available for many species in the included genera.

The main sources of information on the various taxa have been obtained from literature searches, including regional floras (including Lid and Lid, 2005; Online Atlas of the British and Irish Flora), published reports and risk assessments (Fremmede Arter i Norge – med Norsk svartliste, Netherlands Food and Consumer Product Safety Authority (NVWA), GB Non Native Species Secretariat (GB-NNSS), Harmonia database), scientific publication databases (Google Scholar, ISI Web of Science), and various online databases and sites (DAISIE, IUCN, Global Invasive Species Database, Qbank, and eMonocot.org). Nomenclature of all taxa follows The Plant List (http://www.theplantlist.org/). The main source of information for species and volumes traded in Norway in the aquarium and pond plant trade was the report 'Vurdering av akvatiske organismer for positivlister - Akvatiske organismer – planter' from NZB (Fosså, 2010)

Each taxon in the NEA ToRwas researched, as well as species within each genus. Information gathering focused on answering the ToR questions: (I) species survivability under Norwegian conditions; (II) possible negative impacts on ecosystems and other species; (III) possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites.

Species search queries consisted of the species name, genus only, binomial name, vernacular name in English and Norwegian, plus one of the following search terms: 'alien', 'introduced', 'invasive', 'invasion', 'spread', 'impact', 'ecology', 'tolerance', 'assessment', 'risk'.

The search terms were divided into primary search terms that led to a termination of the search if no relevant results were found: 'alien', 'introduced', 'invasive', 'invasion', 'assessment', 'risk' and secondary terms that were only used to gather additional information for suspect species: 'spread', 'impact', 'ecology', 'tolerance'.

Genus search queries consisted of the genus name and the species binomial for each of the species in the genus, plus the query terms above. Literature retrieved from these searches was evaluated and checked for relevance and information value. The information sources cited in the assessments are comprised mainly of taxon-specific scientific articles, databases, fact-sheets, and risk assessments.

In order to assess NEA ToR question III possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, the above-mentioned information sources were queried using the genus and species names, and vernacular names in English and Norwegian on Annex in combination with the search terms 'harmful', 'hitchhiker', 'pathogen', 'danger', and 'parasites'.

3 Assessment results

The two-stage screening approach (Fig. 2.2-1) resulted in all taxa being evaluated using information from scientific studies as well as popular scientific publications obtained from public and closed databases and divided into three categories. As a result of the first stage screening all taxa were scored for past and current natural and alien distribution, and subsequently grouped into three distribution categories: **Category 1**: Taxa occurring in tropical climates. **Category 2**: Taxa occurring in temperate and continental climates. **Category 3**: Taxa occurring natively in Norway. The **second stage** resulted in the following actions for each category: Taxa in Category 1 were individually assessed for their ability to survive below 5° C; Taxa in Category 2 were individually assessed using a modified version of the NAPRA Risk Assessment Scheme for non-native species; Taxa in Category 3 were assessed as a group to determine the risk of introgression to natural populations.

3.1 Category 1. Thermophilic species

Taxa in Category 1 are thermophilic species that are only expected to survive iin Norway if kept inside or kept outside in heated ponds or effluents, or under extreme climatic change (>RCP 8.5). Some of the taxa are known to be invasive in Mediterranean and tropical climate conditions, e.g., *Eichhornia crassipes* (Mart.) Solms and *Salvinia molesta* D.S.Mitch., but these would be unable to survive under Norwegian climate conditions. A key criterion to both the NEA and the risk assessment is survival below 5° C, given that this is a cut-off temperature that results in exemption from import permit requirements. The 5° C threshold is also key to species survival under Norwegian conditions. The individual assessments of the Category 1 taxa focused on their natural and alien distributions and the climate zones in these areas. Depending on the assessment, taxa could either remain in Category 1 or be moved to Category 2.

3.1.1 Taxa in Category 1

Taxa included in Category 1
Eichhornia crassipes (Mart.) Solms
Isoëtes velata A. Braun
Myriophyllum spp. (thermophilic species not included in categories 2 and 3)
Najas spp. (thermophilic species not included in categories 2 and 3)
Potamogeton antaicus Hagstr.
P. australiensis A.Benn
P. chamissoi A.Benn
P. chongyangensis W.X.Wang
P. delavayi A.Benn
P. drummondii Benth
P. floridanus Small
P. gayi A.Benn
P. hoggarensis Dandy
P. intortusifolius J.B.He, L.Y.Zhou & H.Q.Wang
P. iriomotensis Masam
P. marianensis Cham. & Schltdl
P. montevidensis A.Benn
P. papuanicus G.Wiegleb
P. paramoanus R.R.Haynes & Holm-Niels
P. parmatus Hagstr
P. polygonus Cham. & Schltdl
P. punense A.Galán
P. quinquenervius Hagstr.
P. richardii Solms
P. sclerocarpus K.Schum
P. solomonensis G.Wiegleb
P. spirilliformis Hagstr
P. stenostachys K.Schum
P. sulcatus A.Benn.
P. sumatranus Miq.
P. tennesseensis Fernald
P. tepperi A.Benn.
P. tricarinatus F.Muell. & A.Benn
P. ulei K.Schum
P. uruguayensis A.Benn. & Graebn
Salvinia molesta D.S.Mitch. (syn. Salvinia adnata Desv.)
Utricularia spp. (thermophilic species not included in categories 2 and 3)

3.2 Category 2. Temperate and continental species

Taxa in Category 2 occur in temperate and continental climates (Köppen-Geiger climate classification). Key for the assessment of these taxa is their survival below 5° C, as well as their ability and likelihood of entry (and escape), establishment, spread, and impact in Norway. All taxa were assessed using the modified NAPRA Scheme sections A and B. Based on the results of the Section A assessments, taxa for which there is no evidence from their non-native distribution areas that they exhibit characteristics of invasiveness were assessed as posing a low risk to Norwegian biodiversity. All other were further subjected to a full risk assessment using Section B of the modified NAPRA Scheme.

3.2.1 Category 2 taxa posing a low risk and excluded after section A assessments

Species that fulfilled the following criteria based on the Section A modified NAPRA Scheme assessment were assessed as posing a low risk to Norwegian biodiversity: taxa that do not have any characteristics of invasiveness where they occur, and among the alien taxa found in Europe have only non-established populations. All taxa in category 2 that were not excluded based on the criteria above were subjected to a full risk assessment. The following taxa pose a low risk to Norwegian biodiversity and were not assessed further:

Category 2 taxa
Elodea callitrichoides (Rich.) Casp.
Potamogeton amplifolius Tuck
P. bicupulatus Fernald
P. biformis Hagstr
P. brasiliensis A.Benn.
P. cheesemanii A.Benn.
P. confervoides Rchb.
P.cristatus Regel & Maack
P. distinctus A. Benn.
P. diversifolius Raf.
P. ferrugineus Hagstr.
P. foliosus Raf.
P. fontigenus Y.H.Guo, X.Z.Sun & H.Q.Wang
P. fryeri A.Benn.
P. heterocaulis Z.S.Diao
P. hillii Morong
P. illinoensis Morong
P. juzepczukii P.I.Dorof. & Tzvelev
P. kashiensis Z.S.Diao
P. lacunatifolius Papch
P. linguatus Hagstr.
P. maackianus A.Benn.
P. mandschuriensis (A.Benn.) A.Benn.

Category 2 taxa
P. nanus Y.D.Chen
P. nomotoensis Kadono & T.Nog.
P. oakesianus J.W.Robbins
P. ochreatus Raoul
P. octandrus Poir.
P. ogdenii Hellq. & R.L.Hilton
P. oxyphyllus Miq.
P. pulcher Tuck.
P. reniacoensis Sparre
P. richardsonii (A.Benn.) Rydb.
P. robbinsii Oakes
P. sarmaticus Mäemets
P. sibiricus A.Benn.
P. spathuliformis (J.W.Robbins) Morong
P. spirillus Tuck.,
P. strictifolius A.Benn
P. subnitens Hagstr.
P. suboblongus Hagstr.
P. tubulatus Hagstr.
P. vaseyi J.W.Robbins
P. acutifolius Link ex Roem. & Schult
P. antaicus Hagstr.
P. coloratus Hornem
P. skvortsovii Klinkov

3.2.2 Category 2 taxa subjected to a full risk assessment

Based on the results from the Section A assessments, taxa were either assessed as posing a low risk to Norwegian biodiversity (3.2.1. above) or further subjected to a full risk assessment using Section B of the modified NAPRA Scheme (see Table below). Information on the taxonomy, distribution, ecology, and other properties relevant to invasiveness or subsequent control is included. The full risk assessments can be found in Appendix II. For the genus *Potamogeton*, the whole genus is presented as all species have the same risk assessment.

Category 2 taxa subjected to a full risk assessment
Ceratophyllum submersum L.
Crassula helmsii (Kirk) Cockayne
Egeria densa Planch.
Eleocharis vivipara Link
Hydrilla verticillata (L.f.) Royle
Lagarosiphon major (Ridl.) Moss
Lemna gibba L.
Myriophyllum aquaticum (Vell.) Verdc.
Myriophyllum heterophyllum Michx.
Myriophyllum quitense Kunth
Najas guadalupensis (Spreng.) Magnus subsp. *guadalupensis*
Najas minor All.
Potamogeton schweinfurthii A.Benn.
P. wrightii Morong
P. epihydrus Raf.
Salvinia natans L.
P. nodosus Poir.
Trapa natans L.
Vallisneria spiralis L.
Wolffia arrhiza (L.) Horkel ex Wimmer

3.2.2.1 Ceratophyllum submersum

Ceratophyllum submersum L. is used in aquaria and as an ornamental plant in outdoor ponds (Fosså, 2010). Fosså (2010) estimates that more than 2000 plants are traded per year. *C. submersum* typically occurs in mesotrophic to eutrophic still water bodies such as lakes, ponds and ditches, is tolerant of salt and in some areas apparently preferentially occurs in brackish water (Lansdown, 2013a). The species is not native to Norway, and is not included on the Norwegian Red List (Henriksen and Hilmo, 2015)or on the Norwegian list of exotic species (Gederaas et al., 2012). However, Klaveness (2001) lists *Ceratophyllum submersum* as a species that occasionally escapes in Norway. The main distribution of *C. submersum* is Central Europe, but it also occurs in North Africa and parts of Central Africa, and east to southern Russia and possibly Kazakhstan. *C. submersum* is found mainly centrally in Europe, from France and the UK to southern Sweden and the Baltic States into European Russia, and in the south from scattered localities in Spain to Italy, Greece, and the Ukraine. In Scandinavia, this species occurs in Denmark, Sweden, and Finland. The species is established in southern Sweden (Jonsell, 2001; Karlsson, 1998; Riksmuseet, 2005), but it is rare and occurs only in few areas in the south, where it is found in nutrient-rich lakes and ponds (Naturhistoriska Riksmuseet, 2011) . It was first recorded in Sweden in 1779 in the southern Skåne province (Nordstedt 1920 in Naturhistoriska Riksmuseet, 2011). Skåne has a continental climate, according to definitions of the EU Biogeographic Areas. It has also established in southern Finland (Hämet-Ahti et al., 2005; Pihlajaniemi, 1999). Although the species was first reported in Sweden in 1779, and in Finland in 1966, these populations have not spread, and the species remains rare (NOBANIS, 2016). The species is not known to be

invasive and no negative impacts of the organism are known on biodiversity (NOBANIS, 2016).

Entry is very likely because more than 2000 plants are traded in Norway each year. Establishment is likely as sporadic populations might occur in Norway (Klaveness, 2001) and the species occurs in neighboring countries. Spread is assessed as being very slow as other Nordic populations have persisted without spreading for decades (Finland) and centuries (Sweden). Under current climate conditions and in a 50-year perspective impact is assessed as being minimal and the conclusion of the risk assessment of *C. submersum* is that it poses a low risk with high confidence.

Ceratophyllum submersum	**RISK**	**CONFIDENCE**
ENTRY	**very likely**	**high**
ESTABLISHMENT	**likely**	**high**
SPREAD	**very slowly**	**high**
IMPACT	**minimal**	**high**
CONCLUSION	**low**	**high**

3.2.2.2 Crassula helmsii

Crassula helmsii (Kirk) Cockayne is used as an ornamental plant in outdoor ponds (Fosså, 2010). The volume of trade in Norway is unknown. It is an amphibious, succulent, perennial plant, native to Australia and New Zealand, and can form dense monospecific mats on the water surface. Flowers are small and white, and are only produced above the water surface. Vegetative propagation from fragments of the plant gives the plant the capacity to spread and colonise new waterbodies (EPPO, 2007).The species tolerates frost and is wintergreen. The species shows tolerance to a wide variety of habitats, with acceptable chemistries ranging from acid to alkaline. Suitable waterbodies include slow-flowing rivers, marshes and peat bogs. The dense mats formed by this species deplete oxygen, thereby affecting other aquatic organisms, outcompete native plant species, and may affect the breeding success and survival of threatened aquatic plants and amphibians. Mats choke ponds and drainage ditches, impede water flow, and adversely affect recreational activities (Branquart et al., 2013a). It is important to note that *C. helmsii* is one of five introduced aquatic plants that were banned from sale in the UK as of April 2014 (http://www.bbc.com/news/science-environment-21232108)

Entry is likely because the species is available to purchase from vendors on the Internet for use in aquaria and garden ponds. Establishment is moderately likely and spread can be rapid because suitable habitats are present in Norway and the climatic zones are similar to those of its native habitat. Winter cold temperatures would not prohibit the invasion of *C. helmsii.* Impacts should be considered similar to those seen in other countries where the species has invaded and become established. Impacts can be major locally. The formation of the dense mats is considered highly problematic for the population viability of local biota (macrophytes, algae, amphibians, invertebrates, even birds; Watson, 1999; Langdon et al., 2004; EPPO, 2007; Hussner, 2009). At this stage and under the current climate change scenarios the

impacts are considered major with a medium confidence. Under current climate conditions and in a 50-year perspective, the impacts are considered major with medium confidence and the overall risk from *C. helmsii* is assessed to be high with medium confidence.

Crassula helmsii	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**medium**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**rapidly**	**medium**
IMPACT	**major**	**medium**
CONCLUSION	**high**	**medium**

3.2.2.3 Egeria densa

Egeria densa Planch. is used in aquaria as an ornamental plant (Fosså, 2010). Fosså (2010) estimates that more than 1000 plants are traded annually in Norway. *E. densa* is a submerged perennial that can live either rooted or free floating, with leaves that are smooth and whorled. *E. densa* originates from warm/temperate areas of South America (Brazil, Argentina, Uraguay), but in Europe only male *E. densa* are present in nature, because imported and cultivated plants are male (Matthews et al., 2014). *E. densa* thrives in various types of freshwater habitats, from acid to eutrophic environments. It prefers flowing systems but may also be found in still waters. It is not light demanding and is able to develop in deep and turbid waters (Branquart et al., 2013b). *E. densa* is highly competitive, has a high relative growth rate, can propagate vegetatively, and is found on all continents (except Antarctica). The root system and stems are not very strong and break easily, allowing plant fragments to be carried by currents to colonise new areas. It forms dense monospecific stands that often colonise the entire water column, restrict water movement, cut off light, produce anoxic conditions, and trap sediments in the system (Yarrow et al., 2009).

Entry is likely because the species is available to purchase from vendors on the Internet for use in aquaria. Establishment and spread are assessed as being slow to moderate because a number of freshwater habitats in Norway are suitable for *E. densa* survival, but development and multiplication of the species in other countries has shown a natural slow spread and the growth optimum is in waters between 15 and 25°C (reviewed in Yarrow et al., 2009). Impacts should be considered similar to those seen in other countries where the species has invaded and become established, such as outcompeting native submerged species by forming a dense canopy (Matthews et al., 2014; Santos et al., 2011; Yarrow et al., 2009). Under current climate conditions and in a 50-year perspective the impacts are considered major with a medium confidence. The conclusion of the assessment is that *E. densa* poses a moderate risk with a medium confidence.

Egeria densa	RISK	CONFIDENCE
ENTRY	**likely**	**medium**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**slowly**	**medium**
IMPACT	**major**	**medium**
CONCLUSION	**moderate**	**medium**

3.2.2.4 Eleocharis vivipara

Eleocharis vivipara Link is used in aquaria as an ornamental plant (Fosså, 2010). Fosså (2010) estimates that less than 1000 plants are traded annualy in Norway. *E. vivipara* Link is native to the southern and southeastern United States (USDA, 2016).The Invasive Species Compendium reports it as invasive, but provides very little specific information (CABI, 2011). It is a perennial plant in the Cyperaceae family, forming dense clumps and often growing entirely vegetatively. It fruits from spring to autumn, and its native habitat is reported to be sandy and peaty soils, ditches, pond margins, shallow waters bordering pine-flatwoods, and pine-palmetto scrub. Identification of vegetative (often aquatic) specimens is sometimes tentative.

Entry is likely as the species is traded in Norway. The probability of establishment is assessed as being unlikely, as its natural habitat in the US is classified as a humid subtropical climate according to the Köppen climate classification (Kottek et al., 2006). The capacity for spreading is assessed as being slow. Under current climate conditions and in a 50-year perspective the overall risk of impact on biodiversity and ecosystems is assessed as minimal, as no negative impacts have been reported. The overall risk is assessed to be low for *E. vivipara*, with medium confidence.

Eleocharis vivipara	RISK	CONFIDENCE
ENTRY	**likely**	**medium**
ESTABLISHMENT	**unlikely**	**low**
SPREAD	**slowly**	**medium**
IMPACT	**minimal**	**low**
CONCLUSION	**low**	**medium**

3.2.2.5 Hydrilla verticillata

Hydrilla verticillata (L.f.) Royle is an important aquarium plant species and over 2000 individuals are traded annually in Norway (Fosså, 2010). It is widespread in the temperate and tropical regions of the Eastern Hemisphere. It is considered a noxious plant in the USA and has been introduced in many European countries. This aquatic plant is believed to be native to Africa, and south and southeast Asia (Zhuang, 2011). It is a rooted, submerged macrophyte, with leaves in a whorl. As an apparent survival strategy in conditions that are unfavourable for growth, the plant produces two types of specialized hibernating organs (turions and tubers; Netherland, 1997). *H. verticillata* spreads horizontally by means of branches that grow over the bottom of a waterbody and can sprout new plants from root

fragments or from stem fragments containing as few as two whorls of leaves. In Europe, there is no seed formation because only female flowers are produced. The species thrives in environmental conditions varying from lentic to lotic, eutrophic to oligotrophic, acid to alkaline, with high to low light availability, and tropical to temperate climates (Sousa, 2011). It is assumed that different strains of *H. verticillata* have become adapted to different ecological conditions. This applies particularly to strains that are indigenous in Europe; they have adapted to a temperate climate and to mesotrophic or slightly meso-eutrophic alkaline waterbodies, with a high dominance of bicarbonate (Q-Bank, 2016b). *Hydrilla* is very competitive and has frequently been reported to dominate the native macrophyte communities that it invades and can have deleterious impacts on invertebrates, fish, and waterfowl (Barrientos and Allen, 2008; Rybicki and Landwehr, 2007; Theel et al., 2008). Large stands of *Hydrilla* can interfere with navigation, fisheries, and recreational activities such as swimming, diving, and water-skiing (Langeland, 1996).

Entry is assessed as being likely because the species is imported for trade (Fosså, 2010). It is also available to purchase from vendors on the Internet for use in aquaria. Establishment and spread are assessed as being moderately likely because a number of freshwater habitats in Norway are suitable for *Hydrilla* survival, development, and multiplication, but the species shows optimum growth between 25 and 36°C (McFarland and Barko, 1990; McFarland and Barko, 1999). Impacts should be considered similar to those seen in other countries where the species has invaded and become established. This includes outcompeting native macrophytes, additional effects on different biological communities, and forming dense monospecific stands in water bodies. Under current climate conditions and in a 50-year perspective the impacts are considered major with a medium confidence. The conclusion of the assessment is that *H. verticillata* poses a moderate risk with a medium confidence.

Hydrilla verticillata	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**medium**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**moderately fast**	**medium**
IMPACT	**major**	**medium**
CONCLUSION	**moderate**	**medium**

3.2.2.6 Lagarosiphon major

Lagarosiphon major (Ridley) Moss is used in aquaria as an ornamental plant, and more than 1000 plants are traded in Norway annually (Fosså, 2010). It is a perennial, submerged, rooted, aquatic plant with leaves that alternate spirally along the stems. Outside its native range in southern Africa, only female plants are known and all proliferation is by vegetative reproduction. Male flowers, fruits, and seeds have not been recorded outside of the native range of the species. Numerous adventitious roots, along with rhizomes, anchor the plant in the sediment (Matthews et al., 2012a). *L. major* occurs in lakes, riparian zones, watercourses, and wetlands, with a preference for cooler, clear fresh waters under high light intensities, with silty or sandy bottoms. The species grows in still or slow-moving waters with

low and high nutrient concentrations and can tolerate a high pH (National Heritage Trust, 2003). It forms monospecific stands that often occupy the entire water volume, from the bottom to the surface, outcompete native submerged vegetation, restrict water movement, cut off light, and interfere with recreational activities (McGregor and Gourlay, 2002).

Entry is likely because the species is deliberately imported to Norway for trade (Fosså, 2010). It is also available to purchase from vendors on the Internet for use in aquaria. Establishment is assessed as being moderately likely because a number of freshwater habitats in Norway are suitable for *L. major* survival, development, and multiplication. Spread is assessed as being slowly because in other countries the species has shown a slow spread, and the optimum growth is in water temperatures between 18 and 23° C (Matthews et al., 2012a). Impacts should be considered similar to those seen in other countries where the species has invaded and become established. Dense mats of *L. major* can restrict the passage of boats and limit recreational activities. *L. major* has been reported to outcompete native submerged aquatic vegetation (e.g. Charophytes, *Myriophyllum* spp., *Potamogeton* spp.) and affect associated assemblages of aquatic invertebrates and vertebrates (Caffrey et al., 2010; Keenan et al., 2009; Rattray et al., 1994). Under current climate conditions and in a 50 year perspective the impacts are considered major with a medium confidence. The conclusion is that *L. major* presents a moderate risk with a medium confidence.

Lagarosiphon major	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**medium**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**slowly**	**medium**
IMPACT	**major**	**medium**
CONCLUSION	**moderate**	**medium**

3.2.2.7 Lemna gibba

In Norway, the duckweed *Lemna gibba* L. is used both for garden ponds and aquaria, but is not among the most popular plants and the estimated import volume to Norway is less than 100 shipments per year (Fosså, 2010; batch size not defined). *L. gibba* occurs in all continents, except Antarctica and Australia. It occurs most frequently in areas with Mediterranean climates, particularly throughout the Mediterranean basin, eastern Africa, and southwestern North America (Kumar, 2013). *L. gibba* occurs more or less throughout Europe, reaching as far north as southern Sweden, and being widespread and abundant throughout its European range; it may be increasing due to its ability to exploit waterbodies subject to anthropogenic nutrient enrichment (Lansdown, 2011a). *L. gibba* is a rapidly growing plant found in still or slowly flowing, eutrophic water. In highly eutrophic sites it may form dense masses that exclude other species (Online Atlas of the British and Irish Flora: http://www.brc.ac.uk/plantatlas/index.php?q=plant/lemna-gibba). It reproduces mainly by vegetative budding, although it flowers slightly more frequently than other Lemnaceae. It was once considered as "probably native" in Norway, when it was found in

three nutrient rich ponds in Oslo between 1861-84, but is no longer present here (Lid and Lid, 2005).

