Risk analysis of the Water Primrose, *Ludwigia peploides* (Kunth) P.H. Raven

Risk analysis report of non-native organisms in Belgium

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Adopted in date of : 11 March 2013

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Etienne Branquart (Cellule Espèces Invasives, Service Public de Wallonie) developed the risk analysis template that was used for this exercise.

The general process of drafting, reviewing and approval of the risk analysis for selected invasive alien species in Belgium was attended by a steering committee, chaired by the Federal Public Service Health, Food chain safety and Environment. RBINS/KBIN was contracted by the Federal Public Service Health, Food chain safety and Environment to perform PRA's for a batch of species. ULg was contracted by Service Public de Wallonie to perform PRA's for a selection of species. INBO and DEMNA performed risk analysis for a number of species as in-kind contribution.

Steering committee members were:

Tim Adriaens	Research Institute for Nature and Forest (INBO)
Olivier Beck	Brussels Environment (BIM)
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Rationale and scope of the Belgian risk analysis scheme

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species. It strongly promotes the use of robust and good quality risk assessment to help underpin this approach (COP 6 Decision VI/23). More specifically, when considering trade restrictions for reducing the risk of introduction and spread of a non-native organisms, full and comprehensive risk assessment is required to demonstrate that the proposed measures are adequate and efficient to reduce the risk and that they do not create any disguised barriers to trade. This should be seen in the context of WTO and free trade as a principle in the EU (Baker et al. 2008, Shine et al. 2010, Shrader et al. 2010).

This risk analysis has the specific aim of evaluating whether or not to install trade restrictions for a selection of absent or emerging invasive alien species that may threaten biodiversity in Belgium as a preventive risk management option. It is conducted at the scale of Belgium but results and conclusions could also be relevant for neighbouring areas with similar eco-climatic conditions (e.g. areas included within the Atlantic and the continental biogeographic regions in Europe).

The risk analysis tool that was used here follows a simplified scheme elaborated on the basis of the recommendations provided by the international standard for pest risk analysis for organisms of quarantine concern[1] *produced by the secretariat of the International Plant Protection Convention (FAO 2004). This logical scheme adopted in the plant health domain separates the assessment of entry, establishment, spread and impacts. As proposed in the GB non-native species risk assessment scheme, this IPPC standard can be adapted to assess the risk of intentional introductions of non-native species regardless the taxon that may or not be considered as detrimental (Andersen 2004, Baker et al. 2005, Baker et al. 2008, Schrader et al. 2010).*

The risk analysis follows a process defined by three stages : (1) the <u>*initiation process*</u> *which involves identifying the organism and its introduction pathways that should be considered for risk analysis in relation to Belgium, (2) the* <u>*risk assessment stage*</u> *which includes the categorization of emerging non-native species to determine whether the criteria for a quarantine organism are satisfied and an evaluation of the probability of organism entry, establishment, spread, and of their potential environmental, economic and social consequences and (3) the* <u>*risk management stage*</u> *which involves identifying management options for reducing the risks identified at stage 2 to an acceptable level. These are evaluated for efficacy, feasibility and impact in order to select the most appropriate. The risk management section in the current risk analysis should however not been regarded as a full-option management plan, which would require an extra feasibility study including legal, technical and financial considerations. Such thorough study is out of the scope of the produced documents, in which the management is largely limited to identifying needed*

1 A weed or a pest organism not yet present in the area under assessment, or present but not widely distributed, that is likely to cause economic damages and is proposed for official regulation and control (FAO 2010).

actions separate from trade restrictions and, where possible, to comment on cost-benefit information if easily available in the literature.

This risk analysis is an advisory document and should be used to help support Belgian decision making. It does not in itself determine government policy, nor does it have any legal status. Neither should it reflect stakeholder consensus. Although the document at hand is of public nature, it is important to realise that this risk assessments exercise is carried out by (an) independent expert(s) who produces knowledge-based risk assignments sensu Aven (2011). It was completed using a uniform template to ensure that the full range of issues recognised in international standards was addressed.

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted (after Baker et al. 2008):

2. *Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based;*
3. *The risk assessment deals with potential negative (ecological, economic, social) impacts. It is not meant to consider positive impacts associated with the introduction or presence of a species, nor is the purpose of this assessment to perform a cost-benefit analysis in that respect. The latter elements though would be elements of consideration for any policy decision;*
4. *Completed risk assessments are not final and absolute. New scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.*

Ludwigia peploides (Photo: Père Igor ; Wikimedia Commons).

Executive summary

PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

- Entry in Belgium

Because of its aesthetic value, *L. peploides* – originated from the America - is introduced intentionally as an ornamental plant. Readily purchasable in garden centers and on the internet (sometimes sold under different names), horticultural trade is considered as the main pathway of entry in Belgium. Invasion by natural dispersion from neighboring countries, particularly from northern France, can be considered as a possible secondary pathway and may become increasingly important in the coming years.

- Establishment capacity

Able to grow in a broad range of habitats, *L. peploides* can colonize most of the wetlands, ditches, and slow flowing rivers in Belgium. Many of these wetlands habitats are endangered, sensitive or have a high biodiversity status (e.g. natural reserve or Natura2000 sites). Nowadays mostly found in the Flanders district, the species could benefit from slight climatic warming and colonize most of the territory's water systems.

- Dispersion capacity

Fragmentation of stems and dispersion through water flow is the main mode of natural dispersal of *Ludwigia peploides.* Anthropogenic activities may enhance dispersal through dissemination of plant fragments, e.g. with management machinery and equipment or through weed cutting or negligent aquacultural practice. Its high degree of phenotypic plasticity and genetic polymorphism allows the species to adapt to a broad range of conditions, habitats and water regimes, enhancing further invasions.

EFFECT OF ESTABLISHMENT

- Environmental impacts

Rapid development of dense mat of stems and leaves causes competitive exclusion, declines in native biodiversity, affecting particularly native flora (through allelopathy) as well as invertebrates, and fishes due to a reduction of the quality of their habitat. High density of *L. peploides* alters chemical characteristics of the environment and may cause hypoxia. Heavy infestation alters water chemistry and reduces and/or blocks slow-moving waterways (impacting irrigation or drainage) and may also cause hyper-sedimentation and silting of lakes, ponds and ditches.