In Norway, the species is commercialized for use in aquaria, and the risk of accidental entry is assessed as being likely. The probability of establishment is assessed as moderately likely, as it is common in the milder climate of Skåne in southern Sweden, and rare up to Svealand (Naturhistoriska Riksmuseet, 2003). The capacity for spreading is assessed as moderate. Establishment of *L. gibba* causes changes in ecosystems regarding light availability, and duckweeds can spread rapidly across quiet bodies of water that are enriched in nutrients. Eutrophication may cause this species to become invasive, and the overall risk of impact on biodiversity and ecosystems is assessed as minor. Under current climate conditions and in a 50-year perspective, the overall risk from *L. gibba*, is assessed as being moderate with medium confidence.

Lemna gibba	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**medium**
ESTABLISHMENT	**moderately likely**	**medium**
SPREAD	**moderately fast**	**medium**
IMPACT	**minor**	**medium**
CONCLUSION	**moderate**	**medium**

3.2.2.8 Myriophyllum

The watermilfoil genus, *Myriophyllum*, includes several species that are important in the aquarium plant trade in Norway, and it is estimated that over 5000 individuals are traded annually (Fosså, 2010). Fosså (2010) lists the following species as being included in the commercial aquarium trade in Norway: *Myriophyllum aquaticum* (a South American species that is invasive in both North America and Europe (DAISIE, accessed 2016; Q-Bank, accessed 2016), *M. mattogrossense* Hoehne (a tropical species from Brazil (tropica.com, accessed 2016)), *M. mezianum* Schindl. (a tropical species from Madagascar (Tropicos, accessed 2016)), *M. pinnatum* (Walter) Britton, Sterns & Poggenb. (a temperate species from northeastern to southern US (Aiken, 1981)), *M. propinquum* A.Cunn. (a temperate species from New Zealand, that is invasive in temperate areas in China, Japan, South Korea and Russia (Orchard, 1979; New Zealand's National Institute of Water and Atmospheric Research (NIWA, accessed 2016), *M. simulans* Orchard (a southeastern Australia native (Orchard, 1986)), and *M. tuberculatum* Roxb. (a subtropical species from India to China (Flora of China Editorial Committee, 2007)).

The genus contains about 69 species of freshwater aquatic plants. *Myriophyllum* has a cosmopolitan distribution with its centre of diversity in Australia (> 37 endemics). *Myriophyllum* species are notoriously difficult to identify using vegetative morphology alone, which is commonly all that is available for these highly clonal plants (Moody and Les, 2010).

The following species of *Myriophyllum* are native to Norway, followed by Red List assessment status in parentheses (Henriksen and Hilmo, 2015):*Myriophyllum verticillatum* L. (VU,

Vulnerable), *Myriophyllum spicatum* L. (LC, Least Concern), *Myriophyllum sibiricum* Kom. (LC, Least Concern), *Myriophyllum alterniflorum* DC. (LC, Least Concern).

The widespread invasive alien species of the genus, *M. aquaticum* (Vell.) Verdc., *M. heterophyllum* Michx., and *M. spicatum*, have drawn attention from international natural resource managers (Moody and Les, 2010). DAISIE, EPPO, and Q-Bank include the following established European invasives: *Myriophyllum heterophyllum* (a North American species extending into Ontario, Canada (Aiken, 1981)) and (DAISIE, 2008a; DAISIE, 2008b; EPPO, 2015; Q-bank, 2016a).

Category 2 includes the non-tropical species, *Myriophyllum aquaticum*, *M. heterophyllum*, and *M. quitense*. For full assessments see Appendix II.

Entry for *Myriophyllum aquaticum* is assessed as being very likely as it is commonly traded in Norway. Establishment is assessed as being likely as it is an invasive species, and it appears to survive under the conditions that occur in Norway. Although some populations survive cold winters, the tolerance of this species to cold European winters has not been fully described (NNSS, 2011). Under a warmer climate scenario, the species is assessed as being likely to be able to establish and spread in southern Norway. Impact is considered moderate as infestations alter aquatic ecosystems by shading out algae that serve as the basis of the aquatic food chain (EPPO, 2004). Under current climate conditions and in a 50-year perspective the overall risk is assessed to be moderate for *M. aquaticum* with high confidence.

Myriophyllum aquaticum	**RISK**	**CONFIDENCE**
ENTRY	**very likely**	**high**
ESTABLISHMENT	**likely**	**high**
SPREAD	**moderately**	**high**
IMPACT	**moderate**	**high**
CONCLUSION	**moderate**	**high**

Entry of *M. quitense* is assessed as being likely as the species is traded elsewhere in Europe, and milfoils are recognized as being difficult to identify. The tolerance of this species to cold European winters is not well described (NNSS, 2015). Under a warmer climate scenario, the species might be able to establish in southern Norway. Impact is considered moderate. Under current climate conditions and in a 50 year perspective the overall risk is assessed to be low for *M. quitense* with medium confidence.

Myriophyllum quitense	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**high**
ESTABLISHMENT	**unlikely**	**medium**
SPREAD	**slowly**	**medium**
IMPACT	**minimal**	**medium**
CONCLUSION	**low**	**medium**

Entry for *Myriophyllum heterophyllum* is assessed as being very likely as it is commonly traded in Norway. Establishment is assessed as likely, as this species can tolerate cold winter temperatures and can survive ice cover during the winter months (Brunel et al., 2010). Under a warmer climate scenario, the species would be even more likely to be able to establish in southern Norway. The species can spread rapidly because it is very tolerant of desiccation (Barnes et al., 2013), meaning that hitchhiker fragments are likely to remain viable for prolonged periods, thereby enabling introduction of viable fragments to new locations. Impacts can be major, as dense mats of *M. heterophyllum* reduce light to other submerged plants and can affect water quality by reducing oxygen levels, resulting in fish avoiding the infested area (Hussner, 2015 in EPPO, 2015). *M. heterophyllum* also blocks canals and water control systems, and management options need to be applied to remove the species from these areas (EPPO, 2015). Under current climate conditions and in a 50-year perspective the overall risk is assessed to be high for *M. heterophyllum* with high confidence. EPPO (2015) concludes that *M. heterophyllum* poses an unacceptable risk in the EPPO region; and recommends that *M. heterophyllum* should be included in its list of quarantine pests.

Myriophyllum heterophyllum	**RISK**	**CONFIDENCE**
ENTRY	**very likely**	**high**
ESTABLISHMENT	**likely**	**high**
SPREAD	**rapidly**	**high**
IMPACT	**major**	**high**
CONCLUSION	**high**	**high**

3.2.2.9 Najas guadalupensis

Najas guadalupensis (Spreng.) Magnus is used in aquaria as an ornamental plant, and less than 2000 plants are traded in Norway annualy (Fosså, 2010). It is an annual, growing submerged in aquatic habitat types such as ponds, ditches, and streams. The species is characterized by a high number of subspecies, some of which have been shown to have a hybrid origin. One of these, *Najas guadalupensis* ssp. *guadalupensis*, is native to North, Central, and South America, and it is found as far north as Alberta, Ontario, and Quebec in Canada where it occurs in climate zones similar to those currently in Norway and to a greater extent under climate change scenarios. *Najas guadalupensis* is commercialized in the aquarium trade in Norway, but the subspecies is not specifically mentioned (Fosså, 2010). *N. guadalupensis* has been reported to be an invasive plant in North America, but the subspecies has not been reported to be invasive. Several subspecies of *Najas* are reported to have a hybrid origin, possibly also *N. guadalupensis* ssp. *guadulupensis,* since it is closely related to other subspecies (Les et al., 2010). Since *Najas guadalupensisis* is traded and different subspecies may easily be confused with each other, the species is evaluated here rather than the subspecies.

The likelihood of entry is assessed as being very likely as the species is imported, and establishment of the subspecies is assessed as being moderately likely as the species has been reported to be invasive in parts of North America (unknown subspecies). The likely speed of spreading is assessed as being slow, as it seems not to have particular competitive advantages and is reported to spread slowly in North America. In addition, ecosystem degradation has not been reported for the species, and therefore the likely impact is assessed as being minor. Under current climate conditions and in a 50-year perspective the overall risk is assessed to be low for *Najas guadalupensis*, but with a low confidence level as it is uncertain whether the subspecies *Najas guadalupensis* ssp. *guadalupensis* is imported to Norway, and, if so, the extent of its import.

Najas guadalupensis	**RISK**	**CONFIDENCE**
ENTRY	**very likely**	**medium**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**slowly**	**low**
IMPACT	**minor**	**low**
CONCLUSION	**low**	**low**

3.2.2.10 Najas minor

Najas minor All. is not reported as being traded in Norway (Fosså, 2010). It is native to Europe and western Asia, and has become invasive in USA (first record in 1934). It is compact and bushy, and can grow to more than 1 m in height. It prefers stagnant or slow-moving waters, such as ponds, lakes, and reservoirs. *N. minor* is tolerant of turbid and eutrophic conditions, and can replace native species in these habitats, but Trebitz and Taylor (2007) only found it in a subset of the Great Lakes in USA. The route of introduction of *N. minor* to USA is not clear, as it is not used in aquaria etc., but genetic analyses suggest that multiple introductions have occurred (Les et al., 2015). It may have been accidentally introduced together with other cultivated plants, or it may have been introduced by boat traffic (Les et al., 2015; Stratford and Hoyle, 2011). *N. minor* can form dense, monospecific stands in the shallow waters that may alter the environmental conditions and make them unfavourable for many native species (Stallings et al., 2015). It reproduces by seeds and fragmentation, and is easily spread by boat traffic and currents (Stratford and Hoyle, 2011).

N. minor is not commercialized, but the risk of accidental entry to Norway is assessed as being moderately likely, as it has been introduced to USA by an unknown pathway. The probability of establishment is assessed as being likely, as it is already present in central Europe and has good spreading capacity. The likely speed of spreading is likewise assessed as being moderately fast. The overall risk of impact on biodiversity and ecosystems is assessed as moderate, as some negative impacts have been reported in some habitats in its introduced range in USA. Under current climate conditions and in a 50-year perspective the overall risk is assessed as being moderate for *N. minor*, with medium confidence.

Najas minor	RISK	CONFIDENCE
ENTRY	**moderately likely**	**medium**
ESTABLISHMENT	**likely**	**medium**
SPREAD	**moderately fast**	**medium**
IMPACT	**moderate**	**medium**
CONCLUSION	**moderate**	**medium**

3.2.2.11 Potamogeton

Seven species of *Potamogeton* L. are listed as being traded in Norway according to Fosså (2010): *P. crispus*, *P. dentatus* (syn. for *P. lucens*), *P. gayi*, *P. natans*, *P. perfoliatus*, *P. schweinfurthii*, and *P. wrightii*. Of these, the following are native in Norway: *P. crispus*, *P. lucens* (on the Norwegian Red List as vulnerable), *P. natans*, and *P. perfoliatus*. *Potamogeton* L. is a species-rich genus with a wide and global distribution. In Norway, 15 species are recorded, of which six are on the Norwegian Red List (Artsdatabanken, http://www.artsdatabanken.no/). In tropical or sub-tropical areas around 30 species are found, and in temperate regions (excluding Norway) around 40 species are found. Of these, six species that occur in sub-tropical or temperate areas are also found in Europe, outside Norway (eMonocot, http://www.emonocot.org/). In addition to the high number of species, numerous hybrids are also reported (Kaplan and Fehrer, 2013). Many taxa are very difficult to distinguish from each other on the basis of morphological features alone.

There are few reports of introduced *Potamogeton* species. *Potamogeton crispus* (native to Eurasia, Africa, and Australia) has been reported to be an invasive species in North America and India (Bhatt, 2012; Catling and Dobson, 1985). DAISIE (http://www.europe-aliens.org/) lists four *Potamogeton* species as being introduced in Europe: *P. compressus* (to Hungary), *P. epihydrus* (established in UK in 1907, Online Atlas of the British and Irish Flora), *P. nodosus* (to Luxenbourg), and *P. trichoides* (to Belgium). In addition, *P. lucens* and *P. natans* have been reported as being invasive in India (Bhatt, 2012). Of these, the following are reported to be native in Norway: *P. crispus*, *P. compressus*, *P. trichoides*, *P. lucens* and *P. natans*. *Potamogeton compressus*, *P. trichoides* and *P. lucens* are on the Red List in Norway (Artsdatabanken, http://www.artsdatabanken.no/).

Potamogeton species that are not included in categories 1 and 3 or excluded after completion of Section A modified NAPRA Scheme were subject to full risk assessments. These are: *P. schweinfurthii, P. wrightii, P. epihydrus,* and *P. nodosus.* These species were assessed together and the combined results are presented.

P. schweinfurthii A.Benn., *P. wrightii* Morong, *P. epihydrus* Raf., and *P. nodosus* Poir. share some morphological similarities with *P. natans* (already present in Norway) and may possibly be confused with this taxon. *P. schweinfurthii* and *P. wrightii* are commercialized in the aquarium trade in Norway, and all four taxa may possibly be for sale for use in garden ponds. Only *P. enhydrus* is reported to be an alien in UK, but it has not been reported to be spreading rapidly or to be invasive (i.e., to threaten biodiversity or ecosystems). Establishment is therefore assessed as being unlikely, and the likely speed of spreading is

assessed as being slow as there are no reports of rapid spreading. The likelihood of a negative impact is assessed as being minimal for all four taxa as negative impacts have not been reported elsewhere. Under current climate conditions and in a 50-year perspective the overall risk is assessed as being low for *P. schweinfurthii* A.Benn., *P. wrightii* Morong, *P. epihydrus* Raf. and *P. nodosus* Poir., with medium confidence.

***Potamogeton* cf above**	**RISK**	**CONFIDENCE**
ENTRY	**moderately likely**	**medium**
ESTABLISHMENT	**unlikely**	**medium**
SPREAD	**slowly**	**low**
IMPACT	**minimal**	**medium**
CONCLUSION	**low**	**medium**

3.2.2.12 Salvinia natans

Salvinia natans (L.) All. is used in aquaria and ponds as an ornamental plant, and less than 1000 plants are traded annually in Norway (Fosså, 2010). Fosså (2010) reports that the majority of plants imported into Norway are from cultivation in Denmark, the Netherlands, Singapore, and Sweden. The species is used as an ornamental plant in garden ponds but is traded less frequently than other *Salvinia* species (Lansdown, 2013b). It is a free-floating fern, growing in large populations at the surface of stagnant waters or in weak currents, such as in ditches, canals, ponds, and oxbows. It is often associated with Lemnaceae and other floating plants. It is considered as an annual in the wild, but can be perennial when grown under conditions of artificial cultivation (Lansdown, 2013b). *S. natans* is an Eurasiatic (palaeotemperate) species, essentially located in central and eastern Europe and Asia, from the Caucasus to China and Japan. In Europe, it is sparsely distributed from the Rhine valley (Germany) to Russia, and southwards, from northern Italy to the Danube basin towards the Black Sea, and to northern Greece. The species appears to be declining throughout much of its European range with some local extinctions, but the cause of the decline is not known (Lansdown, 2013b). It is exceptional and very unstable westwards in Belgium, France, and in northwestern Spain. It occurs in the following Mediterranean countries, among others: France, Greece, Croatia, Italy, and Spain (Lansdown, 2013b). It does not normally occur in Scandinavia. Only a single find of *Salvinia natans* has been reported from Scandinavia, and this concerned a temporary or residual specimen (Artsdatabanken, 2016).

Entry is assessed as being likely as the species is in the aquarium and pond plant trade. Establishment is assessed as being unlikely as despite the species being in trade, only a single transient establishment has been recorded from southern Sweden (Artdatabanken, 2016). Spread is assessed as being likely to occur very slowly, as this population has not spread, and the species remains extremely rare (Artdatabanken, 2016). The impact is assessed as being minimal as no negative impacts of this species are known. Under current climate conditions and in a 50-year perspective the overall risk is assessed to be low for *S. natans* with high confidence.

Salvinia natans	RISK	CONFIDENCE
ENTRY	**likely**	**high**
ESTABLISHMENT	**unlikely**	**high**
SPREAD	**very slowly**	**high**
IMPACT	**minimal**	**high**
CONCLUSION	**low**	**high**

3.2.2.13 Trapa natans

Trapa natans L. is traded on a small-scale in Norway for use in aquaria, with fewer than 500 plants traded annually (Fosså, 2010). It is a floating annual aquatic plant, growing in slow-moving water up to 5 m deep, native to warm temperate parts of Eurasia and Africa. It formerly occurred in Sweden, but was last reported in 1916 and has since been extinct (Naturhistoriska Riksmuseet, 1999). *T. natans* is native to Eurasia and Africa and is partly cultivated for its edible nuts. The species was formerly widespread in continental Northern Europe, particularly during the sub-boreal period. It should not be confused with the Chinese water chestnut, an *Eleocharis* species (*E. dulcis*) with edible corms. Globally, the species is considered as being of Least Concern (Lansdown, 2011b), but according to Hummel and Kiviat (2004) it is of conservation concern in Europe and Russia, and is on some regional and national Red Lists in Europe. The species is known to be a serious pest in other parts of the world (including northeastern USA), and, given climate change, it is not impossible that the species could exhibit a higher degree of invasiveness in the future, including in Norway.

Entry is assessed as being very likely as the species is currently commercialized on a small scale. The probability of establishment is assessed as being unlikely, as it is in decline in Europe as a whole, and there are currently no signs of a sudden spread in Scandinavia. The speed of spreading is assessed as being likely to be moderate, considering climate change scenarios and invasiveness in the USA. The overall risk of impact on biodiversity and ecosystems is assessed as being moderate, since it is crowds out native species in its non-native range (Fofonoff et al., 2003). Under current climate conditions and in a 50-year perspective the the overall risk for *T. natans* is assessed as being moderate with medium confidence.

Trapa natans	RISK	CONFIDENCE
ENTRY	**very likely**	**medium**
ESTABLISHMENT	**unlikely**	**low**
SPREAD	**moderately fast**	**low**
IMPACT	**moderate**	**low**
CONCLUSION	**moderate**	**medium**

3.2.2.14 Vallisneria spiralis

Vallisneria spiralis L. is used in aquaria as an ornamental plant, and more than 5000 plants are traded annually in Norway (Fosså, 2010). It is native to Africa, north and south of the Sahara, from Europe east through the Caucasus and the Middle East to Kazakhstan, the

Indian Sub-continent, Myanmar, and Thailand. *V.spiralis* is a submerged macrophyte, possessing strap-shaped leaves, up to 1 m long. It can be found in static or flowing freshwater habitats, including lakes, ponds, watercourses, and wetlands, with a minimum temperature of 5° C (Collas et al., 2012). In central and western Europe the species only occurs in geothermally heated waterbodies, which are relatively rare habitats (Ejsmont-Karabin and Hutorowicz, 2011; Hussner and Lösch, 2005). *V. spiralis* is able to reproduce vegetatively and can disperse via water (hydrochory), humans, and bird vectors, displaying a strong reproductive potential (Hussner and Lösch, 2005; Van Leeuwen, 2012). Impacts reported up to now include displacement of native macrophytes, effects on the drainage of different waterbodies, and effects on recreational use of waterbodies (CABI, 2012; Ejsmont-Karabin and Hutorowicz, 2011).

Entry is assessed as being likely because the species is a common aquarium plant in Norway (Fosså, 2010). Establishment and spread are unlikely and very slow, respectively, as *V. spiralis* only occurs in thermally abnormal freshwater habitats in central and western Europe and similar waterbodies are not present in Norway today or in a 50-year perspective. However, the species may become naturalized in central and western Europe if, due to global warming, average water temperatures increased by as little as only one or two degrees. The impact is assessed as being moderate, as although *V. spiralis* has completely displaced native submerged macrophytes in heated lakes in Poland (Babko et al., 2010; Ejsmont-Karabin and Hutorowicz, 2011), this is unlikely to occur in Norway. Under current climate conditions and in a 50-year perspective, the overall risk for *V. spiralis* is assessed to be low with medium confidence.

Vallisneria spiralis	**RISK**	**CONFIDENCE**
ENTRY	**likely**	**high**
ESTABLISHMENT	**unlikely**	**medium**
SPREAD	**very slowly**	**low**
IMPACT	**moderate**	**medium**
CONCLUSION	**low**	**medium**

3.2.2.15 Wolffia arrhiza

Wolffia arrhiza (L.) Horkel ex Wimmer is traded in Norway for use in aquaria, but it is estimated that less than 100 individual shipments are imported each year (Fosså, 2010; batch size not defined, but one individual is about 1 mm across). It is an aquatic plant that grows in quiet water bodies such as ponds. It is native to Europe, Africa, western Asia and possibly Brazil. It is not known to be invasive (DAISIE, 2008c). *Wolffia arrhiza* (L.) Horkel ex Wimmer is the smallest European vascular plant. It was recently found in Sweden as a new species for the Nordic countries, but was suggested to have spread naturally to Scandinavia by bird-mediated dispersal (Ljungstrand, 2013).

The risk of entry is assessed as being moderately likely. The probability of establishment is assessed as being moderately likely, as it has established in the milder climate of southern Sweden. The speed of spreading is likewise assessed as being moderately fast. The overall

risk of impact on biodiversity and ecosystems is assessed as being minor, as it is not known to be invasive anywhere. Under current climate conditions and in a 50-year perspective the overall risk for *W. arrhiza* is assessed to be low with medium confidence

Wolffia arrhiza	**RISK**	**CONFIDENCE**
ENTRY	**moderately likely**	**low**
ESTABLISHMENT	**moderately likely**	**low**
SPREAD	**moderately fast**	**low**
IMPACT	**minor**	**low**
CONCLUSION	**low**	**medium**

3.3 Category 3. Species native to Norway

Taxa in **Category 3** are native to Norway, and these taxa can therefore obviously survive under Norwegian conditions. If escaped plants come into contact with native plants then it is likely that they will be able to reproduce with native plants or spread vegetatively through local populations. As part of the assessment of negative impact on native biodiversity, the impact of introgression of novel genetic material on native populations and the risk for loss of genotypes adapted to local environments were assessed, while taking into account the likelihood of escaped plants meeting native populations, for both common and Red-Listed species. Based on the screening of these variables, it was concluded for the species in category 3 that the import of these species could have a negative impact on Norwegian biodiversity, specifically regarding impacts on ecosystems and other species. The threat of introgression on native populations of red-listed species is lower than that for non red-listed species, due to the lower likelihood of encounter, but could be potentially threatening to these species. In summary, category 3 taxa pose a potential danger to Norwegian biodiversity, but the risk is low with moderate confidence. It should be noted that several of these species are not traded in the aquarium and pond plant trade in Norway, but part of entire genera that were included on the ToR Annex 1.

3.3.1 Taxa occurring in Norway and *not included* on the Norwegian Red List

The following species from Annex 1 in the Terms of Reference occur as native species in Norway and are not listed on the Norwegian Red List. It should be considered that several of these species are not traded in the aquarium and pond plant trade in Norway, but part of entire genera that were included on the ToR Annex 1. This is the case for *Isoëtes echinospora* Durieu*, I. lacustris* L., *Myriophyllum spicatum* L., *M. sibiricum* Kom.*, M. alterniflorum* DC.*, Potamogeton alpinus* Balb.*, P. berchtoldii* Fieber*, P. gramineus* L.*, P. obtusifolius* Mert. & W.D.J.Koch*, P. polygonifolius* Pourr.*, P. praelongus* Wulfen, *Utricularia intermedia* Hayne*, U. minor* L.*, U. xochroleuca* R.W.Hartm*, U. stygia* G.Thor*,* and *U. vulgaris* L. The following species are one of several species in a genus that are traded in Norway:

Eleocharis vivipara Link*, Eleocharis acicularis* (L.) Roem & Schult. Lastly, *Acorus calamus* L.*, Calla palustris* L.*, Ceratophyllum demersum* L.*, Lemna minor* L.*, L. trisulca* L.*, Littorella uniflora* (L.) Ascherson*, Nymphaea alba* L.*, Potamogeton crispus* L.*, P. natans* L., *P. perfoliatus* L.*, Ranunculus aquatilis* L., and *Spirodela polyrrhiza* (L.) Schleid. are traded in Norway. Under current climate conditions and in a 50-year perspective the overall risk for these species is assessed to be low with moderate certainty:

Taxa occurring in Norway and not included on the Norwegian Red List
Acorus calamus L.
Calla palustris L.
Ceratophyllum demersum L.
Eleocharis vivipara Link
Eleocharis acicularis (L.) Roem & Schult.
Isoëtes echinospora Durieu
I. lacustris L.
Lemna minor L.
L. trisulca L.
Littorella uniflora (L.) Ascherson
Myriophyllum spicatum L.
M. sibiricum Kom.
M. alterniflorum DC.
Nymphaea alba L.
Potamogeton alpinus Balb.
P. berchtoldii Fieber
P. crispus L.
P. gramineus L.
P. natans L.
P. obtusifolius Mert. & W.D.J.Koch
P. perfoliatus L.
P. polygonifolius Pourr.
P. praelongus Wulfen
Ranunculus aquatilis L.
Spirodela polyrrhiza (L.) Schleid.
Utricularia intermedia Hayne
U. minor L.
U. xochroleuca R.W.Hartm
U. stygia G.Thor
U. vulgaris L.

3.3.2 Taxa occurring in Norway and *included* on the Norwegian Red List

The following species from Annex 1 in the ToR occur as native species in Norway and are included on the Norwegian Red List. The Norwegian Red List category is indicated for each species (Near threatened, NT; Vulnerable, VU; Endangered, EN). It should be considered that several of these species are not traded in the aquarium and pond plant trade in Norway, but part of entire genera that were included on the ToR Annex 1. This is the case for

Myriophyllum verticillatum L., *Potamogeton compressus* L., *P. friesii* Rupr., *P. lucens* L., *P. pusillus* L., *P. rutilus* Wolfg., *P. trichoides* Cham. & Schltdl., and *Utricularia australis* R.Br. The following species are one of several species in a genus that are traded in Norway, but less significant for trade than the other species: *Elatine triandra* Schkuhr, *Eleocharis parvula* (Roem & Schult.) Link ex Bluff, Nees & Schauer, and *Najas marina* L. Lastly, *Hydrocharis morsus-ranae* L., *Lemna trisulca* L., and *Riccia fluitans* L. are traded in Norway. Under current climate conditions and in a 50-year perspective the overall risk for these species is assessed to be low with moderate certainty:

Taxa occurring in Norway and included on the Norwegian Red List
Elatine triandra Schkuhr – NT
Eleocharis parvula (Roem & Schult.) Link ex Bluff, Nees & Schauer – VU
Hydrocharis morsus-ranae L. – EN
Lemna trisulca L. – NT
Myriophyllum verticillatum L. – VU
Najas marina L. – EN
Potamogeton compressus L. – EN
P. friesii Rupr. – NT
P. lucens L. – VU
P. pusillus L. – EN
P. rutilus Wolfg. – NT
P. trichoides Cham. & Schltdl. – EN
Riccia fluitans L. – NT
Utricularia australis R.Br. - VU

3.4 Introduction of harmful hitchhiker organisms, including pathogens and parasites

Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, were assessed for all species. As part of the assessment all taxa included in the ToR were investigated for their capacity to act as vectors for harmful hitchhiker organisms, including pathogens and parasites.

In general, little is known about harmful hitchhiker organisms associated with aquatic IAS, and even less about those associated with aquatic IAS that have spread and established as a result of the aquarium and pond plant trade. None of the plant species in the ToR are reported to have acted as vectors for harmful hitchhiker organisms, including pathogens and parasites. The risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites for species in the ToR Annex I are considerd low with moderate certainty.

4 Risk reducing measures

Banning the import and sale of invasive aquatic plants via the plant trade and creation of awareness among aquatic plant hobbyists and water managers are probably the most effective methods for controlling the introduction and spread of invasive plant species. Although banning the import and sale of aquatic IAS would probably be effective to some extent and reduce much of the trade in outlawed species, it could lead to antipathy among hobbyists, who could easily continue to exchanging material and import banned species by making arrangements via the Internet. Implementation of a ban would concurrently require implementation of a method for ensuring that the ban is followed, and a schedule of punitive measures for those who do not abide by the ban. The main advantage of creating awareness among hobbyists is that it provides the opportunity for collaboration with trade organizations and retailers through positive dialogue. Such collaboration could reduce the risks to Norwegian biodiversity associated with aquatic IAS while simultaneously creating goodwill among traders and users.

One option that would be a compromise between banning trade and relying on trade organizations, such as NZB, to inform retailers and hobbyists about the potential dangers of aquatic invasive alien species, is adoption of a code of conduct for trade organizations and retailers. Two examples of such codes of conduct that are already in place is one that has been signed by stakeholders in the Netherlands to prevent the introduction and spread of aquatic invasive plant species (Convenant waterplanten, 2010), and the Council of Europe Code of Conduct on horticulture and invasive alien plants (Heywood and Brunel, 2008).

The Dutch example is a voluntary agreement between the government and the horticulture sector (i.e., plant nurseries and retailers) with the objective of preventing the sale of invasive species and increasing public awareness and stakeholder involvement in measures to avert new introductions of potential invaders. The Dutch Code of Conduct includes two appendices, one that lists species that should not be traded or sold, and one that lists species that should only be sold with accompanying additional information about the potentially harmful effects of these species on Dutch biodiversity. Public outreach campaigns have included flyers and posters displayed in stores, and labelling of non-native plant species with warning logos and messages on harmful effects and appropriate disposal (Verbrugge et al., 2014). In the period 2010-2012, the Netherlands Food and Consumer Product Safety Authority (NVWA) monitored compliance of retailers and producers concerning species on sale and proper labeling, and found limited availability of information and a lack of knowledge among sales personnel regarding the species lists issued in the code of conduct to be major impediments for their engagement. Furthermore, a low frequency of meetings and a lack of guidance were major obstacles identified by the signatory partners to the code of conduct. Overall, compliance with the prohibited species (appendix 1) showed promising results, but for the other species (appendix 2) the results were less clear-cut.

In Norway, registered pet shops run regular campaigns on various aspects of responsible keeping of the plants and animals in which they trade, including background information on which species are legal and why, and about the consequences of releasing non-native organisms into natural ecosystems (Fosså, 2010). Providing clear information to customers and other stakeholders regarding the potential risks associated with deliberate release of specific plants or animals could reduce the probability of this occurring. It is important to raise awareness of the different species, including publicity regarding their identification and their impacts on the aquatic habitats. In addition, providing alternatives to the IAS may reduce their likelihood of purchase. Funding of awareness campaigns for specific relevant target groups may reduce the risk of release of aquatic invasive plants.

5 Uncertainties

Assessing the risk of entry, establishment, spread, and potential impact of species not occurring in Norway is not straightforward, and inherently full of uncertainties. Some uncertainty is attached to the occurrence of scientific literature on IAS, or the scientific quality of existing literature. For example, in some cases invasiveness of species may not have been investigated or determined. With regard to each of the risk categories, these can be assessed by likelihood, but a specific likelihood also has an associated confidence level. In this report the uncertainties can be grouped into four major categories: 1) Uncertainties related to taxonomy and nomenclature; 2) Uncertainties relating to climatic tolerance and niche; 3) Uncertainties relating to habitat requirements, and ecological and biological characteristics; and 4) Uncertainties relating to hitchhiker organisms, including pathogens and parasites.

5.1 Taxonomic and nomenclatural uncertainties

Taxonomic uncertainties occur among some of the taxa screened. These can be due to: lack of clarity regarding whether natural populations belong to one or more species, e.g., such as might be the case with aberrant or geographically isolated populations that have been described as separate species in the past; morphological identification challenges, e.g., in many cases species are simply hard to identify, for instance because flower/fruit characteristics are absent and needed for correct identification; and lastly uncertainties can be related to lack of concordance between experts on how to delimit specific species.

There were a few taxonomic and nomenclatural uncertainties for the taxa screened. These include, for example: *Acorus calamus* for which the taxonomic position of various cytological taxa within *A. calamus* have been contested, but there seems to be a morphological overlap between different varieties and they are generally treated as one species; *Elatine triandra* for which the taxonomy of the entire genus is somewhat controversial due to widespread phenotypic plasticity, and only few robust morphological characters exist for taxonomic classification; *Ranunculus aquaticus* for which a large number of species names have been synonymized, which suggests large phenotypic plasticity and may mean that outdated synonyms are used in commercial trade.

A number of aquatic invasive alien species are hard to identify using morphology, and several studies have highlighted the potential of mislabelled material (Ghahramanzadeh et al., 2013; Moody et al., 2008; Van De Wiel et al., 2009). Taxonomically distinct species may be misidentified and confused. The risk assessments here have attempted to adhere to the scientific names used in trade, but it is important to be aware of that due to misidentifications, other species could actually be traded. This introduces some uncertainty, the extent of which is difficult to estimate, but can be expected to be greaest for taxa with close morphological similarity.

5.2 Uncertainties relating to climatic tolerance and niche

The initial screening of taxa analysed in this report is based on climate conditions in past and current distribution areas as well as inferred climatic tolerances of the organisms. For the majority of the taxa, information on their biology and ecology is limited. In this assessment, distributions for a number of species were poorly known or uncertain, making it difficult to assess whether a species has established permanently in regions with climates similar to those occurring in the risk assessment area. Thus, for many organisms there is uncertainty related to whether or not they can establish populations under Norwegian conditions. Furthermore, although aspects of the climatic conditions of the current distribution area of some taxa suggest that they could survive in Norway, there is uncertainty relating to the organisms' tolerance for frost, precipitation, wide temperature fluctuations, and length of growing season. These add further uncertainty to the assessment of whether escaped or released specimens would be able to survive and reproduce under Norwegian conditions.

5.3 Uncertainties relating to habitat requirements, ecological and biological characteristics

Several environmental factors affect the probability of a species being able to establish and spread in new environments. In general, a species distribution is determined by the combination of climate conditions and the availability of additional necessary resources. The lack of information regarding these aspects of an individual species' ecology introduces uncertainties regarding their ability to establish and spread. This uncertainty is compounded by poor knowledge of the biology and ecology of many taxa, making it difficult to assess the probability of establishment, spread, and impact of taxa should they enter the risk assessment area. For the most invasive taxa, the amount of information published is relatively extensive (see chapter 1). However, for taxa that have not been reported to be invasive, there is generally very little available information about reproductive ability, spreading rate, or ecological impact. As investigations on many of these species are lacking, there is uncertainty regarding whether they have the potential to become invasive under specific circumstances, such as following an accidental introduction to another region.

Another aspect addressed in this assessment was the possible impact on native species of introductions of non-native genetic material of the same species. For native species that are on the Red List in Norway, protective measures are required. However, species that are not on the Red List may also only be present in small populations, and there is some uncertainty regarding the impact of novel genetic material on these populations. The novel genetic material may be adapted to habitat requirements, and ecological and biological conditions in the species' original distribution, and the native material may be adapted to conditions in Norway. It is therefore difficult to assess the possible impact of such invasions, as there is uncertainty regarding both the invasiveness of the incoming material and the genetic composition of the native material.

5.4 Uncertainties related to hitchhiker organisms, including pathogens and parasites

Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, were assessed for all species. In general, little is known about harmful hitchhiker organisms associated with aquatic IAS and even less about those associated with aquatic IAS that have spread and established as a result of the aquarium and pond plant trade. None of the plant species included in the ToR are reported to have been vectors for harmful hitchhiker organisms, including pathogens and parasites.

6 Answers to the Terms of Reference

The terms of reference of the risk assessment requested by the Norwegian Environment Agency are answered by VKM as follows:

The NEA requested VKM to undertake an assessment of the risks of negative impacts on biodiversity in Norway resulting from the import and keeping of selected species of freshwater plants for aquaria and garden ponds. The species and taxa in question are listed in Annex I.

The main issues to be included in the assessment of the risks of negative impacts on biodiversity, in a 50-year perspective, were:

I. Species survivability under Norwegian conditions
II. Possible negative impacts on ecosystems and other species (including transfer of genetic material to native populations)
III. Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites

All taxa in Annex I (included as Appendix I to this report) of the ToR were assessed using specific screening. In the preliminary screening all taxa were classified into three categories based on their past and current distributions, and the following actions were undertaken for each category:

Category 1: Taxa occurring in tropical climates. In stage 2, these taxa were individually assessed for their ability to survive below 5° C. Taxa that can survive below 5° C were transferred to category 2.

Category 2: Taxa occurring in temperate and continental climates. In stage 2, these taxa were individually assessed using the modified two-stage NAPRA Scheme. Species for which there is no evidence from their non-native distribution areas that they exhibit characteristics of invasiveness were not assessed beyond section A, and all other species were fully risk assessed using both section A and B of the scheme.

Category 3: Taxa occurring naturally in Norway. These taxa were assessed as a group to evaluate the risk of vegetative spread through native population and the risk of introgression to natural populations.

Taxa in category 1 are thermophilic species that are not expected to survive below the cut-off temperature of 5° C, and, in Norway, are only expected to survive if grown inside or outside in heated ponds or effluents, or under conditions of extreme climatic change (>RCP 8.5). These taxa were individually screened to determine their ability to survive below 5° C, but not subjected to full risk assessment. In summary, all taxa in category 1 were assessed as posing a low risk to Norwegian biodiversity.

Taxa in category 2 occur in temperate and continental climates (Köppen-Geiger climate classification) and all were assessed using the modified NAPRA Scheme. This assessment consisted of two sections, Section A and Section B. Based on the results of the Section A

assessments, species for which there is no evidence from their non-native distribution areas that they exhibit characteristics of invasiveness were assessed as posing a low risk to Norwegian biodiversity. The risk to Norwegian biodiversity from import of species in this category was assessed as being low. All species in category 2 that were not excluded based on the criteria above were subjected to a full risk assessment using section B of the modified NAPRA Scheme.

Taxa in category 3 are considered to be indigenous in Norway and can obviously survive and establish under Norwegian conditions. It should be noted that several of these species are not traded in the aquarium and pond plant trade in Norway, but are part of entire genera that were included on the ToR Annex 1. If imported plants escape or are released and come into contact with native plants then it is likely that these will be able to reproduce with native plants or spread vegetatively through local populations. The impact of novel genetic material on native populations is difficult to predict, but confers a risk of loss of genotypes that are adapted to local environments. However, the likelihood of escaped plants coming into contact with native populations is assessed as being low, especially for species on the Red List. In summary, category 3 taxa pose a potential hazard to Norwegian biodiversity, but the risk is still assessed as low.

The risks of negative impacts on Norwegian biodiversity stemming from the import and keeping of taxa on Annex I of the ToR were assessed per category as follows:

Category 1: Taxa occurring in tropical climates. **Low risk**, as these are thermophilic species that cannot survive below 5° C. These taxa will only survive inside or outside in heated ponds or effluents, or under climatic change exceeding RCP8.5.

Category 2: For species for which there is no evidence from their non-native distribution areas that they exhibit characteristics of invasiveness, there is a **low risk**. For all other taxa a **specific risk** per taxa has been derived (see box below) based on the Section B risk assessments.

Category 3: Taxa occurring naturally in Norway. **Low risk.**

The Section B full risk assessments of species in category 2 not excluded after the Section A assessments provide taxon-specific answers to theToR, as outlined in the box below.

Category 2: Modified NAPRA Section B Individual full risk assessments:		
Species	**Risk**	**Confidence**
Ceratophyllum submersum	Low	High
Crassula helmsii	**High**	**Medium**
Egeria densa	Moderate	Medium
Eleocharis vivipara	Low	Medium
Hydrilla verticillata	Moderate	Medium
Lagarosiphon major	Moderate	Medium
Lemna gibba	Moderate	Medium
Myriophyllum aquaticum	Moderate	High
Myriophyllum heterophyllum	**High**	**High**
Myriophyllum quitense	Low	Medium
Najas guadalupensis	Low	Low
Najas minor	Moderate	Medium
Pomatogeton schweinfurthii, *P. wrightii, P. epihydrus and P. nodosus*	Low	Medium
Salvinia natans	Low	High
Trapa natans	Moderate	Medium
Vallisneria spiralis	Low	Medium
Wollfia arrhiza	Low	Medium

Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, were assessed for all species. In general, little is known about harmful hitchhiker organisms associated with aquatic IAS and even less about those associated with aquatic IAS that have spread and established as a result of the aquarium and pond plant trade (Chapter 5.4 and Chapter 7). None of the plant species in the ToR have been reported to act as vectors for harmful hitchhiker organisms, including pathogens and parasites, and we assess this risk to be low to Norwegian biodiversity.

The effects of climate beyond a 50-year perspective (Ch 8.1) and the potential negative impacts on biodiversity of the exporting country (Ch 8.3) are reported in chapter 8. No immediate risks associated with climate change beyond a 50-year perspective were identified for species in category 3. However, it should be stressed that climate change beyond a 50-year perspective will ameliorate the risks assessed for species in category 2, and necessitate reassessment of risks for species in category 1. The potential of negative impacts on biodiversity in the exporting country for aquatic plants in the aquarium and pond trade exists, but practically all species currently traded in the aquarium and pond plant trade in Norway originate from cultivation.

Conclusions

Responding to the ToR, and specifically to the assessment of the risks of negative impacts on biodiversity with regard to: I) Species survivability under Norwegian conditions; II) Possible negative impacts on ecosystems and other species; and III) Possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, the following conlclusions have been reached:

All species in categories 1 and 3, and those in category 2 that do not have any characteristics of invasiveness where they occur, have limited distributions in Europe, and among the alien species in Europe have only non-established populations, pose a low risk to Norwegian biodiversity with regard to points I-III above.

It is important to note that while there is a possibility that Red-listed species in Category 3 could cause negative effects on Norwegian biodiversity by transferring novel genetic material to locally adapted genotypes found in native populations, this would require that the plants escaped from the aquarium/garden pond, established, spread and subsequently came into contact and hybridized with native populations. VKM conclude that the probability that such events will occur is low, and therefore still concludes that the risk to Norwegian biodiversity from import and hold of category 3 species is low.

For the species in category 2 that were fully risk assessed with the modified NAPRA form, it is concluded that *Crassula helmsii* and *Myriophyllum heterophyllum* pose a high risk with respectively medium to high confidence to Norwegian biodiversity with regard to points I-III above. In addition, *Egeria densa*, *Hydrilla verticillata*, *Lagarosiphon major*, *Lemna gibba*, *Myriophyllum aquaticum*, *Najas minor*, *Trapa natans* pose a moderate risk with medium to high confidence depending on the species to Norwegian biodiversity with regard to points I-III above. All other species pose a low risk with low to high confidence, depending on the species, to Norwegian biodiversity with regard to points I-III above.

7 Data gaps

Assessing the risk of entry, establishment, and spread of species not occurring in the risk assessment area will always involve uncertainties, as data on invasion by those species does not (yet) exist. However, considerable literature and information is available for most species assessed as part of this request from the NEA, and, for most species, the assessments are based on ample evidence.

Some data gaps, as follows, exist, especially for poorly known species or subspecies:

- There is a need for more information on species occurrence in order to assess whether a species has permanently established in climates similar to those found in the risk assessment area (Norway).

- Data on the biology and ecology of many taxa are required in order to assess which impacts a species might exert if it invades the risk assessment area.

- A number of species are difficult to identify using morphology alone, and several studies on species in trade have shown that such material is often mislabelled. There is a need for general taxonomic data for most species assessed in this report.

- There is a need for data on the consequences of genetic introgression from non-native populations in trade on species already present in Norway.

- With regard to the possible risks caused by the introduction of harmful hitchhiker organisms, including pathogens and parasites, it should be noted that little is known about harmful hitchhiker organisms associated with aquatic IAS, and even less about those associated with aquatic IAS that have spread and established as a result of aquarium and pond plant trade.

8 Additional information

The ToR requests that any known negative effects on biodiversity of the exporting country be stated in the report. Furthermore, any known effects on ecosystem services should be mentioned. In cases where taxa are likely to affect ecosystem services or may be particularly affected by climate change beyond the specified timeframe, this should be stated in the report. These factors should, however, not be included as a part of the actual risk assessment.

8.1 Impact of climate beyond a 50-year perspective

Climate change during the next 50 years could result in warmer climates in Norway, and species currently occurring south of Norway could spread northwards under such milder conditions and pose a risk to Norwegian biodiversity. A warmer climate would increase the risk of invasion, establishment, and spread of all the species occurring in temperate climates, but currently not established in Norway. The effects of climate beyond a 50-year perspective are difficult to predict, and depend on factors such as development and prevalence of sustainable energy sources, climate change mitigation, sustainable ecosystem services, and population growth. During the preparation of this risk assessment, no immediate risks associated with climate change beyond a 50-year perspective were identified for species in category 3. However, it should be stressed that climate change beyond a 50-year perspective will ameliorate the risks assessed for species in category 2, and necessitate reassessment of risks for species in category 1.

8.2 Ecosystem services

Human wellbeing depends on wide array of benefits derived from natural ecosystem processes, such as production of materials for food, shelter, or medicine, provision of clean water and clean air, nutrient cycling, and flood regulation (Hassan et al., 2005; McLaughlan et al., 2014). Hence there are growing worries about the potentially wide-reaching impacts of invasive non-native species (Gutiérrez et al., 2014; Simberloff and Von Holle, 1999; van Wilgen et al., 2008). However, the direct and indirect consequences of invasive species are difficult to measure, and even more difficult to predict (Lockwood et al., 2013; Simberloff, 2011; Simberloff, 2013). Indeed, a recent review of impacts on ecosystem services of Europe's 10 worst invasive species concluded that there were few well-documented negative effects, and that a number of species were positive for ecosystems and human wellbeing, e.g., bivalves that improve water quality (McLaughlan et al., 2014). However, the negative effects of many aquatic invasive plants are well known. For example, *M. heterophyllum* blocks canals and water control systems, forcing management options to be applied to remove the species from these areas (EPPO, 2015). In the USA, *M. heterophyllum* has been recorded as reducing house price values by 20-40 % when the species grows along lakeshores (Halstead et al., 2003). In Germany, dense stands occurring in shallow lakes in

the vicinity of Dusseldorf have been regularly cut in summer using a weed cutting boat without any long-term effect (Hussner et al., 2005; Hussner and Krause, 2007). Mechanical control of *M. heterophyllum* in these lakes, where 190 tonnes of fresh weight was removed, cost in the region of 45,000 € (Hussner and Krause, 2007). In the Netherlands, management of this invasive species is estimated at 100.000 – 1.000.000 euros/year (Verbrugge et al., 2015). Negative impacts of aquatic invasives on ecosystem services can be severe, and limiting entry of these species seems to be the most effective measure to avoid escalating management costs.

8.3 Negative impacts on biodiversity in the exporting country

The potential of negative impacts on biodiversity in the exporting country for aquatic plants in the aquarium and pond trade exists, but the majority of the traded material in Norway is derived from cultivated stock. Many aquatic plants are easy to propagate vegetatively, thus limiting the need to harvest material from the wild.

The taxa listed in the ToR include no species listed on CITES appendices I and II. They do include a number of species that are in global, regional, national or IUCN Red Lists. However, NZB (Fosså, 2010) reports that practically all species currently included in the Norwegian aquarium and pond plant trade originate from cultivation. This implies that the volume of trade in wild harvested species is minimal, if any, and the risk of negative impacts on biodiversity in the exporting country is assessed as being low.