RISK MANAGEMENT

In Belgium *L. peploides* is available in horticultural trade and subsequent (non)accidental introduction into the wild is highly likely to occur. Most of the time this happens through disposal of garden wastes in natural areas. Spread from populations in neighbouring countries, though possible is considered as a secondary pathway of entry in our country. Once established and if detected early enough, small populations, can be controlled with a relatively high chance of success. At later stages of invasion, control actions to keep the population to an acceptable level are considered as extremely difficult and expensive.

Means of control include mechanical removing by rotovation or handpulling, introduction of a control agent (e.g.the beetle *Lysathia ludoviciana)* and the use of chemicals such as halosulfuron-methyl, glyphosate and triclopyr based herbicide. It is important to note that the use chemical weed control in an aquatic environment is extremely regulated in Belgium. Above-mentioned means may also have undesirable collateral impacts. The practical control options should then focus on prevention and integrated non-chemical methods. Increasing public awareness on *L. peploides* and as a result, its subsequent limitation of use, remains the most effective mean of control of this species.

Preventive actions should lead to a total ban of any *L. peploides* trade through amendments of existing legislation. Promoting, highlighting and supporting an "Invasive Species Code of Practice" (such as proposed by AlterIAS) to commercial sector bodies and to the great public could raise awareness on environmental risks caused by *L. peploides* introduction (and subsequent possible dissemination into the wild and invasion).

Résumé

PROBABILITE D'ETABLISSEMENT ET DE DISSEMINATION (EXPOSITION)

- Introduction en Belgique

Du fait de sa valeur esthétique, *Ludwigia peploides,* d'origine américaine, a été initialement introduite de manière délibérée comme plante ornementale. Elle est actuellement largement vendue dans le commerce et sur internet (parfois sous différents noms) pour ses qualités esthétiques. Le commerce horticole est considéré comme la principale voie d'introduction de cette espèce en Belgique. Son envahissement par dispersion naturelle au départ des pays voisins et plus particulièrement du Nord de la France, peut être considéré comme une éventuelle voie d'introduction secondaire qui pourrait prendre de l'importance dans les années à venir.

- Capacité d'établissement

L. peploides est capable de croître dans différents types d'habitats aquatiques et peut coloniser la majorité des zones humides, les fossés et les cours d'eau à débit lent de Belgique. Un grand nombre de ces habitats humides sont en danger ou sensibles et bénéficient d'un statut de protection en raison de leur haute valeur pour la biodiversité (p. ex. les réserves naturelles ou les sites Natura 2000). Aujourd'hui, cette espèce se retrouve principalement en Flandre mais un léger réchauffement climatique pourrait lui permettre de coloniser la majorité des réseaux hydrographiques du territoire.

- Capacité de dispersion

La fragmentation des tiges et leur dispersion par le courant constitue le principal mode de dispersion naturelle de *Ludwigia peploides.* Les activités anthropiques peuvent favoriser cette dispersion par transport de fragments de la plante, notamment par le biais de machines et équipements utilisés pour la gestion des cours d'eau, le désherbage ou les pratiques aquacoles négligées ou non contrôlées. *L. peploides* présente un degré élevé de plasticité phénotypique et son polymorphisme génétique lui permet de s'adapter à un large éventail d'habitats et de régimes hydrologiques, ce qui favorise grandement sa capacité de dispersion.

EFFET DE L'ETABLISSEMENT

- Impacts environnementaux

Le développement rapide de *L. peploides* en tapis denses de tiges et de feuilles induit une exclusion par compétition des espèces indigènes. Portant particulièrement préjudice à la flore indigène (par allélopathie), des effets néfastes s'observent également sur les populations d'invertébrés et de poissons du fait de la diminution de la qualité de leur habitat. Une forte densité de *L. peploides* modifie les caractéristiques chimiques de l'environnement et peut conduire à l'hypoxie du milieu aquatique. Les denses tapis de plantes entravent le libre écoulement des cours d'eau (empêchant l'irrigation ou le drainage) et peut provoquer une hypersédimentation et un envasement des étangs, rivières et fossés.

GESTION DES RISQUES

En Belgique, *L. peploides* est disponible dans le commerce horticole et son introduction (non)accidentelle subséquente dans la nature est donc hautement probable. Ceci est en général souvent le fait de dépôts de déchets de jardin dans la nature. La dissémination à partir des pays voisins, bien qu'elle soit possible, est considérée comme une voie d'introduction secondaire de l'espèce dans notre pays. Une fois établies, les petites populations détectées suffisamment tôt peuvent être contrôlées avec un taux de réussite relativement élevé. Aux stades ultérieurs de l'envahissement, les actions de contrôle de l'espèce pour maintenir les populations existantes à un niveau acceptable sont considérées comme extrêmement difficiles et onéreuses.

Les moyens de contrôle de l'espèce comprennent l'arrachage mécanique par sarclage ou arrachage manuel, l'introduction d'un agent de contrôle (p. ex. le coléoptère *Lysathia ludoviciana*) ou l'utilisation de substances chimiques comme des désherbants à base d'halosulfuron-méthyle, de glyphosate et de *triclopyr*. Il est cependant important de noter que l'utilisation de substances chimiques de désherbage dans l'environnement aquatique est strictement régulé en Belgique. Les moyens de contrôle repris ci-dessus peuvent cependant avoir des effets collatéraux indésirés. Les mesures pratiques de contrôle de l'espèce devront par conséquent privilégier la prévention et les méthodes non chimiques intégrées. Une prise de conscience accrue du public, et son impact subséquent pour une limitation dans l'utilisation de *L. peploides,* reste actuellement le moyen de contrôle le plus efficace pour contrôler cette espèce.