It cannot be ruled out that there is a minority of hobbyists that is interested in the possession of rare and endangered species from natural populations, but this is a group of people that is hard to stop through import regulations, as material in international trade could be unmarked or intentionally mislabelled.

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Appendix I

List of taxa included in the Terms of Reference (Annex I).

Plantae	**Planter; Plants**	
Ricciaceae	**Gaffelmosefamilien**	
Riccia fluitans L.	Vassgaffelmose; Crystalwort	
Pteridophyta (Divisjon)	**Karsporeplanter; Ferns**	
Salviniaceae		
Salvinia molesta D.S. Mitchell	Giant Salvina	
Salvinia natans (L.) All.	Floating Watermoss	
Lycopodiophyta (Divisjon)	**Kråkefotplanter; Lycopods**	
Isoetaceae	**Brasmegrasfamilien; Quillworts**	
Isoëtes spp. L.	Alle arter brasmegras; Quillworts - All species	
Angiospermae (Klasse)	**Dekkfrøede planter; Flowering Plants**	
Acoraceae	**Kalmusrotfamilien; Sweet-Flag family**	
Acorus calamus L.	Kalmusrot; Sweet Flag	
Araceae	**Myrkonglefamilien; Arum family**	
Calla palustris L.	Myrkongle; Bog Arum	
Lemna spp. L.	Andematslekten, Duckweeds	Kun de 3 arter som er listet i Fosså- rapporten: Lemna gibba Lemna Minor Lemna trisulca
Spirodela polyrrhiza (L.) Schleid	Stor andemat; Greater Duckweed	
Wolffia arrhiza (L.) Horkel ex Wimm.	Rootless Duckweed	

Ceratophyllaceae	**Hornbladfamilien; Hornwort family**	
Ceratophyllum spp. L.	Alle arter i hornbladslekten; Hornworts – All species	
Crassulaceae	**Bergknappfamilien; Stonecrop family**	
Crassula helmsii (Kirk) Cockayne	Swamp Stonecrop, New Zealand Pygmyweed	
Cyperaceae	**Starrfamilien; Sedge family**	
Eleocharis spp. R. Br.	Alle arter i sumpsivaksslekten; Sedge family - All species	
Elatinaceae	**Evjeblomfamilien; Waterwort family**	
Elatine triandra Schkuhr	Trefelt evjeblom; Threestamen Waterwort	
Haloragidaceae	**Tusenbladfamilien; Watermilfoil family**	
Myriophyllum spp. L.	Alle arter i tusenbladslekten; Water milfoils – All species	
Hydrocharitaceae	**Froskebittfamilien; Frogbit family**	
Egeria densa Planch.	Brasiliansk vasspest; Large-flowered Waterweed	
Elodea spp. Rich	Alle arter i vasspestslekten Spike Rushes unntatt *Elodea nuttallii* og *Elodea canadensis*	
Hydrilla verticillata (L.f.) Royle	Hydrilla	
Hydrocharis morsus-ranae L.	Froskebitt; Frogbit	
Lagarosiphon major (Ridley) Moss	Curly Waterweed	
Najas spp. L.	Alle arter i havfruegrasslekten; Naiads – All species	

Vallisneria spiralis L.	Tape Grass	
Lentibulariaceae	**Blærerotfamilien; Bladderwort family**	
Utricularia spp. L.	Alle arter i blærerotslekten; Bladderworts – All species	
Lythraceae	**Kattehalefamilien; Loosestrife family**	
Trapa natans L.	Vassnøtt; Water Chestnut	
Nymphaeaceae	**Nøkkerosefamilien; Water Lily family**	
Nymphaea alba. L.	Hvit nøkkerose; White Waterlily –	
Plantaginaceae	**Maskeblomstfamilien; Snapdragon family**	
Littorella uniflora (L.) Aschers	Tjerngras, Tjønngras; American Shoreweed	
Pontederiaceae	**Vannhyasintfamilien; Water Hyacinth family**	
Eichhornia crassipes (Mart.) Solms	Vannhyasint; Water Hyacinth	
Potamogetonaceae	**Tjernaksfamilien; Pondweed family**	
Potamogeton spp. L.	Alle arter i tjernaksfamilien; Pondweed family - All species	
Ranunculaceae	**Soleiefamilien; Buttercup family**	
Ranunculus aquatilis L.	Kystvassoleie; Common Water-Crowfoot, White Water-Crowfoot	

Appendix II

Section A and B assessments of category II species. Note that some species where only assessed using section A.

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Ceratophyllum submersum* L.

Author: Hugo de Boer

Reviewer: Iris Stiers

Risk Assessment Area: Norway

Introduction to genus/species: *Ceratophyllum submersum* L. is not native to Norway, and is neither included on the Norwegian Red List (ABD, 2015) nor the Norwegian list of exotic species (ADB, 2012).

The IUCN Red List of Threatened Species includes the following on *Ceratophyllum submersum* (Lansdown 2013). The distribution of *Ceratophyllum submersum* is obscured by confusion with *C. muricatum*, particularly in the eastern part of its range. *C. submersum* apparently occurs mainly in central Europe, occurring also in North Africa and parts of central Africa, east to southern Russia and possibly to Kazakhstan. In Europe, *C. submersum* is found mainly in the centre, from France and the UK to southern Sweden and the Baltic States into European Russia and in the south from scattered localities in Spain to Italy, Greece and the Ukraine. It is native to Albania; Austria; Belarus; Belgium; Bulgaria; Cameroon; Chad; Croatia; Czech Republic; Denmark; Estonia; France (Corsica, France (mainland)); Germany; Greece (East Aegean Is., Greece (mainland)); Hungary; Italy (Italy (mainland), Sicilia); Kazakhstan; Kenya; Latvia; Liechtenstein; Lithuania; Luxembourg; Macedonia, the former Yugoslav Republic of; Moldova; Montenegro; Netherlands; Nigeria; Poland; Romania; Russian Federation (Central European Russia, East European Russia, Kaliningrad, South European Russia); Serbia (Serbia); Slovakia; Slovenia; Spain (Baleares, Spain (mainland)); Sweden; Switzerland; Tanzania, United Republic of; Turkey (Turkey-in-Europe); Ukraine (Krym, Ukraine (main part)); United Kingdom (Great Britain, Northern Ireland). In Sweden, it is rare and occurs only in few areas in southern Sweden, where it is found in nutrient-rich lakes and ponds (NRM 2011 Virtuella Floran). It was first recorded in Sweden in 1779 in the southern Skåne province (Nordstedt

1920 in NRM 2011 Virtuella Floran). Skåne has a continental climate by definition of the EU Biogeographic Areas.

Fosså (2010) conjectures that the species is probably present in Norway. Klaveness (2001) lists *Ceratophyllum submersum* as a species that is either rare, disappeared from the Norwegian flora, or could rarely escape from cultivation.

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?	Not relevant	*Ceratophyllum submersum* is used in aquaria and as an ornamental plant in outdoor ponds (Fosså 2010).
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	No	
5. Where is the organism native?	*C. submersum* apparently occurs mainly in central Europe, occurring also in North Africa and parts of central Africa, east to southern Russia and possibly to Kazakhstan. In Europe, *C. submersum* is found mainly in the centre, from France and the UK to southern Sweden and the Baltic States into European Russia and in the south from scattered localities in Spain to Italy, Greece and the Ukraine (Lansdown, 2013).	
6. What is the global distribution of the organism?	See above.	
7. What is the distribution of the organism in Europe?	It is native to Albania; Austria; Belarus; Belgium; Bulgaria; Cameroon; Chad; Croatia; Czech Republic; Denmark; Estonia; France (Corsica, France (mainland)); Germany; Greece (East Aegean Is., Greece (mainland)); Hungary; Italy (Italy (mainland), Sicilia); Kazakhstan; Kenya; Latvia; Liechtenstein; Lithuania; Luxembourg; Macedonia, the former Yugoslav Republic of; Moldova; Montenegro;	

	Netherlands; Nigeria; Poland; Romania; Russian Federation (Central European Russia, East European Russia, Kaliningrad, South European Russia); Serbia (Serbia); Slovakia; Slovenia; Spain (Baleares, Spain (mainland)); Sweden; Switzerland; Tanzania, United Republic of; Turkey (Turkey-in-Europe); Ukraine (Krym, Ukraine (main part)); United Kingdom (Great Britain, Northern Ireland) (Lansdown, 2013).	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	No. It appears to establish only in seldom cases and no literature could be found to suggest that it becomes invasive.	
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	*Ceratophyllum submersum* is sold and used in aquaria and as an ornamental plant in outdoor ponds (Fosså 2010). It generated income for those that cultivate and trade the species.	
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	*Ceratophyllum submersum* material is only available from cultivation. This species is very easy to propagate and is widely shared among hobbyists and through retailers.	

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	very few	high	
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.			International aquarium and pond trade, namely intentional trade from aquarium plant nurseries to wholesalers and retailers in Norway (Fosså, 2010).
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very likely	high	As little as 2000 individuals are estimated to be imported per year, but the species is very easy to propagate (Fosså, 2010). Most people will propagate the species themselves, through other hobbyists, or get locally propagated material through retailers.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Insufficiently marked commercial material could be imported without documentation. Private import of material could occur through the internet or international travel. Plants as part of aquaria could be moved across borders into Norway through personal moving.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment	very likely	very high	Import of *Ceratophyllum submersum* is currently not regulated and material is

on the key issues that lead to this conclusion).			imported for Norwegian aquarium and pond trade.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	Viable plant material would need to survive sewage treatment facilities if disposed of through waste water; would need to spread from outside ponds, or would need to be dumped with aquarium contents into a suitable habitat.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	high	The species has established in both southern Sweden (Jonsell, 2001; Karlsson, 1998; Naturhistoriska riksmuseet, 2005) and southern Finland (Hämet-Ahti et al. 2005; Pihlajaniemi, 1999).
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	medium	The species occurs in warmer climates in Sweden and Finland. Under a warmer climate scenario the species would be likely to be able to establish in southern Norway.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	widespread	very high	*C. submersum* typically occurs in mesotrophic to eutrophic still water bodies such as lakes, ponds and ditches, the latter particularly where they function as "wet fences". It is tolerant of salt and in some areas apparently preferentially occurs in brackish water (Lansdown, 2013).
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	medium	
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	medium	Eutrophic estuaries and brackish areas and lakes are common in southern Scandinavia, and are minimally managed.
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread,	likely	high	The species is easy to propagate.

adaptability, genetic variation, to facilitate its establishment?			
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	likely	high	The species has established in both southern Sweden (Jonsell, 2001; Karlsson, 1998; Naturhistoriska riksmuseet, 2005) and southern Finland (Hämet-Ahti et al. 2005; Pihlajaniemi, 1999).
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	low	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	likely	high	*C. submersum* typically occurs in mesotrophic to eutrophic still water bodies such as lakes, ponds and ditches. It is tolerant of salt and in some areas apparently preferentially occurs in brackish water (Lansdown, 2013). The species has established in both southern Sweden (Jonsell, 2001; Karlsson, 1998; Naturhistoriska riksmuseet, 2005) and southern Finland (Hämet-Ahti et al. 2005; Pihlajaniemi, 1999).

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	high	The species grows in closed water systems (Lansdown, 2013).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minimal	high	The species is rare in Scandinavia (NORBANIS, 2016), and human interaction with this species does not involve the rare established populations.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	medium	The species would need to be manually removed from areas where it occurs. This would require removal of all vegetative matter. However, the species is rare and targeted eradication should be feasible.
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	Southern Norway	high	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	very slowly	high	The species was first reported in Sweden in 1779, and in Finland in 1966. These populations have not spread, and the species remains rare (NORBANIS, 2016).

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minor	medium	No data exists for this, but the species is rare and known only from few localities (NORBANIS, 2016).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minimal	very high	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	very high	
2.16. 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	medium	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	minimal	high	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Southern Norway	high	
2.20. Estimate the overall impact of species in NNorway (using the comment box to indicate any key issues).	minimal	very high	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	high	
Summarise Establishment	likely	high	
Summarise Spread	very slowly	high	
Summarise Impact	minimal	high	
Conclusion of the risk assessment	low	high	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Crassula helmsii* (Kirk) Cockayne

Author: Iris Stiers

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: *C. helmsii* is an amphibious, succulent, perennial plant, native to Australia and New Zealand, that can form dense monospecific mats on the water surface. Flowers are small and white and are only produced above the water surface. Vegetative propagation from fragments of the plant gives the plant the capacity to spread and colonise new water bodies (EPPO 2007). The species tolerates frost and is wintergreen. The species shows a tolerance to a wide variety of habitats with chemistry ranging from acid to alkaline, including water bodies, slow-flowing rivers, marshes and peat bogs. The dense mats that are formed by this species deplete oxygen thereby affecting other aquatic organisms, outcompete native plant species and may affect the breeding success and survival of threatened aquatic plants and amphibians. Mats choke ponds and drainage ditches, impede water flow and adversely affect recreation activities (Branquart et al. 2013).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	**Name:** *Crassula helmsii* (Kirk) Cockayne **Synonyms:** *Tillaea helmsii* Kirk, T. recurva (Hook.f.) Hook.f., *Bullardia recurva* Hook.f., *Crassula recurva* (Hook.f.) Ostenf. non N.E. Br. **Preferred common name:** Australian swamp stonecrop, New Zealand pigmyweed
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	EPPO 2007 RA Ireland 2014 GB NNSS 2011
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Partly valid	Partly valid - completed for the UK, Ireland, and the EPPO region, not specifically for Norway
5. Where is the organism native?	Australia and New Zealand	
6. What is the global distribution of the organism?	Also reported in the USA and NE Asia	
7. What is the distribution of the organism in Europe?	Belgium, Spain, Ireland, Italy, Denmark, France, Germany, Portugal, Scotland, Slovakia, Switzerland, Turkey, Wales, the Netherlands, United Kingdom	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Especially in the UK. The species can potentially exclude native wetland vegetation and affect other associated organisms (Dean et al. 2015, D'Hondt et al. 2016)
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species.		

Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	very high	Garden pond plant Sale through internet, horticulture and aquarium trade, pet shops, garden centers.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Intentional trade Accidental as a contaminant		Intentional for trade but also as a contaminant with other plants offered for sale, and on boats and other equipment
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	medium	This is a pecies used in aquaria, but it is uncertain how many individual plants that are imported each year (Fosså 2011).
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Contaminant with other plants offered for sale, and on boats and other equipment.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment	likely	high	*C. helmsii* is deliberately imported for trade. It is also available to purchase from

on the key issues that lead to this conclusion).			vendors on the internet for use in garden ponds.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	high	Primarily through dumping plant material, but may also escape from garden ponds.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	medium	*C. helmsii* can survive a wide range of climatic variation, from averages of 30°C in the summer to less than -6°C in winter (EPPO, 2007). Winter cold temperatures do not prohibit the invasion of *C. helmsii.* Species is winter-green and frost tolerant. According to the Geiger Climatic Zones *C. helmsii* is present in the Cfb and Cfc zones, the same climatic zone is present in the Atlantic region of Norway.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	medium	*C. helmsii* can grow in several different growth forms according to the prevailing environmental conditions (Sheppard 2006; EPPO, 2007). There are likely no limitations present to restrict its establishment.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	lmedium	*C. helmsii* colonises a wide variety of freshwater habitats with chemistry ranging from acid to alkaline, including water bodies, slow-flowing rivers, marshes and peat bogs (Branquart et al. 2013). The assessor assumes that many water bodies in Norway are suitable for the establishment of this organism as it has a wide tolerance of environmental conditions.
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	high	*C. helmsii* is not naturally controlled by any predator, parasite or pathogen in Norway.

1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very likely	high	Plant ability to grow from fragments. Recent D'hondt et al. (2016) showed that established populations of *C. helmsii* across western Europe have a widespread potential to reproduce generatively by seed.
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	Suitable habitats and similar climatic zones are present in Norway.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	Freely available on the internet followed by dumping of plant material in nature.
1.15. Estimate the overall likelihood of establishment Norway (mention any key issues in the comment box).	moderately likely	medium	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	major	medium	Relative to other species, I believe it can spread rapidly.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	medium	Dumping of plant material in water bodies. Movement of plant fragments from one water body to another by boats, anglers, flood, current...
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	ponds, wetlands, lakes, canals and slow-flowing watercourses but also muddy substrates along the shore	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	rapidly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	major	high	The formation of the dense mats is considered highly problematic for the population viability of local biota (macrophytes, algae, amphibians, invertebrates, even birds; Watson 1999; Langdon et al. 2004; EPPO 2007; Hussner 2009).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	major	high	Dense infestations of *C. helmsii* can deplete the oxygen content of water which can affect other organism groups. Unusual for an aquatic plant, it also utilizes Crassulacean acid metabolism (CAM) which enables it to take up carbon dioxide at night (Center for Aquatic Plant Management, 2004). Such a metabolic adaptation confers an advantage for plants growing where the supply of inorganic carbon for photosynthesis is deficient or limited during the day.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	There is no evidence for this
2.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minor	high	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting	minimal	high	

from introduction of the organism? (specify in the comment box)			
2.18. 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 Norway?	major	low	Can be major locally. If climate change projections are realized then establishment + spread will take place with major impacts. There are no known natural control agents.
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	ponds, wetlands, lakes, canals and slow-flowing watercourses but also muddy substrates along the shore	lmedium	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	major	high	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	moderately likely	low	
Summarise Spread	rapidly	medium	
Summarise Impact	major	medium	
Conclusion of the risk assessment	high	medium	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Egeria densa* Planchon

Author: Iris Stiers

Reviewer: Kjersti Sjøtun

Risk Assessment Area: Norway

Introduction to genus/species: *E. densa* is a submerged perennial that can live either rooted or free floating with leaves that are smooth and whorled. The flowers emerge above the water surface via long stalks. In Europe, only male *E. densa* are present in nature, because imported and cultivated plants are male (Matthews et al. 2014). *E. densa* thrives in various types of freshwater habitats, from acid to eutrophic environments. It prefers flowing systems but may also be found in still waters. This aquatic weed is not light demanding and is able to develop in deep and turbid waters (Branquart et al. 2013). *E. densa* is highly competitive, has a high relative growth rate, can propagate vegetative and is found on all continents (except Antarctica). The root system and stems are not very strong and break easily, allowing plant fragments to be carried by currents to inhabit new areas. As observed for most non-native Hydrocharitaceae species, this submerged perennial aquatic plant makes dense monospecific stands which often colonise the entire water column, restrict water movement, cut off light, produce anoxic conditions and trap sediments in the system (Yarrow et al. 2009).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	**Name:** *Egeria densa* Planchon **Synonyms:** *Elodea densa* (Planch.) Caspary , *Anacharis densa* (Planch.) Vict., *Philotria densa* (Planch.) Small & St. John **Preferred common name:** Brazilian waterweed, Large-flowered waterweed A number of species are visually similar to *E. densa* and it is therefore important to differentiate these species in order to prevent misidentification. Visually similar species: *Elodea nuttallii, Elodea canadensis, Hydrilla verticillata, Lagarosiphon major*
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	RA Ireland 2014 GB NNSS 2015 Risk analysis of the Brazilian Waterweed *Egeria densa* Planch. - Risk analysis report of non-native organisms in Belgium (2013) Risicoanalyse van de uitheemse Egeria (*Egeria densa*) in Nederland (2014)
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Partly valid	Partly valid - completed for the UK, Ireland, Belgium and the Netherlands not specifically for Norway
5. Where is the organism native?	Parts of Argentina, Brazil and Uruguay	
6. What is the global distribution of the organism?	Algeria, Kenya, South Africa, Japan, Indonesia, Mexico, US, Costa Rica, Cuba, Australia, New Zealand, El Salvador, Guadeloupe, Jamaica, Martinique, Nicaragua, Puerto Rico, Bolivia, Polynesia	

7. What is the distribution of the organism in Europe?	Austria, Azores, Belgium, France, Germany, Hungary, Italy, The Netherlands, Spain, Switzerland, UK, Ireland	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Pest species in its native range. Where it is invasive, *Egeria densa* can seriously threaten native aquatic communities (Yarrow et al. 2009; Santos et al. 2011)
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	very high	It is a popular aquarium plant. Sale through internet, horticulture and aquarium trade, pet shops, garden centers.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Intentional trade Accidental as a contaminant		Intentional for trade but also as a contaminant on plants offered for sale, and on boats and other equipment
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	medium	Popular aquarium plant.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Contaminant on plants offered for sale, and on boats and other equipment. *E. densa* – together with other invasive submerged plants – is often sold generally as 'oxygenating plants' in garden centers.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment	likely	high	*Egeria densa* is deliberately imported for trade. It is also available to purchase from

on the key issues that lead to this conclusion).			vendors on the internet for use in aquaria.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Primarily through dumping plant material , but may also escape from garden ponds and aquaria.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	Given that this is popular aquarium plant and that it has a wide ecological amplitude the assessor would say that climatic conditions are moderately similar. *E. densa* has been observed surviving under ice during the winter period (Champion and Tanner 2000) while the optimal growth temperature is between 15 and 25°C (reviewed in Yarrow et al. 2009). According to the Geiger Climatic Zones. *E. densa* is currently present in the Cfa, Cfb and Cfc zones, the same climatic zone is present in the Atlantic region of Norway.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	*E. densa* can tolerate a wide variation of abiotic factors. It thrives in various types of freshwater habitats, from acid to eutrophic environments. It prefers flowing systems but may also be found in still waters. This aquatic weed is not light demanding and is able to develop in deep and turbid waters (Branquart et al. 2013). *E. densa* is able to switch from C3 to C4 when the concentration of free CO2 is limiting and is able to use bicarbonate ions (HCO3-) as a dissolved inorganic carbon source (Spencer and Bowes 1990; Yarrow et al. 2009). As low carbon availability acts as a limiting factor in freshwater

			ecosystems for plant growth (Santamaria 2002), this property can increase the weedy potential of this plant.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	A number of freshwater habitats in Norway are suitable for *Egeria densa* survival, development and multiplication.
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	high	The assessor could not find evidence regarding how competition of existing species would affect establishment of *E. densa*. *E.densa* has several competitive advantages (use of HCO_3^-, high RGR, not light demanding...) There are no known natural predators, parasites or pathogens of this species.
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very likely	high	Only clonal spread in its non-native range. The species fragments rapidly (pers.obs).
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	Suitable habitats and similar climatic zones are present in Norway.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	Popular aquarium plant, freely available on the internet followed by dumping of plant material in nature.
1.15. Estimate the overall likelihood of establishment in	moderately likely	medium	

Norway (mention any key issues in the comment box).			

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	medium	Natural spread is slow in other countries.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	medium	Dumping of plant material in water bodies. Movement of plant fragments from one water body to another by boats, anglers.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	Lakes, ponds, ditches, still and slow flowing water; meso- to eutrophic water bodies	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	high	Outcompeting native submerged species by forming a dense canopy (Yarrow et al. 2009; Santos et al. 2011; Matthews et al. 2014).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	moderate	medium	Changes in light and nutrients levels resulting from the establishment of dense *E. densa* beds may impact plankton communities (Darrin 2009). *E. densa* has been reported to negatively affect fish communities (Matthews et al 2014). In high densities, *E. densa* may cut off light, deplete oxygen, increase water temperature, alter nutrient cycles and alter the morphology and hydrology of rivers and lakes by restricting water movement and trapping sediments (Mazzeo et al. 2003; Matthews et al. 2014). Interference with recreational use has been reported.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	There are no native species within the same genus.
2.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minor	high	There is some information available that *E. densa* can serve as food for fishes (Lake et al. 2002) but these are not necessarily damaging.
2.17. How important might other impacts not already covered by previous questions be resulting from introduction of the	minimal	high	Positive impacts: submerged species can create a clear water face and serve as refuge for aquatic organisms. If no other

organism? (specify in the comment box)			submerged species are present, it may be a benefit that *E. densa* is present.
2.18. 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 Norway?	minor	low	Actually minor to moderate. If climate change projections are realized then establishment + spread will take place with moderate impacts. There are no known natural control agents.
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Lakes, ponds, ditches, still and slow flowing water; meso to eutrophic water bodies	low	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	moderately likely	low	
Summarise Spread	slowly	medium	
Summarise Impact	moderate	medium	
Conclusion of the risk assessment	moderate	medium	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Elodea callitrichoides* (Rich.) Casp.