Les actions préventives devraient mener à la suppression totale du commerce de *L. peploides* par le biais d'amendements à la législation existante. Parallèlement, des campagnes de sensibilisation visant à limiter son utilisation et préconisant un "Code de conduite face aux espèces envahissantes" (comme proposé par AlterIAS LIFE) pour les entreprises commerciales et le grand public pourraient entraîner une prise de conscience des risques environnementaux liés à l'introduction de *L. peploides* (ainsi que les modalités de sa dissémination et de son envahissement subséquents potentiels).

Samenvatting

WAARSCHIJNLIJKHEID VAN VESTIGING EN VERSPREIDING (BLOOTSTELLING)

- Introductie in België

Omwille van haar esthetische waarde werd de van oorsprong Amerikaanse *L. peploides* opzettelijk als sierplant geïntroduceerd. Vermits deze soort vlot verkrijgbaar is in tuincentra en op het internet (soms aangeboden onder andere namen), wordt de tuinbouwsector beschouwd als de voornaamste introductieweg in België. Invasie door natuurlijke verspreiding vanuit de buurlanden, met name vanuit Noord-Frankrijk, kan worden beschouwd als een mogelijke secundaire weg die in de komende jaren nog aan belang kan winnen.

- Vestigingsvermogen

Omdat *L. peploides* in een ruime waaier aan habitats gedijt, kan ze de meeste watergebieden, sloten en traag stromende rivieren in België koloniseren. Heel wat van deze habitats zijn bedreigd of gevoelig en hebben een hoge biodiversiteitsstatus (vb. natuurgebieden of Natura2000 gebieden). De soort, die vandaag overwegend in Vlaanderen wordt aangetroffen, kan haar voordeel doen met een lichte klimaatopwarming en is in staat de meeste watersystemen op het grondgebied in te lijven.

- Verspreidingsvermogen

Ludwigia peploides verbreidt zich vooral door fragmentatie van de stengels en verspreiding via waterlopen. Antropogene activiteiten, vb. door machines en uitrusting gebruikt voor het beheer, het afsnijden van onkruid, of door onachtzame praktijken bij aquacultuur, kunnen de verbreiding van plantfragmenten nog verder in de hand werken. Door haar hoge fenotypische plasticiteit en genetisch polymorfisme kan de soort zich aan een ruime waaier van omstandigheden, habitats en waterregimes aanpassen, wat verdere invasies kan bevorderen.

EFFECTEN VAN DE VESTIGING

- Milieu-impact

De snelle ontwikkeling van ondoordringbare matten van stengels en bladeren veroorzaakt competitieve exclusie van inheemse soorten, een verarming van de inheemse flora en aantasting van de fitness van gevoelige inheemse plantensoorten (door allelopathie) en een vermindering van de habitatkwaliteit voor ongewervelden en vis. De soort wijzigt ook de chemische karakteristieken van de omgeving. Zware aantasting veroorzaakt hypoxie, verandert de chemische samenstelling van het water, vermindert het debiet of sluit traag stromende waterlopen af (met gevolgen voor de irrigatie, drainage in meren, vijvers en sloten) en kan ook hypersedimentatie en verzilting veroorzaken.

RISICOBEHEER

L. peploides is in België beschikbaar in de horticulturele sector.Als gevolg daarvan is de kans op (on)opzettelijke introductie ervan in het wild bijzonder groot. Dit gebeurt wellicht voornamelijk door het dumpen van tuinafval in de natuur. Hoewel de verspreiding van populaties vanuit buurlanden niet uit te sluiten valt, wordt deze introductieweg in ons land als secundair beschouwd. Op voorwaarde dat ze snel genoeg wordt opgemerkt, kan de soort gecontroleerd worden met een relatief hoge kans op succes. In latere stadia van invasie zijn controleacties om de populatie op een aanvaardbaar peil te handhaven doorgaans bijzonder moeilijk en duur.

Bestrijding kan gebeuren door mechanische verwijdering (uitfrezen of manueel uittrekken) met manuele nazorg voor verwijdering van alle plantfragmenten, biologische bestrijding (vb. de kever *Lysathia ludoviciana)* of chemische bestrijding met herbiciden op basis van halosulfuron-methyl, glyfosaat en triclopyr. Het gebruik van chemische onkruidbestrijding in aquatisch milieu in België is zeer strikt gereglementeerd. Alle vermelde methodes kunnen ongewenste neveneffecten hebben. De praktische controleopties moeten daarom focussen op preventie en op geïntegreerde niet-chemische methodes.

Voornaamste middel in de strijd tegen deze soort blijft een beperking van het gebruik door een verhoogde bewustmaking van het publiek. Preventieve acties moeten leiden tot een totaal verbod op de handel van *L. peploides* via wijzigingen van de bestaande wetgeving. Het bevorderen, belichten en ondersteunen van een “Gedragscode Invasieve Planten” (zoals voorgesteld door AlterIAS) voor de commerciële sector en voor het grote publiek kunnen het bewustzijn voor de milieurisico's veroorzaakt door de vestiging en invasie van *L. peploides* vergroten.

STAGE 1: INITIATION

Precise the identity of the invasive organism (scientific name, synonyms and common names in Dutch, English, French and German), its taxonomic position and a short morphological description. Present its distribution and pathways of quarantine concern that should be considered for risk analysis in Belgium. A short morphological description can be added if relevant. Specify also the reason(s) why a risk analysis is needed (the emergency of a new invasive organism in Belgium and neighboring areas, the reporting of higher damages caused by a non native organism in Belgium than in its area of origin, or request made to import a new non-native organism in the Belgium).

1.1 ORGANISM IDENTITY

Scientific name :	***Ludwigia peploides*** (Kunth) P.H. Raven, 1963
Synonyms:	*Jussiaea patibilcensis* Kunth., 1823 *Jussiaea peploides* Kunth., 1823 *Jussiaea polygonoides* Kunth., 1823 *Jussiaea repens* var. peploides (Kunth.) Griseb., 1866 *Ludwigia adscendens* var. peploides (Kunth.) H. Hara, 1953 *Ludwigia clavellina* var. peploides (Kunth.) H. Hara *Jussiaea gomezii* Ram. Goyena, 1909 *Jussiaea diffusa* auct non Forssk
Common names :	Kleine waterteunisbloem (NL); Jussie rampante, Jussie d'Orx (FR) ; California water primrose, creeping water primrose, creeping water primrose, floating primrose, floating primrose willow, floating primrose willow, floating water primrose, marsh purslane (EN); berro de clavo, berro de clavo, clavo de playa, clavo de playa, duraznillo de agua, enramada de las taraias, flor de arenal, flor de arenal, flor de laguna, onagraria (SP); Flutende Heusenkraut (DE).
Taxonomic position:	Domain: *Eukaryota* / Kingdom: *Plantae* / Phylum: *Spermatophyta* / Subphylum: *Angiospermae* / Class: *Dicotyledonae* / Order: *Myrtales* / Family: *Onagraceae* / Genus: *Ludwigia* / Species: *Ludwigia peploides*

Remark*: Information presented in the following descriptive chapters are largely inspired from the "Invasive Species Compendium" Pest Risk Analysis (PRA available athttp://www.cabi.org)* and the EPPO PRA on *Ludwigia peploides* (EPPO 2011).

1.2 SHORT DESCRIPTION

L. peploides is an emergent and floating herbaceous perennial macrophyte. It has glabrous or pubescent stems of 1-30 dm that can creep horizontally or grow vertically. Early growth resembles a rosette of rounded leaves growing on the water's surface. leaves are alternate, polymorphic, less than 10 cm long and oblong to round, often lanceolate at flowering. The species exhibits root dimorphism and has adventitious roots that form at nodes and ensure oxygen uptake. Flowers grow from leaf axils are 5-merous (pentamerous), with bright yellow petals, and can be from 7 to 24 mm long. The fruit is a five-angled reflexed capsule, about 3 cm long that contains 40-50 seeds of 1.0-1.5 mm long, embedded in the inner fruit wall (EPPO, 2004; The Jepson Online Interchange, 2009).

Remark: attention should be drawn to the fact that *L. peploides* is very likely to be confused with other *Ludwigia* species. Zardini *et al.* (1991) report that taxa of the sect. *Oligospermum* are "notoriously difficult taxonomically; morphological distinctions between them are often not sharp". The entire sect. *Oligospermum* is a polyploid complex whose members form a very closely related group. *L. peploides* is especially similar to *Ludwigia grandiflora* and *Ludwigia hexapetala.* These plants can be distinguished by their flowers. *L. peploides* has stems that grow more horizontally, the petals are usually 1.0-1.5 cm long and anthers are 1.0-1.7 mm, whereas *L. grandiflora* and *L. hexapetala* have stems that grow vertically and have larger petals and anthers. Additionally, the small leaves at the base of the flower are triangular to egg-shaped in *L. peploides*, whereas those of *L. hexapetala* are ovate (Dandelot, 2004).

1.3 ORGANISM DISTRIBUTION

Native range

L. peploides is native to South and Central America and parts of the USA. Countries where *L. peploides* grows originally are listed below:

- Central America: Cuba, Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti; Honduras, Jamaica, Nicaragua; Panama, Puerto Rico .

- **South America**: Argentina (where it is known to occur in Buenos Aires, Corrientes, Entre Rios, Formosa, Mendoza, Salta, Santa Fe, Tucuman), Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela.

- **North America** : United States (Alabama, Arkansas, California, Florida, Georgia, Indiana, Illinois, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, Tennessee, Texas) and Mexico.

Note : It is suggested that the species may also be native to Australia (McGregor *et al.*, 1996; USDA-ARS, 1997) but there is some disagreement about this (CEH, 2007).
Recent reports of the plant from New York and Washington, USA indicate that its range may be expanding in the USA (Peconic Estuary Program, 2009; Washington State Department of Ecology, 1994-2009; The Jepson Online Interchange, 2009).

Introduced range

Belgium:
L. peploides was first observed in Belgium in 1995 (Flora data Bank, accessed in 2013), and

has since established isolated populations in Flanders (Flandrian and Brabant district essentially). Although most of the available records are reliable, it is realistic to assume that some misidentification with *L. grandiflora* is possible.

Rest of Europe:
L. peploides is established in France (Dutartre *et al.*, 2007), including Corsica (Jeanmonod & Schlüssel, 2007), Greece (Zotos *et al.*, 2006), Italy (Celesti-Grapow *et al.*, 2009), the Netherlands (Holverda *et al.* 2009), Spain (Verloove & Sánchez Gullón, 2008), Turkey (near Antalya; Güner *et al.*, 2000), and the UK (BSBI, 2011).

Other continents:

- **Australasia**: Australia (New South Wales, Northern Territory, Queensland, South Australia, Victoria) (Richardson *et al.*, 2007; Australia's Virtual Herbarium, 2011), New Zealand (north island) (Webb *et al.*, 1988; Roy *et al.*, 2004).
- **Africa**: Madagascar (GBIF Portal, 2011)
- **Asia**: Thailand, Taiwan (GBIF Portal, 2011).

1.4 REASONS FOR PERFORMING RISK ANALYSIS

Ludwigia peploides is able to grow in a wide variety of habitats where it can transform ecosystems both physically and chemically. Its ability to proliferate by means of vegetative growth, coupled with a high degree of phenotypic plasticity (allowing the species to adapt to a broad gradient of ecological conditions; Ruaux *et al.*, 2009), also means that the plant is quite likely to establish upon release. It can form nearly impenetrable mats; displacing native flora and interfering with flood control and drainage systems (possibly affecting agriculture), clogging waterways and impacting navigation as well as recreation (Peconic Estuary Program, 2009). The plant also has allelopathic activity that can lead to dissolved oxygen deficiency, accumulation of sulphide and phosphate, 'dystrophic crises' and intoxicated ecosystems (Dandelot *et al.*, 2005).

L. peploides is a fast-growing emergent aquatic perennial plant that became one of the most damaging invasive plants since its introduction in 1830 (Dandelot *et al.*, 2008). It is often sold as an ornamental, which probably explains its introduction to Europe.

In Belgium, *L. peploides* has a high potential to become a problematic invasive the more so if the climate warms.