Author: Kjersti Sjøtun

Reviewer:

Risk Assessment Area: Norway

Introduction to genus/species: *Elodea callitrichoides* is native to temperate South America, but has been introduced to Europe where it has been reported from Austria, France, Ireland and UK according to information in DAISIE. It was reported in Europe for the first time in UK in 1948, in France in 1958 and in Germany in 1964. It is similar to the highly invasive *E. canadensis* and *E. nuttallii*, but separates from these by having leaves in whorls of three and more widely spread than the other two. However, identification errors have been demonstrated by using genetic markers. It is described as productive and tolerant to disturbance when in its native area. Little is known about its ecology in Europe.

Elodea callitrichoides is not being traded according to Fosså (2010)

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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?	It is a taxonomic unit but can be confused with the invasive *Eloda canadensis* and *E. nuttallii.*	By using genetic markers Vanderpoorten et al (2000) reported misidentifications of *E. callitrichoides* in Europe
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?	Genetic markers should be applied to identify it if in doubt.	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	The UK Amenity forum report it to be "critical-ranked" in a summary of Natural England report 'NECR053 - Horizon-scanning for invasive non-native plants in Great Britain'	The original report was removed from the web site
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	The full risk assessment was not available	
5. Where is the organism native?	Temperate South-America (Argentina, Uruguay)	eMonocot web page
6. What is the global distribution of the organism?	South-America, Europe	
7. What is the distribution of the organism in Europe?	UK, France, Germany, Austria	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	No	
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	None known	
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	None known	

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Eleocharis vivipara* Link

Author: Hans K. Stenøien

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: *Eleocharis vivipara* is a perennial plant in the Cyperaceae family, forming dense clumps and often growing entirely vegetatively (1). It fruits from spring to fall, and is found naturally in the southeastern USA on sandy and peaty soils, ditches, pond margins, shallow waters bordering pine-flatwoods and pine-palmetto scrub. Identification of vegetative (often aquatic) specimens is sometimes tentative. Imported for use in garden ponds and aquarium (<1000 samples each year, Fosså, pers comm).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	*Eleocharis vivipara* may be confused with *E. microcarpa* and *E. brittonii*, and sometimes with *E. baldwinii*. The red-spotted band at the sheath apex and the grey, cancellate achenes are characteristic of E. vivipara (1)
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)		
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	No	
5. Where is the organism native?	SW USA: Florida, Georgia, Mississippi, North Carolina, South Carolina, Texas, Virginia (2)	
6. What is the global distribution of the organism?		
7. What is the distribution of the organism in Europe?	Reported in England (3), but no further information.	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Reported as "invasive" in England, according to the Invasive Species Compendium (3), but lack of detailed information.	
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism? I	few	medium	It is imported and sold in Norwegian stores for usage in garden ponds and aquaria.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	It could be imported through regular mail service from online sales abroad.		Intentional
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately	medium	Fosså estimates approximately 1000 individual shipments imported to Norway each year from the genus as a whole. It is thus a relatively popular plant genus for recreational use, and it seems likely that this species is imported on a regular basis.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	moderately likely	low	The volume of non-regulated import is hard to estimate.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment	likely	medium	It is a relatively popular plant in commercial aquarium and pond industry. There therefore should

on the key issues that lead to this conclusion).			be annual import of the species to Norway.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host? .	unlikely	low	This can only happen by spread from garden pond (which is not very likely for a species primarily reproducing vegetatively), or more or less intentional release from an aquarium into a natural habitat. We know that the latter occurs from time to time. Given that this should be a moderately popular aquarium plant, it seems likely that such release into the wild will happen somewhere in Norway in a 50 year perspective. The probability that the habitat is suitable seems low, though, given the temperate/subtropical distribution of the species in its natural range.
1.7. How likely is it that the organism will be able to establish inNorway, based on the similarity between climatic conditions here and the organism's current distribution?	unlikely	low	It should be too cold for the species in Norway, but given that it is reported in England, it is possible that this can also happen in Norway.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	unlikely	low	See above
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Northern Europe, e.g	isolated	medium	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	moderately likely	low	
1.11. How likely is it that establishment will occur despite counteracting anthropogenic	moderately likely	low	

factors such as existing management practices?			
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very unlikely unlikely	low medium high very high	
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	It is reported as invasive in England.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	moderately likely	medium	Given the relative popularity of the species, and the low but significant risk that the species is intentionally released into the wild.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	unlikely	low	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	medium	It is reported to spread primarily by vegetative means. It is a commonly used plant for ornamental use, but still it is not reported in many places throughout Europe (only seemingly in a limited region of England).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minor	low	It is unclear how this should happen in practice.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	The species is primarily found in close to subtropical conditions (southern USA), and it seems most likely that it should spread in the southernmost parts of Norway, if spread happens.	medium	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	medium	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minimal minor	medium	No negative impact found reported.
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minimal	low	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	This is unknown
2.16. 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	medium	
2.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA	medium	
2.18. 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 Norway?	minimal	low	
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur	[insert text + attach map if possible]		

(provide as much detail as possible).			

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	unlikely	low	
Summarise Spread	slowly	medium	
Summarise Impact	minimal	low	
Conclusion of the risk assessment	low	medium	

REFERENCES:

Flora of North America: http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242357809

Tropicos, Missouri Botanical Garden: http://www.tropicos.org/Name/9904236?tab=distribution

Invasive Species Compendium: http://www.cabi.org/isc/datasheet/114062

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Hydrilla verticillata* (L. f.) Royle

Author: Iris Stiers

Reviewer: Kjersti Sjøtun

Risk Assessment Area: Norway

Introduction to genus/species: *H. verticillata* is a rooted submerged macrophyte with leaves in a whorl. In order to survive conditions which are unfavourable for growth, the plant produces two types of special hibernating organs (i.e. turions and tubers; Netherland 1997). *H. verticillata* spreads horizontally by means of branches which grow over the bottom of a waterbody and it can sprout new plants from root fragments or stem fragments containing as few as two whorls of leaves. In Europe, there is no seed formation because only female flowers are produced. The species thrives in environmental conditions varying from lentic to lotic, eutrophic to oligotrophic, acid to alkaline, with high to low light availability, and tropical to temperate climate (Sousa 2011). It may be assumed that different races of *H. verticillata* have become adapted to different ecological conditions. In particular, this applies to strains which are indigenous in Europe; they are adapted to a temperate climate and to mesotrophic or slightly meso-eutrophic alkaline waterbodies, with a high dominance of bicarbonate (Qbank). Hydrilla is very competitive and has frequently dominated the native macrophyte communities that it invades and can have delirious impacts on invertebrates, fishes and waterfowl (Rybicki and Landwehr 2007; Barrientos and Allen 2008; Theel et al. 2008). Large stands of Hydrilla can interfere with navigation, fisheries, and recreation activities such as swimming, diving, and water-skiing (Langeland 1996).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	**Name:** *Hydrilla verticillata* (L.f.) Royle **Synonyms:** *Elodea verticillata, Hydrilla alternifolia, Hydrilla angustifolia, Hydrilla dregeana, Hydrilla japonica, Hydrilla lithuanica, Hydrilla muscoides, Hydrilla najadifolia, Hydrilla polysperma, Hydrilla subulata, Hydrilla wightii, Udora verticillata, Vallisneria verticillata* **Preferred common name:** hydrilla A number of species are visually similar to *H. verticillata* and it is therefore important to differentiate these species in order to prevent misidentification. Visually similar species: *Elodea nuttallii, Elodea canadensis, Lagarosiphon major, Egeria densa*
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?	South-East Asia and Australia	
6. What is the global distribution of the organism?	*H. verticillata* has a wide and rather disjointed geographical range. This range includes South-East Asia, Australia, Central Africa, the USA and the Panama Canal area.	

7. What is the distribution of the organism in Europe?	Hungary, France, Austria, Belarus, Germany, Ireland, Latvia, Lithuania, Poland, Russian Federation, Spain, Canary Islands, UK (Hussner 2012; Qbank.eu)	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	*Hydrilla* is very competitive and has frequently dominated the native macrophyte communities that it invades (reviewed in Sousa 2011). Infestation has also been shown to alter the physical and chemical characteristics of lakes.
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	very high	Sale through internet, horticulture and aquarium trade, pet shops, garden centers.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Intentional trade Accidental as a contaminant		Intentional for trade but also as a contaminant on plants offered for sale, and on boats and other equipment
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	medium	More than 2000 individual plants (up to 5000) are estimated imported each year (Fosså 2011). The species is used in both ponds and aquaria.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Contaminant on plants offered for sale, and on boats and other equipment. *H. verticillata* – together with other invasive submerged plants – is often sold generally as 'oxygenating plants' in garden centers.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	likely	high	*Hydrilla* is deliberately imported for trade. It is also available to purchase from vendors on the internet for use in aquaria.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Primarily through dumping plant material , but may also escape from garden ponds and aquaria.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	The species shows a wide ecological amplitude so the assessor would say that climatic conditions are moderately similar. The optimum growth temperature is between 25 and 36°C (McFarland and Barko, 1990, 1999) but tubers and turions can withstand ice cover, drying, herbicides, and ingestion and regurgitation by waterfowl (Washington State Department of Ecology, 2006).
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	The species thrives in environmental conditions varying from lentic to lotic, eutrophic to oligotrophic, acid to alkaline, with high to low light availability (Sousa 2011). *H. verticillata* is rarely found in rapid flowing water or shady habitats. *E. densa* is able to switch from C3 to C4 when the concentration of free CO2 is limiting and is able to use bicarbonate ions (HCO3-) as a dissolved inorganic carbon source (Kahara and Vermaat 2003). As low carbon availability acts as a limiting factor in freshwater ecosystems for plant growth (Santamaria 2002), this property can increase the weedy potential of this plant.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	A number of freshwater habitats in Norway are suitable for *Hydrilla* survival, development and multiplication.

1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	high	Results from greenhouse experiments showed that *Vallisneria americana* decreased *H. verticillata* colonization through nutrient draw-down in the water column of closed mesocosms but data from the field experiment, located in a tidal freshwater region that is open to nutrient fluxes, revealed no impact (Chadwell and Engelhardt 2008). *H. verticillata* has several competitive advantages (use of HCO_3^-, high effective survival strategy, rapid growth, easy fragmentation...). Shabana et al. (2003) found that two bacteria strains and 42 fungi isolates collected from aquatic environments in Florida were able to severely set back Hydrilla (76–100% damage). Only 30–40% reduction of the biomass of Hydrilla under field conditions in the USA was found when the leaf-mining fly (Hydrellia pakistanae Deonier) was used as a biocontrol agent (Doyle et al. 2002, 2007). There are no known natural control agents in Europe.
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very likely	high	Mostly clonal spread in its non-native range. The species fragments rapidly.
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	Suitable habitats and similar climatic zones are present in Norway.

1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	Freely available on the internet followed by dumping of plant material in nature.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	medium	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	medium	
2.2. How large is the expected spread of this organism in Northern Europe, e.g., Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	medium	Dumping of plant material in water bodies. Movement of plant fragments from one water body to another by boats, anglers, waterfowl.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	canals, springs, streams, ponds, lakes, rivers, and reservoirs. Oligothrophic to eutrophic waterbodies. Tolerant to salinity and pollution by sewage	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	high	Outcompetes native macrophyte communities and can have delirious impacts on invertebrates, fishes and waterfowl (Rybicki and Landwehr 2007; Barrientos and Allen 2008; Theel et al. 2008).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	moderate	medium	Changes in the energy flow in the ecosystem, decrease of dissolved oxygen. The community of invertebrates can be impacted by low oxygen levels found in lower portions of the water column below canopies formed by Hydrilla stands (Colon-Gaud et al. 2004). Interference with recreational use and aesthetic value has been reported.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	
2.16. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minor	high	In Florida, the invasive South American catfish *Hoplosternum littorale* uses Hydrilla to build nests, and built these nests preferentially in Hydrilla-infested areas (Nico and Muench 2004).
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minor	high	Positive impacts: improvements in the water quality by increased water transparency. Used for water purification, biogas and fertilizer, habitat for macroinvertebrates and food for waterfowl (reviewed in Sousa 2011).

2.18. 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 Norway?	minor	low	Actually minor to moderate. If climate change projections are realized then establishment + spread will take place with moderate impacts. There are no known natural control agents in Europe.
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	canals, springs, streams, ponds, lakes, rivers, and reservoirs. Oligothrophic to eutrophic waterbodies. Tolerant to salinity and pollution by sewage	low	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	moderately likely	low	
Summarise Spread	moderately fast	medium	
Summarise Impact	moderate	medium	
Conclusion of the risk assessment	moderate	medium	

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Barrientos CA and Allen MS (2008) Fish abundance and community composition in native and non-native plants following Hydrilla colonization at Lake Izabal, Guatemala. Fisheries Management and Ecology 15: 99–106.

Chadwell TB, Engelhardt KAM (2008) Effects of pre-existing submerged vegetation and propagule pressure on the invasion success of *Hydrilla verticillata*. Journal of Applied Ecology 45: 514-123

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Lagarosiphon major* (Ridley) Moss

Author: Iris Stiers

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: *L. major* (Ridley) Moss is a perennial, submerged, rooted aquatic plant with leaves that alternate spirally along the stems. The female flower is very small with three white petals that are borne singly in the axils of leaves on a long stem and float on the surface of the water. Outside its South African native range, only female plants are known and all reproduction is by vegetative reproduction. Neither the male flower nor fruit or seeds have been recorded outside of its native range. Numerous adventitious roots along with rhizomes, anchor the species in the sediment (Matthews et al. 2012). *L. major* occurs in lakes, riparian zones, water courses and wetlands with a preference of the cooler, clear fresh waters under high light intensities with silty or sandy bottoms. The species grows in still or slow-moving waters with low and high nutrient concentrations and can tolerate a high pH (National Heritage Trust 2003). As observed for most alien Hydrocharitaceae species, this submerged perennial aquatic plant develops dense monospecific stands which often occupy the entire water volume from the bottom to the surface, outcompete native submerged vegetation, restrict water movement, cut off light and interfere with recreation activities (McGregor and Gourlay 2002).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	**Name:** *Lagarosiphon major* (Ridley) Moss **Synonyms:** *Elodea crispa*, *Lagarosiphon muscoides, Lagarosiphon muscoides* var. *major* **Preferred common name:** curly waterweed A number of species are visually similar to *L. major* and it is therefore important to differentiate these species in order to prevent misidentification. Visually similar species: *Elodea nuttallii, Elodea canadensis, Hydrilla verticillata, Egeria densa*
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	RA Ireland 2014 Victorian WRA 2011 GB NNSS 2011 Risk analysis of the Curly Waterweed *Lagarosiphon major* (Ridley) Moss. - Risk analysis report of non-native organisms in Belgium (2013) Risk analysis of non-native Curly Waterweed (*Lagarosiphon major*) in the Netherlands (2012)
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Partly valid	Partly valid - completed for the UK, Ireland, Belgium and the Netherlands not specifically for Norway
5. Where is the organism native?	Botswana - native and invasive, Lesotho - native and invasive, South Africa, Zambia - native and invasive, Zimbabwe - native and invasive	
6. What is the global distribution of the organism?	Australia (New South Wales, Tasmania), New Zealand	

7. What is the distribution of the organism in Europe?	Hungary, Wales, Scotland, Austria, Belgium, France (including Reunion), Germany, Ireland, Italy, the Netherlands, Spain, Switzerland, UK (including Channel Islands)	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Impacts on native species and the local ecosystem have been considerable. Changes in habitat conditions due to *L. major* may cause species replacement (Caffrey and Acavedo 2007; Caffrey et al. 2010; Stiers et al. 2011, Martin and Coetzee 2014).
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	very high	It is a popular aquarium plant. Sale through internet, horticulture and aquarium trade, pet shops, garden centers.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Intentional trade Accidental as a contaminant		Intentional for trade but also as a contaminant on plants offered for sale, and on boats and other equipment
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	medium	According to Fosså (2011) more than 1000 individual plants are imported to Norway each year.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Contaminant on plants offered for sale, and on boats and other equipment. *L. major* – together with other invasive submerged plants – is often sold generally as 'oxygenating plants' in garden centers.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	likely	high	*L. major* is deliberately imported for trade. It is also available to purchase from vendors on the internet for use in aquaria.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	high	Primarily through dumping plant material, but may also escape from garden ponds and aquaria.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	Given that this is popular aquarium plant and that the invaded habitats span a wide trophic, altitudinal and temperature range the assessor would say that climatic conditions are moderately similar. Winter cold temperatures do not kill *L. major* although the optimum temperatures for growth are between 18 and 23°C (Matthews et al. 2012). According to the Geiger Climatic Zones *L. major* is present in the Cfa, Cfb and Cfc zones, the same climatic zone is present in the Atlantic region of Norway.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	*L. major* can live in a wide range of trophic conditions. *L. major* occurs in lakes, riparian zones, water courses and wetlands with a preference of the cooler, clear fresh waters under high light intensities with silty or sandy bottoms. The species grows in still or slow-moving waters with low and high nutrient concentrations and can tolerate a high pH (National Heritage Trust 2003). *L. major* was reported to have the ability to photosynthesize and grow under very stressful conditions of high pH and low free CO_2 (James et al. 1999), due to more efficient bicarbonate utilization than other species which

			enhances its competitive ability.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	A number of freshwater habitats in Norway are suitable for *L. major* survival, development and multiplication.
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	high	*L. major* is a very aggressive species that is known to replace native species (James et al. 1999). *L. major* is not naturally controlled by any predator, parasite or pathogen in Norway.
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very likely	high	Outside its South African native range, only female plants are known and all reproduction is by fragmentation or vegetative reproduction.
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	Suitable habitats and similar climatic zones are present in Norway.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	Popular aquarium plant, freely available on the internet followed by dumping of plant material in nature.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	medium	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	medium	Natural spread is slow in other countries.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	medium	Dumping of plant material in water bodies. Movement of plant fragments from one water body to another by boats, anglers.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	lakes, ponds, streams, canals and temperate freshwaters with adequate nutrient status.	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	high	*L. major* has been reported to outcompete native submerged aquatic vegetation (e.g. Charophytes, *Myriophyllum* spp., *Potamogeton* spp.) and affect associated assemblages of aquatic invertebrates and vertebrates (Rattray et al. 1994; Keenan et al. 2009; Caffrey et al. 2010).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	moderate		*L. major* alters the chemical composition of the water body by creating stressful conditions of high pH and low carbon dioxide (James et al., 1999). *L. major* can also be an excellent competitor for light and the dense mats can decrease the oxygen levels by limiting water circulation and increased decomposition of dead plants. Dense mats of *L. major* also have the ability to change water hydrology and quality, negatively affecting the ecosystem in which it occurs. Significant changes in abundance and species composition within the macroinvertebrate community have been observed following invasion by *L. major* (Caffrey and Acavedo, 2007). Interference with recreational use has been reported.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	There is no evidence for this
2.16. How important is the impact of the organism as food, a host, a symbiont or a vector	minor	high	

for other damaging organisms (e.g. diseases)?			
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minimal	high	Positive impacts: submerged species can create a clear water face and serve as refuge for aquatic organisms. If no other submerged species are present, it may be a benefit that *L. major* is present.
2.18. 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 Norway?	minor	low	Actually minor to moderate. If climate change projections are realized then establishment + spread will take place with moderate impacts. There are no known natural control agents.
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	lakes, ponds, streams, canals and temperate freshwaters with adequate nutrient status	low	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	moderate	medium	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	moderately likely	low	
Summarise Spread	slowly	medium	
Summarise Impact	moderate	medium	
Conclusion of the risk assessment	moderate	medium	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Lemna gibba* L.

Author: Hans K. Stenøien

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: *Lemna gibba* is a rapidly growing plant found in still or slowly flowing, eutrophic water. In highly eutrophic sites it may form dense masses that exclude other species (1). It reproduces mainly by vegetative budding, although it flowers slightly more frequently than our other Lemnaceae (1). It was once "probably native" in Norway (2), e.g., found in three nutrient rich ponds in Oslo between 1861-84, but is no longer present here. It is considered a cosmopolitan species (2). It is mainly found in regions with a Mediterranean climate (dry, mild) and tropical mountains, except Australia (3). It is used both for garden ponds and aquaria, but not among the most popular plants (estimated import volume of <100 shipments per year, Fosså, pers. comm).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	In the IUCN Red List says that there are no significant taxonomic issues associated with this name. However, there is a degree of confusion over separation of *L. gibba* from *L. minor* when the former is not expanded and this may obscure differences in the distribution of the two species (4). On the other hand, duckweeds are extremely reduced in morphology and present a developmental hybrid of leaf and stem origin. The extreme reduction in plant stature, miniaturization of organs, and its worldwide distribution, combined with high phenotypic plasticity in response to environmental conditions have made taxonomy of Lemnaceae taxonomically challenging. *L. gibba* is genetically overlapping with lineages of *L. turionifera*, possibly also *L. parodiana* (5).
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?	All continents, except Australia	
6. What is the global distribution of the organism?	According to the IUCN Red List (4) *Lemna gibba* is most frequent in areas with Mediterranean climates, particularly throughout the Mediterranean basin, eastern Africa, and south-western	

	North America. It also occurs in parts of Central America, western and southern South America and scattered in eastern and South Africa. In Europe it occurs more or less throughout, as far north as southern Sweden.	
7. What is the distribution of the organism in Europe?	Albania; Austria; Belarus; Belgium; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Denmark; Estonia; Finland; France (Corsica, France (mainland)); Germany; Greece (Greece (mainland)); Hungary; Ireland; Italy (Italy (mainland), Sardegna, Sicilia); Jersey; Latvia; Liechtenstein; Lithuania; Luxembourg; Macedonia, the former Yugoslav Republic of; Moldova; Montenegro; Netherlands; Poland; Portugal (Madeira, Portugal (mainland)); Romania; Russian Federation (Central European Russia, East European Russia, Kaliningrad, North European Russia, Northwest European Russia, South European Russia); Serbia (Serbia); Slovakia; Slovenia; Spain (Baleares, Canary Is., Spain (mainland)); Sweden; Switzerland; Turkey (Turkey-in-Europe); Ukraine (Krym, Ukraine (main part)); United Kingdom (Great Britain, Northern Ireland) (4).	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	No.	Duckweeds may be become invasive when nutrient increase in natural habitats (e.g. due to fertilizers) cause them to get established in environments they are normally not found.
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	Duckweeds can be used in the production of pharmaceuticals (5). Potential for feeding resource for livestock (6).	
10. Describe any known negative effects on the biodiversity in the exporting		

country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	few	medium	It is imported and sold in Norwegian stores for usage in garden ponds and aquaria.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	It could be imported through regular mail service from online sales abroad.		Intentional
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately	medium	Fosså estimates approximately <100 individual shipments imported to Norway each year of this species. It is thus not among the most popular plants for recreational use, but it seems likely that this species is imported on a regular basis.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	moderately likely	low	The volume of non-regulated import is hard to estimate.
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	likely	medium	It is used in commercial aquarium and pond industry. There therefore should be annual import of the species to Norway.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	This can only happen by spread from garden pond or more or less intentional release from an aquarium into a natural habitat. We know that at least the latter occurs from time to time. Given that this should be a low to moderately popular aquarium plant, it still seems likely that such release into the wild will happen somewhere in Norway in a 50 year perspective. The probability that the habitat is suitable may be moderately high, given that the species has been found in Norway before, and that it is growing today in southern Sweden.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	high	It is found in southern Scandinavia today. It grows typically in temperatures ranging from 6 to 30 degrees Celsius (6).
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	low medium	
1.11. How likely is it that establishment will occur despite counteracting anthropogenic	likely	low	

factors such as existing management practices?			
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	likely	medium	
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	medium	
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	Given the not insignificant popularity of the species, and the low but significant risk that the species is intentionally released into the wild.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	medium	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	medium	It is a widespread species today, and it may spread rapidly, especially in eutrophic waters.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minor	low	It is unclear how this should happen in practice.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	It is most likely that Southern Norway would be affected.	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	moderately	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	medium	Establishment of duckweeds causes changes in ecosystems regarding light availability. Members of the duckweed family can spread rapidly across quiet bodies of water enriched in nutrients.
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minor	low	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	This is unknown
2.16. 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	low	
2.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	minor	low	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[insert text + attach map if possible]		

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	medium	
Summarise Establishment	moderately likely	medium	
Summarise Spread	moderately fast	medium	
Summarise Impact	minor	medium	
Conclusion of the risk assessment	moderate	medium	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Myriophyllum aquaticum* (Vell.) Verdc.