4.1 PROBABILITY OF ESTABLISHMENT AND SPREAD (EXPOSURE)

Evidence should be available to support the conclusion that the non-native organism could enter, become established in the wild and spread in Belgium and neighbouring areas. An analysis of all associated pathways from its origin to its establishment in Belgium is required. Organisms intentionally imported may be maintained in a number of intended sites for an indeterminate period. In this specific case, the risk may arise because of the probability to spread and establish in unintended habitats nearby intended introduction sites.

2.1.1 Present status in Belgium

Specify if the species already occurs in Belgium and if it has self-sustaining populations in the wild (establishment). Provide details about the species' abundance and distribution in Belgium if establishment is confirmed and indicate the potential area of further spread within Belgium.

Deliberately introduced in the mid-nineties, *L. peploides* is nowadays established in the Flandrian and Brabant sector in Belgium (see figure 1). Populations are still few (similar to Corsica, Greece, Italy, The Netherlands, Spain, Turkey, and the UK) and invasion is still considered to be at an early stage. In the Meuse, Ardenne, Lorraine and the Kempen district, the species is not yet established and only observed occasionally (Verloove, 2006).

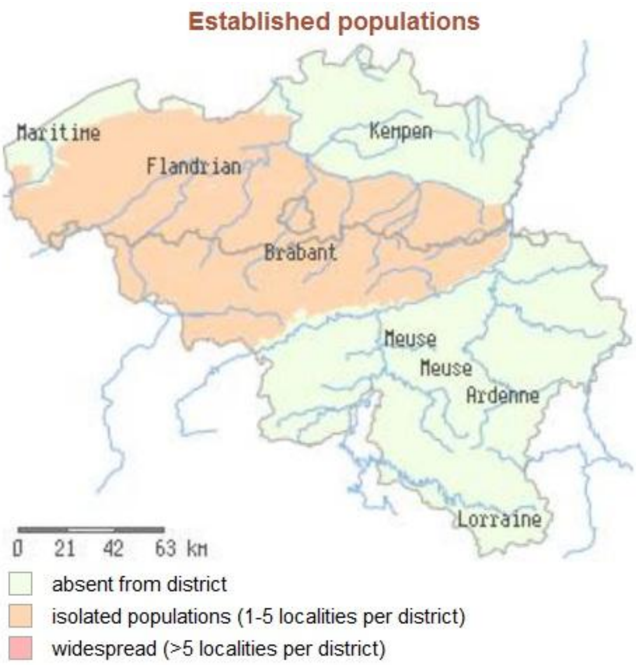


Figure 1. Geographic distribution of *Ludwigia peploides* in Belgium.
Source: http://ias.biodiversity.be/species/show/12

2.1.2 Present status in neighbouring countries

Mention here the status of the non-native organism in the neighbouring countries.

- In France: *L. peploides* was introduced from the Americas to Montpellier in the 1830s, probably for ornamental planting. It has since become one of the most widespread and detrimental aquatic invasive plants in the country (Ruaux *et al.*, 2009). It is actually present at hundreds of sites in Southern and Western France (see figure 2). *L. peploides* more recently spread to some sites in the North and East of France (Dutartre, 2004a).

In Corsica, *L. peploides* was found near the golf course of Lezza where it is cultivated for ornamental purposes. The species grows in the river, and has not outcompeted other vegetation, probably because the water course is only temporary, a sub-optimal condition not allowing the species to exhibit invasive behavior (Jeanmonod & Schlüssel, 2007).

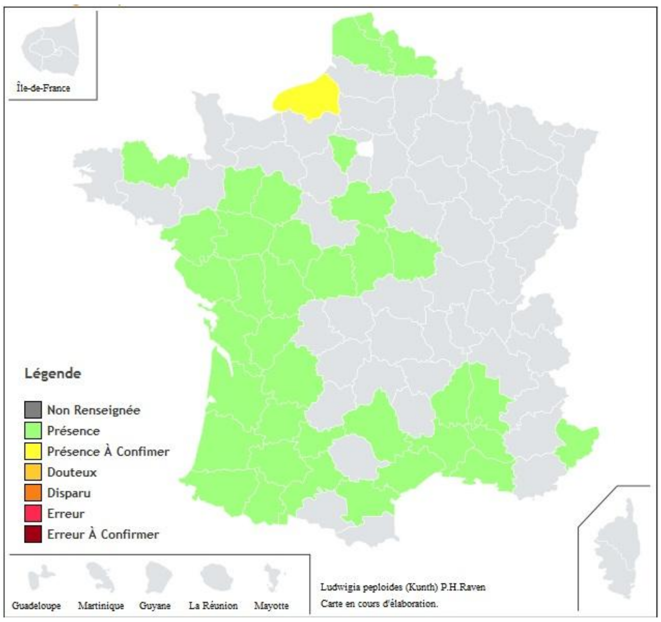


Figure 2. Map of departments where populations of *L. peploides* are established in France. Source: Tela Botanica 2007.

- **In Italy**: The species was first recorded in Italy in 2004 (Galasso & Bonali, 2007). It occurs in Lombardia, Emilia-Romagna and is considered invasive in the provinces of Cremona and Lodi (Banfi & Galasso, 2010).

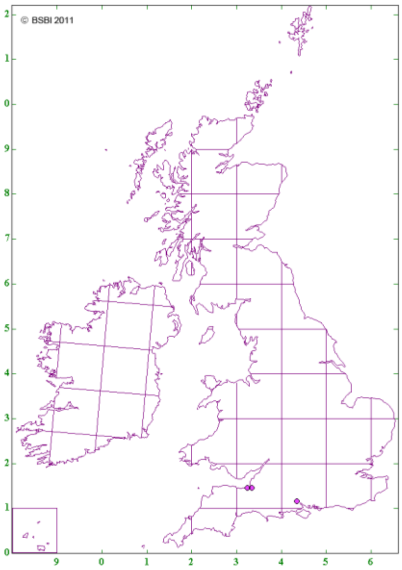
- **In Spain:** According to Verloove & Gullon (2008), *Ludwigia peploides* is well naturalized at various localities along river El Llobregat in the province of Barcelona, and it is also present in La Selva del mar in the Province of Gerona (EPPO 2011).

- **In Greece***:* *L. peploides* was recorded in 2001 in western Greece in 3 localities near lake Lysimachia covering 0.7 ha with a population of over 10 000 individuals (Zotos *et al.* 2006).

- **In the Netherlands**: *L. peploides* was found in 4 sites located in South Holland and North Brabant (see figure 3). The first official records are from 2007 (initially identified as *L. grandiflora* (J. van Valkenburg, pers. comm., 2011 in EPPO PRA). It disappeared from one site without any intervention. It was successfully removed from another site by the water board. A third infestation covering several hundred square meters was removed in 2007, and regrowth has not been observed since (June 2010). One other site is being managed (Proosdij & van Valkenburg, in prep.; EPPO 2011).

Figure 3. Geographic distribution of *L. peploides* in The Netherlands based on records from January 2000 to December 2012. Source: http://waarneming.nl

- **In the UK and Ireland:** In the UK, the species was reported from 3 locations in southern Great Britain in 2006 (DEFRA, 2006 ; see figure 4).



1930-1999 (0 hectads); 2000-2009 (3 hectads); 2010- (0 hectads)

Figure 4. Hectad map of *Ludwigia peploides* in GB and Ireland. Source: Botanical Society of the British Isles Mass Scheme. http://www.bsbimaps.org.uk/atlas/map_page.php?spid=23557.0&sppname=Ludwigiapeploides&commname=Floating Primrose Willow

2.1.3 Introduction in Belgium

Specify what are the potential international introduction pathways mediated by humans, the frequency of introduction and the number of individuals that are likely to be released in Europe and in Belgium. Consider the potential for natural colonisation from neighbouring areas where the species is established and compare with the risk of introduction by the human-mediated pathways. In case of plant or animal species kept in captivity, assess the risk for organisms escape to the wild (unintended introductions).

As in many countries of the EPPO region, *Ludwigia peploides* is available from garden centres or internet shops. In Belgium a recent socio-economic report on the trade of invasive plant demonstrated that *L. peploides* is effectively sold by about 3% of the retailers that took part in the census (over a total of 67 volunteer; Halford *et al*., 2011). It is, however quite often sold under different names and the expansion of this species is mainly due to human transport and introduction for ornamental purposes.

Populations in neighbouring countries are still considered as being at an early stage of invasion. So far, populations in The Netherlands do not seem to spread to a threatening level. In France, however, expansion occurs in the south-western part of the country and more recently also in northern departments. Due to this proximity, further expansion by natural dispersion is likely to occur and represent a threat of invasion in Belgium.

ENTRY IN BELGIUM
Because of its aesthetic value, *L. peploides* is introduced intentionally as an ornamental plant. Readily purchasable in garden centers or on the internet (sometimes sold under different names), commerce represents the main pathway of entry in our country. Invasion by natural dispersion from neighboring countries (particularly northern France) can be considered as a possible secondary pathway of entry in Belgium, and may become increasingly important in the coming years.

2.1.4 Establishment capacity and endangered area

Provide a short description of life-history and reproduction traits of the organism that should be compared with those of their closest native relatives (A). Specify which are the optimal and limiting climatic (B), habitat (C) and food (D) requirements for the organism's survival, growth and reproduction both in its native and introduced ranges. When present in Belgium, specify agents (predators, parasites, diseases, etc.) that are likely to control population development (E). For species absent from Belgium, identify the probability for future establishment (F) and the area most suitable for species establishment (endangered area) (G) depending if climatic, habitat and food conditions found in Belgium are considered as optimal, suboptimal or inadequate for the establishment of a reproductively viable population. The endangered area may be the whole country or part of it where ecological factors favour the establishment of the organism (consider the spatial distribution of preferred habitats). For non-native species already established, mention if they are well adapted to the eco-climatic conditions found in Belgium (F), where they easily form self-sustaining populations, and which areas in Belgium are still available for future colonisation (G).

A/ Life-cycle and reproduction

This species has a seasonal development. In France, leaves appear at the surface of the water in early spring. Up to 50 cm of stem is produced by June, and flowering occurs from July to October. Aerial stems die off during November, and persistent parts sink to the sediment forming a dense mat (Dandelot *et al.*, 2008). The species reproduces primarily through clonal expansion; stem fragments are spread by water currents, animals and humans (Ruaux *et al.*, 2009). *L. peploides* is self-compatible and the species has a very high potential seed output (10,000 – 14,000 seeds per square metre) (Ruaux *et al.*, 2009). In a study of locally collected seed material from nine populations in the middle Loire River in France, seeds had a buoyancy duration of around 2 weeks, and seeds were often viable, indicating that sexual reproduction may also be an important means of survival and spread (Ruaux *et al.*, 2009).

B/ Climatic requirements[2]

L. peploides favors warm and sunny environments. There is a lack of experimental data on cold tolerance of *L. peploides*, yet climate primarily limits its current distribution in Western-Europe. Thermal ponds or waters with artificially raised temperatures may be additional suitable habitats in countries that are not identified as having suitable overall climates (EPPO 2011).

Climate change may facilitate the spread and general establishment in countries like Belgium with at least some area characterized by a continental climate (see chapter 2.1.4.F).

C/ Habitat preferences[3]

In its native range, *L. peploides* occurs in wetlands (Rolon *et al.*, 2008), in the transition zone-between aquatic and terrestrial environments (Hernandez & Rangel, 2009).

Elsewhere, establishment of *L. peploides* often occurs on mud in barren parts of wetlands subject to fluctuating water levels (natural or managed) and in disturbed marginal habitats subject to grazing, (i.e. meadows grazed by cattle or wild geese) or management. The latter include sites with restoration management foraquatic habitats, especially where banks are gradually sloping (EPPO 2011).

2

Organism's capacity to establish a self-sustaining population under Atlantic temperate conditions (Cfb Köppen-Geiger climate type) should be considered, with a focus on its potential to survive cold periods during the wintertime (e.g. plant hardiness) and to reproduce taking into account the limited amount of heat available during the summertime.

3

Including host plant, soil conditions and other abiotic factors where appropriate.