Author: Hugo de Boer

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: The following species of *Myriophyllum* are native to Norway (Henriksen & Hilmo, 2015): *Myriophyllum verticillatum* L. (Rødliste VU-Sårbar), *Myriophyllum spicatum* L. (Rødliste LC-livskraftig), *Myriophyllum sibiricum* Kom. (Rødliste LC-livskraftig), *Myriophyllum alterniflorum* DC. (Rødliste LC-livskraftig).

DAISIE, EPPO and Q-Bank include the following established European invasives: *Myriophyllum heterophyllum* Michx. (a North American species extending into Ontario, Canada (Aiken, 1981) and *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe).

Fosså (2010) lists the following as occurring in commercial aquarium trade in Norway: *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe (DAISIE, accessed 2016; Q-Bank, accessed 2016), *M. mattogrossense* Hoehne (a tropical species from Brazil (tropica.com, accessed 2016)), *M. mezianum* Schindl. (a tropical species from Madagascar (Tropicos, accessed 2016)), *M. pinnatum* (Walter) Britton, Sterns & Poggenb. (a temperate species from northeastern to southern US (Aiken, 1981)), *M. propinquum* A.Cunn. (a temperate species from New Zealand, invasive in temperate areas in China, Japan, South Korea and Russia (Orchard, 1979; New Zealand's National Institute of Water and Atmospheric Research (NIWA)(accessed 2016), *M. simulans* Orchard (a southeastern Australia native (Orchard, 1986), and *M. tuberculatum* Roxb. (a subtropical species from India to China (Flora of China Editorial Committee, 2007)). The material traded as *M. propinquum* is likely mislabeled *M. simulans* (pers. comm. Johan van Valkenburg, 2016).

Only the non-tropical species are assessed here: *Myriophyllum aquaticum*, *M. heterophyllum*, and *M. quitense*.

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	*Myriophyllum aquaticum* (Vell.) Verdc.
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	GB NNSS 2011. *Myriophyllum aquaticum* IR NBDC 2014. *Myriophyllum aquaticum* EPPO 2004. Draft DS *Myriophyllum aquaticum*
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Yes	Recent and thorough
5. Where is the organism native?	South American species (DAISIE, accessed 2016; Q-Bank, accessed 2016)	
6. What is the global distribution of the organism?	South and North America, Europe, and Australia (DAISIE, accessed 2016; Q-Bank, accessed 2016)	
7. What is the distribution of the organism in Europe?	Belgium, France, Ireland, Italy, Spain, Portugal, Great Britain, Germany, Romania (DAISIE, accessed 2016).	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	California (California Invasive Plant Council. 2006. California Invasive Plant Inventory. Cal-IPC Publication 2006-02 (1 February 2007). California Invasive Plant Council. Berkeley, California), Tennessee (Southeast Exotic Pest Plant Council. 1996. Invasive exotic pest plants in Tennessee (19 October 1999). Research Committee of the Tennessee Exotic Pest Plant Council. Tennessee.)
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	No	Significant costs are associated with control of this species, either by mechanical control, manual control or application of

Subnote: Background information		herbicides. Dense infestations can exclude native species, or cause flooding in slow flowing channels (NNSS 2011). Management of this invasive in the Netherlands is estimated at 100.000 – 1.000.000 euros/year (NVWA, 2015. Expertpanelbeoordeling van (potentiële) risico's en managementopties van invasieve exoten in Nederland).
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	No	None known.

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	few	medium	Horticultural trade, aquaria and garden ponds. *Myriophyllum* species are popular in the aquatic nursery trade. Fragmentation of natural populations in flowing systems, perhaps enhanced by recreational boating, angling or by deliberate transplantation (NNSS, 2011).
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	See comment section.		Entry into the Europe is through the aquatic plant trade pathway.
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very likely	high	An estimated 5000 individuals of all *Myriophyllum* species are imported per year into Norway, but the species is easy to propagate (Fosså, 2010). Most people will propagate the species themselves, through other hobbyists, or get locally propagated material through retailers.
1.4. How likely is the organism to enter Norway undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	very likely	medium	Entry into the Europe is through the aquatic plant trade pathway, and *Myriophyllum* species are often misidentified (EPPO, 2015).

1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	very likely	very high	Import of *Myriophyllum aquaticum* is currently not regulated and material is imported for Norwegian aquatic plants trade.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	medium	Viable plant material would need to survive sewage treatment facilities if disposed of through waste water; would need to spread from outside ponds, or would need to be dumped with aquarium or pond contents into a suitable habitat.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	medium	The plant originates from South America and is known not to tolerate very cold winters present in continental Europe. However, it is know to survive most winters in the UK in its current area of distribution. Personal observation suggests that emergent biomass is relatively susceptible to frosts, but submerged biomass tends to tolerate colder conditions, if not encased in ice. This allows regeneration from submerged material in the following spring. However, regrowth from submerged material is slower than from material with emergent biomass that survives over winter. An experimental population survived encasement in ice and overnight temperature of -14.9 degrees C in January 2010. This population is still viable and producing green shoots as of 1st March 2010. It appears that this species is tolerant of much colder temperatures than previously observed. (Newman, Pers. Obs.). The inability to store phosphate in rhizomes overwinter may limit its distribution in colder areas with oligotrophic water, but overwintering in eutrophic ponds is possible due to compensation in continued P

			supply in the following spring (Barko and Smart, 1981; Sytsma and Anderson, 1993). (NNSS, 2011)
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	See comment 1.7.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	widespread	medium	Warm, shallow water and eutrophic conditions favour the growth of *M. aquaticum* (Sutton, 1985), and it is moderately resistant to salinity (Haller et al., 1974). Where introduced and invasive it is common in irrigation lines, ponds, streams and other water bodies (EPPO, 2004).
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	medium	The habit preferences of floating and amphibious macrophytes do not overlap with many native species (except *Glyceria maxima*). Therefore there is little competition from existing species (NNSS, 2011).
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	medium	Eradication may only be feasible in the initial stages of infestation. Mechanical control will increase fragmentation of the plant which will aid dispersal within systems and increase the likelihood of spread between systems (NNSS, 2011).
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	likely	high	Introduced populations spread by asexual (vegetative) means. There are no specialised vegetative propagules, but stems are brittle and small fragments break off parent plants with ease, floating away to become established elsewhere (NNSS, 2011).
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	likely	high	It has entered and established in the following areas: Europe: Austria, France, Germany, Portugal, United Kingdom. Asia: Cambodia, Indonesia (Java), Japan,

			Malaysia, Philippines, Thailand, Vietnam. Africa: Madagascar, South Africa, Zimbabwe. North America: Mexico, USA (Alabama, Arizona, Arkansas, California, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, New York, North Carolina, Massachusetts, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Washington). Central America and Caribbean: Costa Rica, Nicaragua. Oceania: Australia (New South Wales, Queensland, South Australia, Tasmania, Victoria, Western Australia), New Zealand (NNSS, 2011).
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	This species is widely traded in Norway (Fosså, 2010).
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	likely	high	This is an invasive species. It appears to survive in conditions that are present in Norway, but although some populations survive cold winters, the tolerance of this species to cold European winters is not well understood (NNSS, 2011).

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	medium	The risk of the species spreading is high as movement through irrigation and river systems acts to connect countries, facilitating spread regionally (EPPO, 2015). Spread between isolated ponds is difficult and could be mediated by transfer on the feet of large birds (Geese and Swans). Spread within flowing systems is more likely due to increased risk of fragmentation over winter (NNSS, 2011).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	high	Deliberate planting in garden ponds and deliberate / accidental transfer to the wild aids rapid spread, increasing the risk of escape to natural areas (NNSS, 2011).
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	difficult	high	*M. aquaticum* regrows rapidly from shoot fragments and as such mechanical cutting is rarely effective (Jacot-Guillarmod, 1977), however, more effective harvesting systems that remove the biomass and accumulated nutrient reserves may offer control possibilities (Sytsma and Anderson, 1993). (NNSS, 2011).
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	Southern and coastal Norway.	low	
2.5. Estimate the overall speed of future spread of this organism in	moderately	medium	The species been in trade for a long time, but no establishment in the wild has

Norway (using the comment box to indicate any key issues).			been recorded from Sweden (Artdatabanken, 2016) or Norway (Artsdatabanken, 2016). Under a warmer climate scenario the species would be likely to be able to establish in southern Norway.

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	major	medium	*M. aquaticum* provides cover for some aquatic organisms, but it can seriously change physical and chemical characteristics of water bodies, and infestations alter aquatic ecosystems by shading out algae that serve as the basis of the aquatic food chain. In eutrophic coastal or brackish waters conditions it has been observed to displace native species. (EPPO, 2004).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	major	medium	See comment 2.12.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	moderate	medium	In the USA, another species, *M. heterophyllum*, has the potential to hybridise with the native *M. pinnatum* forming *Myriophyllum heterophyllum x pinnatum* which is a more aggressive hybrid. Considering the number of *Myriophyllum* 'species' in trade hybridization in future may result in more aggressive invasive species (Moody & Les, 2002; Thum & Lennon, 2006; Tavalire *et al.*, 2012). (EPPO, 2015).
2.16. 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	high	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting	NA		

from introduction of the organism? (specify in the comment box)			
2.18. 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 Norway?	major	high	
2.19. Indicate any parts of Norway where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Southern and coastal Norway	medium	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	moderate	medium	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	high	
Summarise Establishment	likely	high	
Summarise Spread	Moderately fast	high	
Summarise Impact	moderate	high	
Conclusion of the risk assessment	moderate	high	This is an invasive species. It appears to survive in conditions that are present in Norway, but although some populations survive cold winters, the tolerance of this species to cold European winters is not well understood (NNSS, 2011). Under a warmer climate scenario the species would be likely to be able to establish in southern Norway.

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Myriophyllum heterophyllum* Michx.

Author: Hugo de Boer

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: The following species of *Myriophyllum* are native to Norway (Henriksen & Hilmo, 2015): *Myriophyllum verticillatum* L. (Rødliste VU-Sårbar), *Myriophyllum spicatum* L. (Rødliste LC-livskraftig), *Myriophyllum sibiricum* Kom. (Rødliste LC-livskraftig), *Myriophyllum alterniflorum* DC. (Rødliste LC-livskraftig).

DAISIE, EPPO and Q-Bank include the following established European invasives: *Myriophyllum heterophyllum* Michx. (a North American species extending into Ontario, Canada (Aiken, 1981) and *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe).

Fosså (2010) lists the following as occurring in commercial aquarium trade in Norway: *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe (DAISIE, accessed 2016; Q-Bank, accessed 2016), *M. mattogrossense* Hoehne (a tropical species from Brazil (tropica.com, accessed 2016)), *M. mezianum* Schindl. (a tropical species from Madagascar (Tropicos, accessed 2016)), *M. pinnatum* (Walter) Britton, Sterns & Poggenb. (a temperate species from northeastern to southern US (Aiken, 1981)), *M. propinquum* A.Cunn. (a temperate species from New Zealand, invasive in temperate areas in China, Japan, South Korea and Russia (Orchard, 1979; New Zealand's National Institute of Water and Atmospheric Research (NIWA)(accessed 2016), *M. simulans* Orchard (a southeastern Australia native (Orchard, 1986), and *M. tuberculatum* Roxb. (a subtropical species from India to China (Flora of China Editorial Committee, 2007)). The material traded as *M. propinquum* is likely mislabeled *M. simulans* (pers. comm. Johan van Valkenburg, 2016).

Only the non-tropical species are assessed here: *Myriophyllum aquaticum*, *M. heterophyllum*, and *M. quitense*.

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	Not for the layman, but a taxonomist or trained amateur could easily do this.
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?	Not relevant	*Myriophyllum heterophyllum* is used in aquaria and as an ornamental plant in outdoor ponds. The plant is sold throughout the PRA area as an ornamental aquatic species but never under its proper name (EPPO 2015).
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	EPPO (2015) *Pest risk analysis for Myriophyllum heterophyllum*
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Yes	Recent and thorough
5. Where is the organism native?	North America (Canada, US, Mexico)	
6. What is the global distribution of the organism?	North America; introduced in China	
7. What is the distribution of the organism in Europe?	Austria, Belgium, France, Germany, Hungary, Netherlands, Spain, Switzerland	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Yes
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	Management of this invasive in the Netherlands is estimated at 100.000 – 1.000.000 euros/year (NVWA, 2015. Expertpanelbeoordeling van (potentiële) risico's en managementopties van invasieve exoten in Nederland).	
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	No	None known.

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	very few	high	Plants for planting (either as an intentional import as an ornamental species or a case of misidentification) (EPPO, 2015).
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	See comment section.		Entry into the Europe is through the aquatic plant trade pathway, often misidentified as other *Myriophyllum* species, e.g., *M. scabratum*, *M. propinquum* and *M. hippuroides* (EPPO, 2015).
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very likely	high	An estimated 5000 individuals of all *Myriophyllum* species are imported per year into Norway, but the species is easy to propagate (Fosså, 2010). Most people will propagate the species themselves, through other hobbyists, or get locally propagated material through retailers.
1.4. How likely is the organism to Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	very likely	medium	Entry into the Europe is through the aquatic plant trade pathway, often misidentified as other *Myriophyllum* species, e.g., *M. scabratum*, *M. propinquum* and *M. hippuroides* (EPPO, 2015).
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	very likely	very high	Import of *Myriophyllum heterophyllum* is currently not regulated and material is imported for Norwegian aquatic plants trade.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	medium	Viable plant material would need to survive sewage treatment facilities if disposed of through waste water; would need to spread from outside ponds, or would need to be dumped with aquarium or pond contents into a suitable habitat.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	high	This species has not been found in either Norway or Sweden (Artsdatabanken, 2016; ArtDatabanken, 2016). However, establishment is likely in the temperate climate regions within the EPPO region (EPPO, 2015). The species occurs in clearly defined climatic zones in its native range, Cfa, Cfb, Dfa, Dfb, (based on the Köppen-Geiger climate zones (Kottek *et al.*, 2006), and Cfb and Dfb occur in southern and coastal Norway up to the Lofoten (EPPO, 2015). Under a warmer climate scenario the species would be even more likely to be able to establish in southern Norway.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	It can tolerate high summer temperatures as well as cold winter temperatures where it can be covered by ice during the winter months (Brunel *et al.*, 2010). Invasive populations in Belgium, the Netherlands and Germany thrive in riparian systems, slow moving rivers, canals, irrigation canals, lakes, reservoirs and semi-aquatic systems, including wetlands (EPPO, 2015).
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	widespread	very high	See comment 1.9.

1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	high	The species has impacts on ecosystem services, as seen in other regions where it is present. Dense mats of *M. heterophyllum* reduce light to other submerged plants and can affect water quality by reducing oxygen levels resulting in fish avoiding the infested area (EPPO, 2015).
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	high	Eradication may only be feasible in the initial stages of infestation. This may be possible with the current level of occurrence the species has in the EPPO region. Coordination of all stakeholders is required and should be easy to achieve, especially since the distribution is limited (EPPO, 2015).
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	likely	high	*Myriophyllum heterophyllum* forms dense mats at the surface of the water body reducing light penetration and dissolved oxygen below which can reduce suitable habitats for native plants (Bailey, 2007).
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	likely	high	Invasion in the Netherlands (1999) and Germany (1962) is fairly recent, but it spreads aggressively with significant negative economic impact (EPPO, 2015; NOBANIS, 2016).
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	medium	In Great Britain the species appears to form transient populations (NNSS, 2011).
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	likely	high	This is an invasive species. In its natural distribution it occurs in climate zones that are currently present in southern and coastal Norway (EPPO, 2015).

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	high	The risk of the species spreading is high as movement through irrigation and river systems acts to connect countries, facilitating spread regionally (EPPO, 2015).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minimal	high	Spread may be accelerated by recreational activities in water bodies invaded by the weed (EPPO, 2015). Spread via human activity is one of the main causes of dispersal for *M. heterophyllum* within and between lakes in the USA (Green Mountain Conservation Group, 2015). The potential for long-distance spread of *M. heterophyllum* is high because the species is very tolerant of desiccation (Barnes *et al.* 2013), meaning that hitch-hiker fragments are likely to remain viable for prolonged periods of time, allowing for introduction of viable fragments to new locations. Thus, motorized and non-motorized vessels, fishing equipment, and other water related paraphenalia or machines can all harbour and transport fragments of the plants as people move around (Eiswerth *et al.*, 2000).
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	difficult	high	Eradication may only be feasible in the initial stages of infestation (EPPO, 2015).
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism.	Southern and coastal Norway.	high	

Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.			
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	rapidly	medium	The species been in trade for a long time, but no establishment in the wild has been recorded from Sweden (ArtDatabanken, 2016) or Norway (Artsdatabanken, 2016). EPPO (2015) considers establishment likely in the temperate climate regions within the EPPO region. Climate is not such a strictly limiting factor for submerged aquatic plants as it is for terrestrial plant species. However, the Expert Working Group considers that Tundra and Taiga biomes in Scandinavia and Asia are unlikely to be invaded.

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	major	high	Dense mats of *M. heterophyllum* reduce light to other submerged plants and can affect water quality by reducing oxygen levels resulting in fish avoiding the infested area. Maximum dry weight recorded for this species is very high, measured at 4 kg m-2 in old infestations (fide Hussner, 2015 in EPPO, 2015). Additionally, the pH within *M. heterophyllum* stands can vary between 7 and 10.5 on a daily basis, increasing stress for fish populations and reducing available habitat for other macrophyte species. On the Oranjekanaal in the province of Drenthe (Netherlands) the turbidity of the water decreased greatly when *M. heterophyllum* invaded the canal (Matthews *et al.*, 2013). Retention of sediments can act to impede the lifecycle of high trophic levels by smothering spawning grounds for fish (EPPO, 2015).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	major	high	*Myriophyllum heterophyllum* has both environmental and economic impacts in the EPPO region. The species has impacts on ecosystem services, as seen in other regions where it is present (EPPO, 2015).
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	major	very high	In the USA, *M. heterophyllum* has the potential to hybridise with the native *M. pinnatum* forming *Myriophyllum heterophyllum x pinnatum* which is a more aggressive hybrid and considering the number of *Myriophyllum* 'species' in trade hybridization in future may result in more

			aggressive invasive species (Moody & Les, 2002; Thum & Lennon, 2006; Tavalire *et al.*, 2012). (EPPO, 2015).
2.16. 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	high	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	major	high	
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Southern and coastal Norway	high	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	major	high	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	high	
Summarise Establishment	likely	high	
Summarise Spread	rapidly	high	
Summarise Impact	major	high	
Conclusion of the risk assessment	high	high	EPPO (2015) concludes that *M. heterophyllum* poses an unacceptable risk in the EPPO region; and recommends that *M. heterophyllum* is included in the list of quarantine pests.

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Myriophyllum quitense* Kunth

Author: Hugo de Boer

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: The following species of *Myriophyllum* are native to Norway (Henriksen & Hilmo, 2015): *Myriophyllum verticillatum* L. (Rødliste VU-Sårbar), *Myriophyllum spicatum* L. (Rødliste LC-livskraftig), *Myriophyllum sibiricum* Kom. (Rødliste LC-livskraftig), *Myriophyllum alterniflorum* DC. (Rødliste LC-livskraftig).

DAISIE, EPPO and Q-Bank include the following established European invasives: *Myriophyllum heterophyllum* Michx. (a North American species extending into Ontario, Canada (Aiken, 1981) and *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe).

Fosså (2010) lists the following as occurring in commercial aquarium trade in Norway: *Myriophyllum aquaticum* (Vell.) Verdc. (a South American species that is invasive in both North America and Europe (DAISIE, accessed 2016; Q-Bank, accessed 2016), *M. mattogrossense* Hoehne (a tropical species from Brazil (tropica.com, accessed 2016)), *M. mezianum* Schindl. (a tropical species from Madagascar (Tropicos, accessed 2016)), *M. pinnatum* (Walter) Britton, Sterns & Poggenb. (a temperate species from northeastern to southern US (Aiken, 1981)), *M. propinquum* A.Cunn. (a temperate species from New Zealand, invasive in temperate areas in China, Japan, South Korea and Russia (Orchard, 1979; New Zealand's National Institute of Water and Atmospheric Research (NIWA)(accessed 2016), *M. simulans* Orchard (a southeastern Australia native (Orchard, 1986), and *M. tuberculatum* Roxb. (a subtropical species from India to China (Flora of China Editorial Committee, 2007)). The material traded as *M. propinquum* is likely mislabeled *M. simulans* (pers. comm. Johan van Valkenburg, 2016).

Only the non-tropical species are assessed here: *Myriophyllum aquaticum*, *M. heterophyllum*, and *M. quitense*.

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	*Myriophyllum quitense* Kunth.
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?	There are many synonymous names under which the species might be traded as well: *Myriophyllum chuquitense* Meyen *Myriophyllum elatinoides* Gaudich. *Myriophyllum elatinoides* var. *ternatum* (Gaudich.) Reiche *Myriophyllum pallidum* Rusby *Myriophyllum ternatum* Gaudich. *Myriophyllum ternatum* var. *tetraphyllum* Hook. & Arn. *Myriophyllum titikakense* Remy *Myriophyllum viridescens* Gillies ex Hook. & Arn.	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	Rapid risk assessment (NNSS 2015 *Myriophyllum quitense*)
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Yes	Rapid risk assessment (NNSS 2015 *Myriophyllum quitense*)
5. Where is the organism native?	Western North and South America (NNSS 2015 *Myriophyllum quitense*)	
6. What is the global distribution of the organism?	Western North and South America; Canada outside native distribution, Australia, New Zealand (NNSS 2015 *Myriophyllum quitense*)	
7. What is the distribution of the organism in Europe?	Not present	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	A weed of irrigation channels in south east Australia (Bill, 1969).

9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	No	No
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	No	None known.

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	few	medium	Horticultural trade, aquaria and garden ponds. *Myriophyllum quitense* is an attractive species, and popular in the online aquarium plant trade.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	See comment section.		Entry into the Europe is through the aquatic plant trade pathway.
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very likely	high	An estimated 5000 individuals of all *Myriophyllum* species are imported per year into Norway (Fosså, 2010).
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	very likely	medium	Entry into the Europe is through the aquatic plant trade pathway, *Myriophyllum* species are often misidentified, and this species appears to be available through online sale (EPPO, 2015).
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	very likely	high	Import of *Myriophyllum aquaticum* is currently not regulated and material is imported for Norwegian aquatic plants trade.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	medium	Viable plant material would need to survive sewage treatment facilities if disposed of through waste water; would need to spread from outside ponds, or would need to be dumped with aquarium or pond contents into a suitable habitat.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	M. quitense is common in rivers of Yellowstone National Park (Hellquist,, 2009). In the park it is found in four fast-flowing rivers where it forms emergent or submerged mats. It has been observed in various habitats from eutrophic to highly oligotrophic lakes and rivers (Ceska et al. 1986, Couch and Nelson, 1988). In New Brunswick it is found in upper estuarine waters (McAlpine et al. 2007). Inflorescences form when growing emergent in shallow waters. There appear to be no climatic or environmental barriers to establishment in the RAA (red. Great Britain) and any increase in trade would lead to inevitable escapes and establishment (NNSS, 2015).
1.8. How likely is it that the organism will be able to establish Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	likely	high	See comment 1.7.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	Found in freshwater lakes, rivers and streams, usually in cold nutrient-poor water (NNSS, 2015).
1.10. How likely is it that establishment will occur despite counteracting biological factors	likely	low	The habit preferences of floating and amphibious macrophytes do not overlap

such as competitors, predators, parasites or pathogens?			with many native species (except *Glyceria maxima*). Therefore there is little competition from existing species (NNSS, 2011).
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	low	Mechanical control will increase fragmentation of the plant which will aid dispersal within systems and increase the likelihood of spread between systems (NNSS, 2011).
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	likely	low	Can reproduce from seeds and plant fragments; potential for rapid spread if fragments enter fast flowing rivers or plants set seed in suitable locations (NNSS, 2015).
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	likely	medium	It is listed as non-native in Australia and east-coast Canada (NNSS, 2015).
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	likely	low	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	low	This is an invasive species. There appear to be no climatic or environmental barriers to establishment in southern Norway. The tolerance of this species to cold European winters is not well understood. (NNSS, 2015).

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	medium	The risk of the species spreading is high as movement through irrigation and river systems acts to connect countries, facilitating spread regionally (EPPO, 2015). Spread between isolated ponds is difficult and could be mediated by transfer on the feet of large birds (Geese and Swans). Spread within flowing systems is more likely due to increased risk of fragmentation over winter (NNSS, 2011).
2.2. How large is the expected spread of this organism in on the mechanisms for human-assisted spread.)	moderate	medium	Deliberate use in aquaria, and deliberate / accidental transfer to the wild aids rapid spread, increasing the risk of escape to natural areas (NNSS, 2011). The abundance of this species in aquaria in Norway is not documented.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	moderate	medium	*M. aquaticum* reproduction is by seeds and plant fragments and it overwinters in an evergreen condition. Long distance spread from the west coast to the east coast of Canada has been mediated by availability in the aquarium trade (McAlpine et al., 2007, Hellquist, 2009). Fragmentation in fast flowing rivers will result in rapid spread, and flowering could result in fertile seed set in suitable locations, resulting in possible rapid spread both between and within suitable habitats. (NNSS, 2015).
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and	Southern and coastal Norway	low	

comment on which areas in Norway are most likely to be affected.			
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	medium	Under a warmer climate scenario the species would be more likely to be able to establish in southern Norway.

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minor	medium	
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minor	medium	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minor	medium	In the USA, another species, *M. heterophyllum*, has the potential to hybridise with the native *M. pinnatum* forming *Myriophyllum heterophyllum x pinnatum* which is a more aggressive hybrid. Considering the number of *Myriophyllum* 'species' in trade hybridization in future may result in more aggressive invasive species (Moody & Les, 2002; Thum & Lennon, 2006; Tavalire *et al*., 2012). (EPPO, 2015).
2.16. 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	high	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		

2.18. 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 Norway?	minor	medium	
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Southern and coastal Norway	medium	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	minor	medium	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	high	
Summarise Establishment	unlikely	medium	
Summarise Spread	slowly	medium	
Summarise Impact	minimal	medium	
Conclusion of the risk assessment	low	medium	This is an invasive species. There appear to be no climatic or environmental barriers to establishment in southern Norway. The tolerance of this species to cold European winters is not well understood. (NNSS, 2015). Under a warmer climate scenario the species would be likely to be able to establish in southern Norway.

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Najas guadalupensis* (Spreng.) Magnus

Author: Kjersti Sjøtun

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: *Najas guadalupensisis* is native to North America. The species is characterized by a high number of subspecies, some of which have been shown to have a hybrid origin. *Najas guadulupensis* ssp. *guadulupensis* is native to North, Central and South America and it is found north to Alberta, Ontario and Quebec in Canada. It may therefore have the potential to establish in Northern Europe and perhaps Norway. *Najas guadalupensis* is commercialized in the aquarium trade, but the subspecies is not specifically mentioned (Fosså 2010). The subspecies has not been reported to be invasive. Several subspecies of *Najas* are reported to have a hybrid origin, possibly also *N. guadulupensis* ssp. *guadulupensis* since it is closely related to other subspecies (Les et al. 2010). Very little information is available on possible ecological impact or spreading capacity of *N. guadalupensis* ssp. *guadalupensis.* Since *Najas guadalupensisis* is being traded and different subspecies may easily be mixed up, the species is evaluated here and not the subspecies.

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?	North, Central and South America	
6. What is the global distribution of the organism?	North, Central and South America	
7. What is the distribution of the organism in Europe?	None	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	It is considered as a problematic and invasive plant some places in North America (unknown subspecies), for example Florida	http://wric.ucdavis.edu/information/natural%20aseas/wr_N/Najas_guadalupensis-marina.pdf
9. Describe any known socio-	Aquarium trade	

economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	None known	

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	very few	low	
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Aquarium trade		Unknown which subspecies
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	likely	low	The species is sold through Norwegian web pages and in aquaria shops
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	very unlikely	medium	It is already for sale in Norway
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment	very likely	low	It is already for sale in Norway

on the key issues that lead to this conclusion).			

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	unlikely	low	It is an aquarium plant
1.7. How likely is it that the organism will be able to establish Norway, based on the similarity between climatic conditions here and the organism's current distribution?	unlikely	low	This depends on the subspecies, and the most likely subspecies to establish in North Europe is *N. guadalupensis* ssp. *guadalupensis*. It is unlikely that this subspecies is common in the imported material of the species.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	medium	It inhabits still or slow moving waters and reservoirs.
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	moderately likely	medium	The species is reported to be an initial colonizer of artificial ponds (Les and Mehrhoff 1999)
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	medium	Mechanical removal can break stems of the plants, which my root again and form new vegetation
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	moderately likely	medium	It is not reported to spread widely, but may spread locally
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely	moderately likely	low	

is to establish in Norway? (If possible, specify the instances in the comments box.)			
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	very unlikely	low	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	low	The subspecies *N*ajas *guadalupensis* ssp. *guadalupensismay* well establish in Norway, but is unlikely to be the only, or most frequently subspecies to be imported

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	low	The species does not seem to spread rapidly or far. It has also been questioned to what degree it is introduced in all areas of the USA (Les and Mehrhoff 1999)
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	low	It may spread by stem fragments being attached to boats, ropes, fishing nets etc.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	easy	low	It is an aquarium plant and not likely to be released into lakes or ponds
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	[insert text]	low medium high very high	South Scandinavia
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	low	It is not reported to spread rapidly and seems not to be a very good competitor in general

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minor	low	The species may grow as a weed some places in its presumed introduced range, but it seems not to be a strong competitor
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minor	low	No ecosystem degrading is reported to be caused by the species
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minor	low	
2.16. 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	low	None reported
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	minor	low	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[insert text + attach map if possible]		
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	minor	low	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	medium	The species is sold from Norwegian web sites and in aquaria shops
Summarise Establishment	moderately likely	low	
Summarise Spread	slowly	low	
Summarise Impact	minor	low	
Conclusion of the risk assessment	low	low	

References:

Fosså SA (2010). Sluttrapport for prosjektet "*Vurdering av akvatiske organismer for positivlister*", DNs ref. 08040055. Del 3 Planter.

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Les DH, Sheldon SP, Tippery NP (2010). Hybridization in Hydrophiles: Natural Interspecific Hybrids in *Najas* (Hydrocharitaceae). *Systematic Botany* 35: 736-744.

http://wric.ucdavis.edu/information/natural%20aseas/wr_N/Najas_guadalupensis-marina.pdf

https://drive.google.com/drive/folders/0B3TscF_Fm7UOUENRTGFyckU5UW8

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Najas minor* All.

Author: Kjersti Sjøtun

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: *Najas minor* is native to Europe and western Asia and has become invasive in USA (first record in 1934). It is compact and bushy, and can grow to more than 1 m in height. It prefers stagnant or slow-moving waters, such as ponds, lakes, reservoirs. It is capable of growing in depths of up to 4 m. It is tolerant of turbidity and eutrophic conditions and can replace native species in these habitats, but Trebitz and Taylor (2007) only found it in a subset of the Great lakes in USA. The introduction vector of *N. minor* to USA is not clear as it is not used in aquaria etc., but genetic analyses suggests that multiple introductions have taken place (Les et al. 2015). It may have been accidentally introduced together with other cultivated plants, or by boat traffic (Les et al. 2015, Stratford and Hoyle 2011). *Najas minor* can form dense, monospecific stands in the shallow waters, it may alter the environmental conditions and make it unfavourable for many native species (Stallings et al. 2015). It reproduced by seeds and fragmentation and is easily spread by boat traffic or currents etc. (Stratford and Hoyle 2011), or by birds.

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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?	*Najas minor* All.	It can easily be confused with some other *Najas* species
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	From USA	See:http://nas.er.usgs.gov/queries/GreatLakes/FactSheet.aspx?NoCache=7%2F6%2F2010+9%3A34%3A25+AM&SpeciesID=1118&State=&HUCNumber=DErie
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	It is a very recent risk (July 2016) assessment so it is entirely valide.	
5. Where is the organism native?	Europe, northern Africa and large parts of Asia.	http://e-monocot.org/
6. What is the global distribution of the organism?	Middle, eastern and southern Europe, Northern Africa (Algeria, Egypt, Libya, Morocco, Tunisia), large parts of Asia. Introduced to USA.	http://e-monocot.org/
7. What is the distribution of the organism in Europe?	Belarus, Russia, Ukraine, Austria, Belgium, Czechoslovakia, Germany, Hungary, Netherlands, Poland, Switzerland, Bulgaria, Italy, Romania, Turkey-in-Europe, Yugoslavia, France, Portugal, Spain	http://e-monocot.org/
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	USA	
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	None known	

Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	None known	

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	few	medium	
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Animals (attached seed), ships, together with cultivated plants.		Introduction to USA is most likely unintentional and with an unknown vector. Escapes from waterfowl food plant propagation programmes have been suggested (Les et al. 2015).
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	unlikely	medium	Since the vector of introduction is generally unknown the probability of further introductions to other countries is difficult to assess.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	moderately likely	medium	The species is not traded for aquaria, but the fact that it has accidentally been introduced to USA could imply that it is likely to enter Northern Europe
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	moderately likely	medium	

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	likely	medium	Since the species has been transferred to a suitable habitat in the introduced region, it should be likely to do the same in North Europe
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	likely	medium	The climate conditions in the introduced region in USA is comparable to temperature regimes in parts of Norway
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	medium	
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	likely	medium	The species has had several introductions to the USA, suggesting that provided an introduction vector exists, it can easily become established.
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	likely	medium	The species fragments easily, and can reproduce through fragmentation. This makes it very difficult to control.
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	very likely	medium	The species have spread readily after introduction in the USA
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If	likely	low	The species has had several introductions to the USA, but since the introduction vector is still unknown it is difficult to estimate the risk of

possible, specify the instances in the comments box.)			introduction to Norway. It an appropriate introduction vector should become available the risk could become higher.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	moderately likely	medium	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	likely	medium	The species is present in central Europe, has good spreading capacity and is already invasive in USA

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	medium	The species is present in many countries in central Europe, further spread may possibly be expected with warmer climate.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	moderate	medium	It can be confused with other *Najas* or accidentally follow other plants
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	medium	It is unlikely to be held in aquaria, and would most likely be a pond plant.
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	South Scandinavia	medium	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	moderately	medium	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	medium	The species can form dense meadows excluding native species and altering ecosystems. On the other hand it is not a very common invasive plant in its introduced area, and is considered to have moderate environmental impact in the Great lakes in USA.
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	moderate	medium	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minor	low	*Najas minor* has not been reported to hybridize
2.16. 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	medium	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	moderate	medium	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	South Scandinavia	medium	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	moderate	medium	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	moderately likely	medium	
Summarise Establishment	likely	medium	
Summarise Spread	Moderately fast	medium	
Summarise Impact	moderate	medium	
Conclusion of the risk assessment	moderate	medium	

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http://e-monocot.org/

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Potamogeton* spp.

Author: Kjersti Sjøtun

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: This is a species rich genus with a wide and global distribution. In Norway 15 species are recorded, where six are in the Norwegian red list (Artsdatabanken, http://www.artsdatabanken.no/). In tropical or sub-tropical areas around 30 species are found, and in temperate regions (Norway excluded) around 40 species are found. Of these, six species occurring in sub-tropical or temperate areas are found in Europe outside Norway (eMonocot, http://www.emonocot.org/). In addition to the high number of species numerous hybrids are reported (Kaplan & Fehrer 2013). Many taxa are very difficult to separate from morphological features alone.

Seven species are listed in the trade according to Fosså (2010); *P. crispus*, *P. dentatus* (syn. for *P. lucens*), *P. gayi*, *P. natans*, *P. perfoliatus*, *P. schweinfurthii* and *P. wrightii*. Of these, the following are native in Norway; *P. crispus*, *P. lucens* (on the Norwegian red list as vulnerable), *P. natans*, *P. perfoliatus*.

There are not many reports of introduced *Potamogeton* species. *Potamogeton crispus* (native to Eurasia, Africa and Australia) has been reported to be an invasive species in North-America and India (Catling and Dobson 1985, Bhatt 2012). DASIE (http://www.europe-aliens.org/) lists four *Potamogeton* species as introduced in Europe; *P. compressus* (to Hungary), *P. epihydrus* (established in UK in 1907, Online Atlas of the British and Irish Flora), *P. nodosus* (to Luxenbourg) and *P. trichoides* (to Belgium). In addition, *P. lucens* and *P. natans* have been reported to be invasive in India (Bhatt 2012). Of these, the following are reported to be native in Norway: *P. crispus*, *P. compressus*, *P. trichoides*, *P. lucens* and *P. natans*. *Potamogeton compressus*, *P. trichoides* and *P. lucens* are on the red list of Norway (Artsdatabanken, http://www.artsdatabanken.no/).

Based on the above, the following species will be assessed: *Potamogeton crispus*, *P. lucens*, *P. natans, P. perfoliatus*. *P. schweinfurthii, P. wrightii, P. epihydrus, P. nodosus*, *P. trichoides*, *P. compressus*. *Potamogeton gayi* is a tropical/subtropical taxa from South-America and is not assessed here. However, *P. gayi* may possibly be able to establish in Norway in a time perspective of > 50 years. In order to make the assessment easier to read the taxa are divided in two main groups; present and not present in Norway. Here, *Potamogeton* species which are not present in Norway, but which have been listed in the trade and/or have been recorded as introduced will be assessed: *P. schweinfurthii, P. wrightii, P. epihydrus, P. nodosus.*

Potamogeton schweinfurthii, P. epihydrus and P. nodosus all have more or less lanceolate leaves floating on the surface, and may in that respect superficially resemble *P. natans* (present in Norway).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**COMMENT –not present in Norway**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	*Potamogeton schweinfurthii* A.Benn. *Potamogeton wrightii* Morong *Potamogeton epihydrus* Raf. *Potamogeton nodosus* Poir.	
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	*Potamogeton schweinfurthii*: Not found *Potamogeton wrightii*: Not found *Potamogeton epihydrus*: Not found (It is on the UK red list) *Potamogeton nodosus*. Not found	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?	*Potamogeton schweinfurthii*: Africa, South Europe (Spain, Italy, Greece) *Potamogeton wrightii*: Asia, Australia (tropical, subtropical and temperate distribution) *Potamogeton epihydrus*: North America *Potamogeton nodosus*: Very wide global distribution. Widespread in Europe but not recorded in Scandinavia	
6. What is the global distribution of the organism?	*Potamogeton schweinfurthii*: Several countries in southern Europe, nearly all countries in Africa except for some on the west side, Gulf states, Yemen *Potamogeton wrightii*: Southern parts of middle and far East Asia, IndiPacific Islands *Potamogeton epihydrus*: North America (Canada, USA), Cuba, UK	

	Potamogeton nodosus: Wide global distribution (North and South America, Eurasia, Africa, Australia)	
7. What is the distribution of the organism in Europe?	*Potamogeton schweinfurthii:* Greece, Italy, Spain, Portugal *Potamogeton wrightii:* Not present in Europe *Potamogeton epihydrus:* UK (introduced) *Potamogeton nodosus:* Baltic States, Belarus, Russia, Krym, Ukraine, Austria, Czechoslovakia, Germany, Hungary, Netherlands, Poland, Switzerland, Great Britain, Albania, Bulgaria, Greece, Italy, Romania, Turkey-in-Europe, Yugoslavia, France, Portugal, Spain	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	*Potamogeton schweinfurthii*: No *Potamogeton wrightii*: No *Potamogeton epihydrus*: Introduced and established in UK *Potamogeton nodosus*: No	
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	*Potamogeton schweinfurthii*: Aquaculture trade *Potamogeton wrightii*: Aquaculture trade *Potamogeton epihydrus*: Not known *Potamogeton nodosus*: Not known	
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	None known	

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	very few	medium	All species
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Aquarium trade Web pages		
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately	medium	All species
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	moderately likely	medium	*Potamogeton nodosus:* Moderately likely since it is present close to Scandinavia, *P. epihydrus* moderately likely since it has been detected in several countries and have become introduced unnoticed In addition P. *schweinfurthii*, *P. epihydrus* and *P. nodosus* share some resemblance to *P. natans*,

			which is present in Norway, and may be mixed up with this. *P. wrightii*: Unlikely
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	unlikely moderately likely	medium	*Potamogeton nodosus:* Moderately likely since it is in close vicinity to Scandinavia The other three: Unlikely Potamogeton is a genus used in ponds, an das such not very likely to be imported in Norway

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	If plants are imported for use in ponds an escape is on eth other hand moderately
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	unlikely moderately likely	medium	*Potamogeton epihydrus*: Moderately likely since it already is established in UK *Potamogeton nodosus*: Moderately likely since it already is present close to Scandinavia *Potamogeton schweinfurthii*: Unlikely since it occurs in subtropical areas mainly *Potamogeton wrightii*: Unlikely since it is not present in Europe
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	unlikely moderately likely	medium	*Potamogeton epihydrus*: Moderately likely *Potamogeton nodosus*: Moderately likely *Potamogeton schweinfurthii*: Unlikely *Potamogeton wrightii*: Unlikely
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	moderately widespread	medium	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	unlikely moderately likely	medium	*Potamogeton epihydrus*: Moderately likely *Potamogeton nodosus*: Moderately likely *Potamogeton schweinfurthii*: Unlikely *Potamogeton wrightii*: Unlikely
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	unlikely moderately likely	medium	*Potamogeton epihydrus*: Moderately likely *Potamogeton nodosus*: Moderately likely *Potamogeton schweinfurthii*: Unlikely *Potamogeton wrightii*: Unlikely

1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	unlikely	low	*Potamogeton epihydrus*: Unlikely since it has not been spreading much*Potamogeton nodosus*: Unlikely *Potamogeton schweinfurthii*: Unlikely *Potamogeton wrightii*: Unlikely Not much is known about spreading ways for these species
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	unlikely moderately likely	medium	*Potamogeton epihydrus*: Moderately likely since it has been reported to be introduced to Europe The three others: Unlikely
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	unlikely	medium	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	unlikely	medium	Only *P. epihydrus* has been reported to be introduced to Europe, but it is not reported to be traded.

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minor	low	All four are assessed to have minor spreading. *Potamogeton epihydrus* is spreading slowly, and the others have most likely spread to their distribution limits with in their geographical ranges. Continuous spreading will most likely depend on climate development.
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minor	low	
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	[insert text]		
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	slowly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minimal	medium	All four
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minimal	medium	All four
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	medium	All four
2.16. 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	medium	All four
2.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Europe?	minimal	medium	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[insert text + attach map if possible]		

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	unlikely moderately	medium	Moderate for species reported from in aquarium trade
Summarise Establishment	unlikely	medium	
Summarise Spread	slowly	low	
Summarise Impact	minimal	medium	
Conclusion of the risk assessment	low	medium	

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Kaplan Z, Fehrer J (2013). Molecular identification of hybrids from a former hot spot of *Potamogeton* hybrid diversity. *Aquatic Botany* 105: 34-40.
Online Altlas of the British and Irish Flora: http://www.brc.ac.uk/plantatlas/index.php?q=node/1028

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Salvinia natans* (L.) All.

Author: Hugo de Boer

Reviewer: Hans K. Stenøien

Risk Assessment Area: Norway

Introduction to genus/species: *Salvinia natans* is a free-floating fern, growing in large populations at the surface of stagnant waters or in weak currents: ditches, canals, ponds, oxbows. It is often associated to Lemnaceae and other floating plants. It is considered annual in the wild, but it can be perennial in vitro (Lansdown, 2013). *Salvinia natans* is an Eurasiatic (palaeotemperate) species, essentially located in central and eastern Europe and in Asia, from Caucasus to China and Japan. In Europe, it is sparsely distributed from the Rhine valley (Germany) to Russia, and southwards, from northern Italy, to the Danube basin towards the Black Sea, and to northern Greece. It is exceptional and very unstable westwards in Belgium, in France and in northwestern Spain. It occurs, among others, in the following Mediterranean countries: France, Greece, Croatia, Italy, and Spain (Lansdown, 2013). It does not occur in Scandinavia.

Draft: 2

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	No	
5. Where is the organism native?	In Europe *S. natans* is native in Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Germany; Greece (Greece (mainland)); Hungary; Italy (Italy (mainland)); Lithuania; Macedonia, the former Yugoslav Republic of; Moldova; Poland; Romania; Russian Federation (Central European Russia, East European Russia, South European Russia); Serbia (Serbia); Slovakia; Slovenia; Spain (Spain (mainland)); Turkey (Turkey-in-Europe); Ukraine (Krym, Ukraine (main part)) (Lansdown, 2013).	
6. What is the global distribution of the organism?	Europe, Asia, and possibly North Africa (Algeria) (Daoud-Bouattour et al, 2010).	
7. What is the distribution of the organism in Europe?	In Europe *S. natans* occurs in Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Republic; Germany; Greece (Greece (mainland)); Hungary; Italy (Italy (mainland)); Lithuania; Macedonia, the former Yugoslav Republic of; Moldova; Poland; Romania; Russian Federation (Central European Russia, East European Russia, South European Russia); Serbia	

	(Serbia); Slovakia; Slovenia; Spain (Spain (mainland)); Turkey (Turkey-in-Europe); Ukraine (Krym, Ukraine (main part)) (Lansdown, 2013).	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	No	The species appears to be declining throughout much of its European range with some local extinction, however the cause of the decline is not known (Lansdown, 2013).
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information	The species is used as an ornamental plant in basins but is found in trade less frequently than other *Salvinia* species (Lansdown, 2013). The species is commercialized in the pond plant trade in Norway (Fosså, 2010).	Fosså (2010) reports that the majority of plants imported into Norway are from cultivation in Denmark, the Netherlands, Singapore and Sweden.
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information	No	None known.