Other suitable habitats include margins of ponds and lakes, static or slow-flowing waterways, rivers, shallow ponds, and lakes, canals, oxbow lakes, wetlands, ditch networks. It is also found on sediment bars on river banks (Laugareil, 2002 ; Zotos *et al.*, 2006), and can also colonize brackish waters with salt concentrations reaching 10 g/L (Mesleard & Perennou, 1996) as well as humid pastures.

High athmospheric and soil humidity are always favoured by *L. peploides* and its high degree of genetic polymorphism and phenotypic plasticity (Ruaux *et al.*, 2009) allows it to grow in a broad range of conditions in terms of nutrient levels, types of substrate (gravel banks or fine sediments), pH and water quality (Matrat *et al.*, 2006). It prefers full light but can tolerate shade, in which case biomass production is reduced and is limited by higher flow velocity (greater than 0.25 m/s; Dandelot, 2004) . In general, *Ludwigia* spp. prefer high nutrient conditions (Hussner, 2010) and obtain dominance there (Rejamánková, 1992). Salinity is however a limiting factor for *L. peploides* development.

D/ Food habits[4]

Not applicable.

E/ Control agents

The water primrose beetle, *Lysathia ludoviciana* (is native to the southern USA and Caribbean region) has been observed to selectively feed on *L. peploides* (Campbell and Clark, 1983). Several species from Argentina, including *Tyloderma* spp., *Auleutes bosqi* and *Onychylis* sp. nr. *nigrirostris* have been reported to have *L. peploides* as their only host (Cordo and DeLoach, 1982). Besides these cases of specialized herbivory, *L. peploides* is of little use as a food source; it contains saponins and calcium oxalate, which make it unpalatable to most herbivores. Where it is invasive, it often has far reaching and negative effects on multiple trophic levels (Dandelot *et al.*, 2008).

Besides specific cases of parasitism by insects in its native range (see chapter 2.2.1.B below), *L. peploides* is poorly consumed by herbivorous animals probably due to its high content of saponins and calcium oxalate.

F/ Establishment capacity in Belgium

Probability of establishment in Belgium is high for most slow flowing fresh water courses, isolated water bodies, canals and wet meadows. Nowadays mostly occurring in the Flandrian

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4 For animal species only.

and Brabant sector of the country, slight climate warming may enhance invasion of the Kempen area and more continental parts of the territory (Meuse, Ardenne and Lorraine).

Nowadays, the most important factor limiting survival of *L. peploides* is not directly the mean or the minimum temperature in winter months but the number of days with freezing temperature per year.

While taking into account the IPCC scenario predicted for Belgium, we have not found information on the projected number of ice days in the mid-term future. To solve this lack of information, we made the hypothesis that there is a linear correlation between number of ice days and average minimal temperature in January. The expected increase of harshest winter temperature (in January) will, depend of the different IPCC scenario, ranging from 0.8°C to 3.2°C (Marbaix & van Yperzele, 2004).

If the hypothesis "*number of ice days and frost days are linearly correlated to January minimum average temperature"* is correct, we can expect that, with a raise of average January temperature of 3.2°C in the Ardennes in 2050, winter conditions in Saint-Hubert (554 m) will be similar to those ones observed in Brussels actually. In such a prediction (which is the most extreme evolution in ICPP scenario), a strong decrease in the number of frost days is to be expected. This can conduct to a total release of the climatic limiting factor for *L. peploides* establishment in Belgium. If we now consider the less extreme evolution in ICPP scenario for 2050, which would be an elevation of temperature of 0,8°C in Saint-Hubert, only a limited decrease in the number of frost per year would be observed. This implies that climatic limiting factor for L. peploides establishment would still play a significant role in the (near, 2050) future.

G/ Endangered areas in Belgium

The endangered area consists of wet margins of ponds and lakes, static or slow-flowing waters, rivers, shallow ponds and lakes, canals, oxbow lakes, wetlands, ditch networks, sediment bars on river borders, wet meadows, brackish waters where climatic conditions are suitable. In Belgium, many of these habitats are classified as Natura2000 sites (ecological network of protected areas across the European Union) or nature reserve and the whole territory is considered at risk for further *L. peploides* invasion (see figure 5).

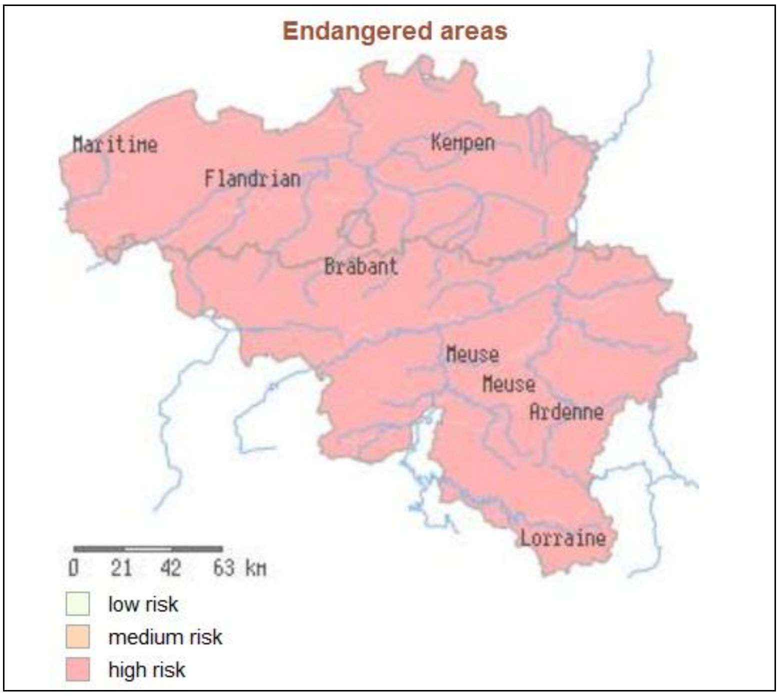

Figure 5: Potential risk map of establishment in endangered areas in Belgium.
Source: http://ias.biodiversity.be/species/show/12