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	very few	high	
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	See comment section.		International pond trade, namely intentional trade from pond plant nurseries to wholesalers and retailers in Norway (Fosså, 2010). The species is used as ornamental plant in basins but is found in trade less frequently than other *Salvinia* species (Lansdown, 2013).
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very likely	high	As little as 1000 individuals of all *Salvinia* species are estimated to be imported per year, but the species is very easy to propagate (Fosså, 2010). Most people will propagate the species themselves, through other hobbyists, or get locally propagated material through retailers.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	likely	medium	Insufficiently marked commercial material could be imported without documentation. Private import of material could occur through the internet or international travel.

1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	very likely	very high	Import of *Salvinia natans* is currently not regulated and material is imported for Norwegian pond trade.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	Viable plant material would need to survive sewage treatment facilities if disposed of through waste water; would need to spread from outside ponds, or would need to be dumped with pond contents into a suitable habitat.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	unlikely	high	Only a single find of *Salvinia natans* has been reported from Scandinavia. This concerned a temporary or remaining (Tillfällig alt. kvarstående förekomst)(Artdatabanken, 2016).
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	unlikely	high	*Salvinia natans* is an Eurasiatic palaeotemperate species, essentially located in central and eastern Europe and in Asia, from Caucasus to China and Japan. In Europe, it is sparsely distributed from the Rhine valley (Germany) to Russia (Lansdown, 2013).
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	widespread	very high	*Salvinia* natans is a free-floating fern, growing in large populations at the surface of stagnant waters or in weak currents: ditches, canals, ponds, oxbows. It is often associated to Lemnaceae and other floating plants. (Lansdown, 2013).
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	unlikely	medium	
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	unlikely	medium	Eutrophic estuaries and brackish areas and lakes are common in southern Scandinavia, and are minimally managed.
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread,	unlikely	high	The species is easy to propagate, but it is considered annual in the wild. In addition, it seems likely that it is showing an overall decline throughout its range.

adaptability, genetic variation, to facilitate its establishment?			
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	very unlikely	high	The species been in trade for a long time, but only a single transient establishment has been recorded from southern Sweden (Artdatabanken, 2016).
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	unlikely	medium	See 1.13 above.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	unlikely	high	The species been in trade for a long time, but only a single transient establishment has been recorded from southern Sweden (Artdatabanken, 2016).

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	minimal	high	The species is in decline along its northern distribution limit (Lansdown, 2013).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minimal	high	Transient populations in Northern Europe are extremely rare, and have never spread (Artdatabanken, 2016).
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	easy	high	Eradication of aquatic plants is always challenging, and transient populations would need to be manually removed from areas where it occurs. This would require removal of all vegetative matter. However, the species is extremely rare and targeted eradication should be feasible.
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	Southern Norway	high	But the level of this threat is very low.
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	very slowly	high	The species been in trade for a long time, but only a single transient establishment has been recorded from southern Sweden (Artdatabanken, 2016). This population have not spread, and the species remains extremely rare.

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minimal	high	
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minimal	very high	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	very high	
2.16. 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	high	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	NA		
2.18. 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 Norway?	minimal	high	

2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Southern Norway	high	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	minimal	very high	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	high	
Summarise Establishment	unlikely	high	
Summarise Spread	very slowly	high	
Summarise Impact	minimal	high	
Conclusion of the risk assessment	low	high	

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Daoud-Bouattour, A., Gammar-Ghrabi, Z., Limam-Ben Saad, S. & Muller, S.D. 2010. *Salvinia natans*. The IUCN Red List of Threatened Species 2010: e.T163996A5688854. . Downloaded on 14 April 2016.

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Trapa natans L*

Author: Hanne Hegre Grundt and Hans K. Stenøien

Author: Hugo de Boer

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: (European) Water chestnut (*Trapa natans*) is an annual aquatic plant of temperate and tropical freshwater habitats. It currently belongs to the Lythraceae family (formerly placed in a family of its own – Trapaceae). *Trapa natans* is native to Eurasia and Africa. It is partly cultivated for its edible nuts. The species was formerly widespread in continental Northern Europe, particularly during the sub-boreal period.

Not to be confused with the Chinese water chestnut, an *Eleocharis* species (*E. dulcis*) with edible corms.

Draft: 26th of February

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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?	Not really	The species is highly variable, and there are a lot of different synonyms out there. Seems to be mostly treated in a wide sense.
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)	Use it in the wide sense	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk	Yes, but relevant for the US http://dnr.wi.gov/files/PDF/pubs/ss/SS1054.pdf	There are also quite a few fact sheets from the US: http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/factsheet/water-chestnut.pdf http://www.seagrant.sunysb.edu/ais/pdfs/WaterChestnutFactsheet.pdf http://www.invasivespeciesinfo.gov/aquatics/waterchestnut.shtml http://www.seagrant.umn.edu/ais/waterchestnut Australia: http://www.weeds.org.au/cgi-bin/weedident.cgi?tpl=plant.tpl&card=W27

assessment)		http://weeds.dpi.nsw.gov.au/Weeds/Details/172
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Valid for the US	
5. Where is the organism native?	Asia, Africa, Europe	According to the Global Invasive Species Database, the alien range is Australia, Burkina Faso, Germany, Sweden, Belgium, Canada, Netherlands and United States, partly in contrast to the native countries listed in the geographic range in the IUCN Red List.
6. What is the global distribution of the organism (excluding Europe)?	Asia, Africa, Australia and USA	
7. What is the distribution of the organism in Europe?	Southern and Central Europe	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes, in Australia and USA	
9. Describe	The species is in trade.	

any known socio-economic benefits of the organism in the risk assessment area.		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	few	very high	It is imported and sold for usage in aquaria.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	It could be imported through regular mail service from online sales abroad, besides regular import and sale in registered stores.		Intentional
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately	medium	Fosså estimates approximately <500 individual shipments imported to Norway each year of this species. It is thus a medium popular plant for recreational use, and it seems likely that this species is imported on a regular basis, possibly in large numbers.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.	moderately likely	low	The volume of non-regulated import is hard to estimate.
1.5. Estimate the overall likelihood of entry into Norway,	very likely	medium	It is used in commercial aquarium industry. There will

based on all pathways (comment on the key issues that lead to this conclusion).			be annual import of the species to Norway.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	This can only happen by spread intentional release from an aquarium into a natural habitat. We know that at least the latter occurs from time to time. Given that this should be a low to moderately popular aquarium plant, it still seems likely that such release into the wild will happen somewhere in Norway in a 50 year perspective. The probability that the habitat is suitable may be moderately high, given that the has been naturally growing in southern Sweden in the past.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	low	
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	isolated	low	
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	moderately likely	low	
1.11. How likely is it that establishment will occur despite	moderately likely	low	

counteracting anthropogenic factors such as existing management practices?			
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	moderately likely	low	
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	unlikely	medium	The species is in decline in Europe as a whole, and there are no signs of a sudden spread in Scandinavia as of today. The species is known to be a serious pest in other parts of the world (including Northeastern USA), and given progressing climate change, it is not impossible that the species could exhibit a higher degree of invasiveness also in Norway in the future.
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	moderately likely	low	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	unlikely	low	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	low	Potentially large, the plant produces ramets that can break off and move away from the rest of the clone and survive to produce seeds. This attribute allows for rapid clonal expansion (1).

2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minor	low	This necessitates intentional spread of the species.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	It is most likely that Southern Norway would be affected, given previous natural range in Southern Sweden.	medium	
2.5. Estimate the overall potential speed for future spread for this organism in Norway (using the comment box to indicate any key issues).	Moderately fast	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	medium	The reduced plant growth combined with the decomposition of the water chestnut plants which die back each year can result in reduced levels of dissolved oxygen in the water, impact other aquatic organisms, and potentially lead to fish kills. The rapid and abundant growth of water chestnut can also out-compete both submerged and emergent native aquatic vegetation (2).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	major	medium	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	
2.16. 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	low	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minor	medium	The plant is nutrient-rich and used as a medicinal plant (3).
2.18. How important are the expected impacts of the organism despite any natural control by other organisms, such	minor	low	

as predators, parasites or pathogens that may already be present in Norway?			
2.19. Indicate any parts of Northern Europe, e.g., Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	[insert text + attach map if possible]	low medium high very high	
2.20. Estimate the overall impact of species in Northern Europe, e.g., Norway (using the comment box to indicate any key issues).	moderate	low	"Moderate" instead of "Minor" because of the relatively large impact of the species in other parts of the non-native species range.

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	very likely	medium	
Summarise Establishment	unlikely	low	
Summarise Spread	moderately fast	low	
Summarise Impact	moderate	low	
Conclusion of the risk assessment	moderate	medium	

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2. O'Neill CR 2006. Water Chestnut (Trapa natans) in the Northeast. NYSG Invasive Species Factsheet Series: 06-1.
3. Shalabh B, Akash J, Jasmine C 2012. *Trapa natans* (water chestnut): an overview. International Research of Pharmacy 3: 31-33.

NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Vallisneria spiralis* L.

Author: Iris Stiers

Author: Iris Stiers

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: *Vallisneria spiralis* is a submerged macrophyte possessing strap-shaped, up to 100 (600) cm long leaves which is widespread in tropical and subtropical areas of both hemispheres. The species can be present in static or flowing freshwater habitats, including lakes, ponds, water courses, and wetlands with a minimal temperature of 5°C (Collas et al. 2012). In central and western Europe (Hussner and Lösch 2005; Ejsmont-Karabin & Hutorowicz 2011) the species is only present in geothermally heated water bodies which are relatively rare habitats. *V. spiralis* is able to reproduce vegetatively and can disperse via water (hydrochory), humans and bird vectors, displaying a strong reproductive potential (Hussner and Lösch 2005; Van Leeuwen 2012). Impacts reported up to now include displacement of native macrophytes, effects on the drainage of different water bodies and on the recreational use (Ejsmont-Karabin & Hutorowicz 2011; CABI 2012).

Draft:

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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	**Name:** *Vallisneria spiralis* L. **Synonyms:** *Vallisneria jacquini* Savi, *Vallisneria jacquiniana* Sprengel, *Vallisneria micheliana* Sprengel, *Vallisneria michelii* Savi, *Vallisneria pusilla* Barbieri ex Bertoloni **Preferred common name:** eelweed, eelgrass, tape grass
2. If not a single taxonomic entity, what are the taxonomic challenges, and how is the taxon defined here?		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	Yes	Risk analysis of non-native Tapegrass (*Vallisneria spiralis*) in the Netherlands (Matthews et al. 2012) Horizon scanning carried out in Great Britain: (http://publications.naturalengland.org.uk/publication/40015).
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	Partly valid	Partly valid - completed for the UK and the Netherlands, not specifically for Norway
5. Where is the organism native?	Northern Africa, Southern Europe and Asia	
6. What is the global distribution of the organism?	Cuba, USA, Jamaica, Russia, New Zealand	
7. What is the distribution of the organism in Europe?	Albania, Austria, Belgium, Bulgaria, Croatia, Denmark, UK, France,	Recently found in Iceland in geothermal ponds (Wasowicz et al. 2014)

	Germany, Greece, The Netherlands, Poland, Romania, Russia, Serbia, Spain, Switzerland, Czech Republic, Hungary, Moldova, Macedonia	
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	Displacement of native submerged macrophytes in heated lakes in Poland (Ejsmont-Karabin & Hutorowicz 2011).
9. Describe any known socio-economic benefits of the organism in the risk assessment area. Subnote: Background information		
10. Describe any known negative effects on the biodiversity in the exporting country resulting from the harvest of this species. Subnote: Background information		

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	very high	Aquarium plant Sale through internet, horticulture and aquarium trade, pet shops, garden centers.
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Intentional trade Accidental as a contaminant		Intentional for trade but also as a contaminant with other plants offered for sale, and on boats and other equipment
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately unlikely	medium	*V. spiralis* is a common aquarium plant in Norway, perhaps since 120 years ago, but in spite of the long use of this species there are no documented establishments in nature in Norway (Fossa 2011).
1.4. How likely is the organism to Norway,	likely	medium	Contaminant with other plants offered for sale, and on boats and other equipment.

undetected? Describe if it is likely to enter undetected as a contaminant, via the internet or as a misidentification.			
1.5. Estimate the overall likelihood of entry into Northern Europe, e.g., Norway, based on all pathways (comment on the key issues that lead to this conclusion).	likely	high	*V. spiralis* is deliberately imported for trade. It is also available to purchase from vendors on the internet for use in garden ponds. e.g. http://www.thatpetplace.com/Vallisneria-spiralis-italian-val-208905

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	high	Dumping of plant material (Hussner and Lösch 2005; Martin and Coetzee 2011).
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	unlikely	high	The species has been recorded in water bodies with a wide variety of temperatures (18.1-39 °C) and does not tolerate water temperatures below 5° C (Collas et al. 2012). In central and western Europe the species is only present in geothermal ponds or thermally abnormal rivers.
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	medium	Static or flowing freshwater habitats, including lakes, ponds, water courses, and wetlands. The species occurs on muddy, sandy and gravelly sediment and can tolerate low light conditions, low to high pH and low and high nutrient conditions (Collas et al. 2012).
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	isolated	low	Restricted due to temperature limit. There are no hot springs in Norway.
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	moderately likely	high	*V. spiralis* is not naturally controlled by any predator, parasite or pathogen in Norway.
1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	moderately likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	moderately likely	high	*V. spiralis* is able to reproduce vegetatively and can disperse via water (hydrochory), humans and bird vectors, displaying a

			strong reproductive potential (Hussner and Lösch 2005; Van Leeuwen 2012).
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	unlikely	medium	
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	moderately likely	medium	Freely available on the internet followed by dumping of plant material in nature.
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	unlikely	medium	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	major	medium	
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	major	medium	Dumping of plant material in water bodies. Movement of plant fragments from one water body to another by boats, anglers, water flow, waterfowl... (Hussner and Lösch 2005; Van Leeuwen 2012).
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	Static or flowing freshwater habitats, including lakes, ponds, water courses, and wetlands with min. temperature of 5°C	low	
2.5. Estimate the overall speed of future spread of this organism in Norway (using the comment box to indicate any key issues).	very slowly	low	

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	moderate	high	*V.spiralis* completely displaced native submerged macrophytes in heated lakes in Poland (Bakbo et al. 2010; Ejsmont-Karabin and Hutorowicz 2011). The plant formed a dense mono-species meadow at a depth of up to 2.5 m (Bakbo et al. 2010).
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minimal	high	No adverse effects of *V. spiralis* where found.
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	
2.16. 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	medium	No information is available on the transmission of parasites and diseases by *V. spiralis*.
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minor	high	In its native habitat the species is known to maintain a high water transparency in the water which inhibits the growth and blooms of blue- green algae (Collas et al. 2012). Used to some extent for phytoremediation (Yan et al. 2011).
2.18. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or	minor	low	According to Hussner and Lösch (2005) *V. spiralis* may become naturalized in Western and Central Europe if, by global warming, average water

pathogens that may already be present in Norway?			temperatures will increase even by only one or two degrees. There are no known natural control agents that are specific to *V. spiralis*.
2.19. Indicate any parts of Norway, where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Static or flowing freshwater habitats, including lakes, ponds, water courses, and wetlands with min. temperature of 5°C	medium	
2.20. Estimate the overall impact of species in Norway (using the comment box to indicate any key issues).	minor	medium	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	likely	high	
Summarise Establishment	unlikely	medium	
Summarise Spread	very slowly	low	
Summarise Impact	minor	medium	
Conclusion of the risk assessment	low	medium	

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NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Adapted version for assessment of risks to Norwegian biodiversity from the import and keeping of aquarium and garden pond plants by the Norwegian Scientific Committee for Food Safety.

Name of organism: *Wolffia arrhiza* (L.) Horkel ex Wimmer

Author: Hanne Hegre Grundt and Hans K. Stenøien

Author: Hugo de Boer

Reviewer: Hugo de Boer

Risk Assessment Area: Norway

Introduction to genus/species: The genus *Wolffia* comprises approximately 10 species and belongs to the family Lemnaceae. They are typically found in warm temperate and tropical regions. *Wolffia arrhiza* is the smallest European vascular plant, and it is distinguished from the duckweeds in *Spirodela* and *Lemna* by being rootless.

Draft: 26th of February

Note:

•Risk assessments should have a forward looking time frame of 50 years or 5 generations for organisms with a generation time of more than 10 yrs.

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE [chose one entry, delete all others]**	**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?	Mostly so	Wolffia species are easily overlooked in the field and/or misidentified, and it has been suggested that even more unknown occurrences of alien Wolffia species might occur in Europe (1).
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)		
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?		
5. Where is the organism native?	Europe, Africa, western Asia, Brazil	The alleged native occurrence in Rio de Janeiro, Brazil, seems a bit odd/suspect. May also be alien in some of the European countries as well (Hungary, Belarus, Italy and Sicily are mentioned in DAISIE).
6. What is the global distribution of the organism (excluding Europe)?	Africa, western Asia, Brazil, California (introduced)	
7. What is the distribution of the organism in Europe?	Europe, apart from the northernmost part	Recently found in Sweden as a new species for the Nordic countries (Ljungstrand 2013)
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or	No, but it is naturalized several places according to some sources (https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?403878) See also: http://www.cabi.org/isc/datasheet/117895	*Wolffia arrhiza* is not mentioned as invasive in the alien databases, but it is, however, named an invasive

ecosystems) anywhere in the world?		aquatic plant in a paper by Ariyaratne (2010). It seems unclear what is meant by invasive and whether other duckweed species are included.
9. Describe any known socio-economic benefits of the organism in the risk assessment area.	Aquarium plant	

SECTION B – Detailed assessment			
PROBABILITY OF ENTRY			
Important instructions: • Entry is the introduction of an organism into Norway. Not to be confused with spread, the movement of an organism within Norway. • For organisms which are already present in Norway, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms that have entered in the past and have no current pathways of entry.			
QUESTION	**RESPONSE [chose one entry, delete all others]**	**CONFIDENCE [chose one entry, delete all others]**	**COMMENT**
1.1. How many known active pathways are relevant to the potential entry of this organism?	moderate number	medium	It is imported and sold for usage in aquaria. It has also been suggested to be naturally spread to Scandinavia by birds (2).
1.2. List relevant pathways through which the organism could enter, and describe the pathway (intentional/ accidental). Where possible give detail about the specific origins and end points of the pathways.	Natural introduction by birds. It could be imported through regular mail service from online sales abroad, besides regular import and sale in registered stores.		Intentional, and natural
1.3. 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? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	moderately	medium	Fosså estimates approximately <100 individual shipments imported to Norway each year of this species. It is thus not among the most popular plants for recreational use, but it seems likely that this species is imported on a regular basis.
1.4. How likely is the organism to enter Norway, undetected? Describe if it is likely to enter undetected as a contaminant, via	moderately likely	low	The volume of non-regulated import is hard to estimate.

the internet or as a misidentification.			
1.5. Estimate the overall likelihood of entry into Norway, based on all pathways (comment on the key issues that lead to this conclusion).	likely	medium	It is used in commercial aquarium industry. There will be annual import of the species to Norway.

PROBABILITY OF ESTABLISHMENT			
Important instructions: • For organisms which are already well established in Norway, only complete question 1.9 and then move onto the spread section.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
1.6. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	moderately likely	medium	It has been suggested to be naturally spread to southern Sweden (2). Transfer can also theoretically happen by intentional release from an aquarium into a natural habitat, even though it is not specifically known to have occurred for this species in Europe (2). Given that this should be a low to moderately popular aquarium plant, it still seems likely that such release into the wild will happen somewhere in Norway in a 50 year perspective. The probability that the habitat is suitable may be moderately high, given that the has been naturally growing in southern Sweden in the past.
1.7. How likely is it that the organism will be able to establish in Norway, based on the similarity between climatic conditions here and the organism's current distribution?	moderately likely	medium	It is found in Southern Sweden today, and is known to survive well with winter temperatures down to 4C.Survive winters by specialized shoots (turions). Summer temperatures seem to be the main limiting factor (2).
1.8. How likely is it that the organism will be able to establish in Norway, based on the similarity between other abiotic conditions here and the organism's current distribution?	moderately likely	low	
1.9. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in Norway?	isolated	low	Occurs in nutrient rich, eutrophic environments, common in the more warmer parts of Europe.
1.10. How likely is it that establishment will occur despite counteracting biological factors such as competitors, predators, parasites or pathogens?	moderately likely	low	

1.11. How likely is it that establishment will occur despite counteracting anthropogenic factors such as existing management practices?	moderately likely	low	
1.12. How likely are the biological characteristics of the organism, e.g., capacity of spread, adaptability, genetic variation, to facilitate its establishment?	moderately likely	low	
1.13. Based on the history of invasion by this organism elsewhere in the world, how likely is to establish in Norway? (If possible, specify the instances in the comments box.)	moderately likely	low	
1.14. If the organism does not establish, then how likely is it that transient populations will continue to occur? Subnote: Red-eared Terrapin, a species which cannot re-produce in GB but is established because of continual release, is an example of a transient species.	moderately likely	low	
1.15. Estimate the overall likelihood of establishment in Norway (mention any key issues in the comment box).	moderately likely	low	

PROBABILITY OF SPREAD			
Important notes: • Spread is defined as the expansion of the geographical distribution of an organism within an area.			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENT**
2.1. How large is the expected spread of this organism in Norway, by natural means? (Please list and comment on the mechanisms for natural spread.)	moderate	low	Known to be able to spread to Scandinavia, probably by natural means (2). Spreads by vegetative means, with a high capacity for spread, and flowering individuals only found in the tropics (2).
2.2. How large is the expected spread of this organism in Norway, by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	minor	low	This necessitates intentional spread of the species.
2.3. Within Norway, how difficult would it be to contain the organism? Subnote: Consider whether the plant is kept as an aquarium or as a garden pond plant.	with some difficulty	low	The plant is extraordinary small.
2.4. Based on the answers to questions on the potential for establishment and spread in Norway, define the area endangered by the organism. Subnote: The assessments are national, but please note and comment on which areas in Norway are most likely to be affected.	It is most likely that Southern Norway would be affected, given previous natural range in Southern Sweden.	medium	
2.5. Estimate the overall potential speed for future spread for this organism in Norway (using the comment box to indicate any key issues).	Moderately fast	low	It is able to spread rather rapidly by vegetative means.

PROBABILITY OF IMPACT			
Important instructions: • Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).			
QUESTION	**RESPONSE**	**CONFIDENCE**	**COMMENTS**
2.12. How important is the current and potential negative impact of the organism on biodiversity (e.g., decline in native species, changes in native species communities, hybridisation) (include any past impact in your response)?	minor	medium	
2.13. How important is the current and potential alteration of ecosystem function (e.g., habitat change, nutrient cycling, trophic interactions), including losses to ecosystem services, caused by the organism (include any past impact in your response)?	minor	medium	
2.14. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their environmental effects more serious?	minimal	low	
2.16. 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	low	
2.17. How important might other impacts (including positive impacts) not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minor	medium	
2.18. 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 Norway?	minor	low	

2.20. Estimate the overall impact of species in Northern Europe, e.g., Norway (using the comment box to indicate any key issues).	minor	low	

RISK SUMMARIES			
	RESPONSE	**CONFIDENCE**	**COMMENT**
Summarise Entry	moderately likely	low	
Summarise Establishment	moderately	low	
Summarise Spread	moderately fast	low	
Summarise Impact	minor	low	
Conclusion of the risk assessment	minor	medium	

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