Establishment capacity in the Belgian geographic districts for the present time and for future predictions climate change based on IPCC scenarios for 2050:

Districts in Belgium	Nowadays environmental conditions for species establishment[5]	Environmental conditions for species establishment under increasing temperature due to climate change
Maritime	Optimal	Optimal
Flandrian	Optimal	Optimal
Brabant	Optimal	Optimal
Kempen	Optimal	Optimal
Meuse	Optimal	Optimal
Ardenne	Sub-optimal	Optimal
Lorraine	Optimal	Optimal

ESTABLISHMENT CAPACITY AND ENDANGERED AREAS IN BELGIUM
Able to grow in a broad range of habitats, *L. peploides* can colonize most of the wetlands, ditches, and slow flowing rivers of the country. Many of these habitats are endangered, sensitive or have a high biodiversity status (e.g. natural reserve or Natura2000 sites). Nowadays mostly found in the Flanders district, the species could benefit from slight warming of air and water temperature and colonize most of the territory's water systems.

5 For each district, choose one of the following options : optimal, suboptimal or inadequate.

2.1.5 Dispersion capacity

Specify what is the rate of dispersal once the species is released or disperses into a new area. When available, data on mean expansion rate in introduced territories can be specified. For natural dispersion, provide information about frequency and range of long-distance movements (i.e. species capacity to colonise remote areas) and potential barriers for spread, both in native and in introduced areas, and specify if the species is considered as rather sedentary or mobile. For human-assisted dispersion, specify the likelihood and the frequency of intentional and accidental movements, considering especially the transport to areas from which the species may easily colonise unintended habitats with a high conservation value.

Since *L. peploides* is very commonly sold as an ornamental, it is most likely that escape from aquaculture explains most of the adventive introductions. Despite its very rapid growth, and invasive nature, it is still marketed and sold, so the risk of introduction, whether accidental or intentional, is still high. Its ability to spread rapidly through vegetative means, coupled with a high degree of phenotypic plasticity (Ruaux *et al.*, 2009), also means that the plant is quite likely to establish upon release.

A/ Natural spread

Fragmentation of stems and dispersion through water flow is the main mode of dispersal of *Ludwigia* spp. Sexual reproduction and transport of the resulting seeds and their role in reproduction remains to be studied further (in France, viable seeds were collected from the wild and germinated in laboratory conditions, but no data are available from outdoor conditions). Seeds are nonetheless considered as an important potential means of dispersal (Ruaux *et al.*, 2009).

Stems can be carried by animals to distant locations, where new populations can establish and grow by vegetative expansion (Ruaux *et al.*, 2009).

Interconnected waterways may be important corridors for the spread of propagules whereas exceptional phenomena such as floodings may be crucial to overcome local barriers for dissemination.

B/ Human assistance

- **Accidental Introduction**

Humans (and possibly birds) are responsible for short distance dissemination of *L. peploides*. Clothing and footwear as well as machinery and equipment used to manage waterways and streams are potential vectors of plant fragments. Negligent disposal of garden/aquaculture/horticulture waste and escape from botanical gardens may be even more common and important at this stage of invasion.

Over long distances, trade for ornamental purposes (aquarium and ponds) can obviously ensure dispersal.

Although still available from online distributors, current educational efforts aim to decrease the probability that this plant will be intentionally introduced, and hopefully cut down on accidental release in areas where this plant may become a noxious weed. 'Hitchhikers' may often be present in horticultural plantings and can thus be distributed along with non-invasive plants. It is possible that this plant may unintentionally be introduced by people intending to cultivate harmless plant.

- **Intentional Introduction**

L. peploides has showy bright-yellow flowers that make it an interesting candidate for aquaculture. Additionally, the plant demonstrates a high degree of phenotypic plasticity, which allows it to adapt to a broad range of growing conditions and water regimes (Ruaux *et al.*, 2009). Unfortunately, the very characteristics that make it a hardy and amenable garden plant, also lend it the ability to invade a broad range of habitats where it is very often invasive (Ruaux *et al.*, 2009). This plant is still offered for sale at local retailers or through internet horticultural distributors, so the probability of intentional introduction remains (Halford *et al*., 2011).

DISPERSAL CAPACITY

Fragmentation of stems and dispersion through water flow is the main natural mode of dispersal of *Ludwigia peploides.* Anthropogenic activities may enhance dispersal through dissemination of plant fragments (through management machinery/equipment or negligent aquaculture practices). Its high degree of phenotypic plasticity and genetic polymorphism allows the species to adapt to a broad range of growing conditions, habitats and water regimes, enhancing further invasions.

4.2 EFFECTS OF ESTABLISHMENT

Consider the potential of the non-native organism to cause direct and indirect environmental, economic and social damages as a result of establishment. Information should be obtained from areas where the pest occurs naturally or has been introduced, preferably within Belgium and neighbouring areas or in other areas with similar eco-climatic conditions. Compare this information with the situation in the risk analysis area. Invasion histories concerning comparable organisms can be considered. The magnitude of those effects should be also compared with those caused by their closest native relatives.

2.2.1 Environmental impacts

Specify if competition, predation (or herbivory), pathogen pollution or genetic effects are likely to cause a strong, widespread and persistent decline of the populations of native species and if those mechanisms are likely to affect common or threatened species. Document also the effects (intensity, frequency and persistency) the non-native species may have on habitat peculiarities and ecosystem functions, including physical modification of the habitat, change to nutrient cycling and availability, alteration of natural successions and disruption of trophic and mutualistic interactions. Specify what kind of ecosystems are especially at risk.

A/ Competition

When invasive, this species causes declines in biodiversity (EPPO, 2004) through shading, competitive exclusion, and chemical allelopathy (biological phenomenon by which an organism produces one or more biochemicals that negatively influence the growth, survival, and reproduction of other organisms). Due to the species's allelopathic activity that has year-long effects on water quality, presence of *L. peploides* can lead to impoverished flora by decreasing seedling survival of vulnerable native taxa (Dandelot et al., 2008). Additionally the plant provides a poor habitat for other biota. The dense matting excludes the growth of native plant species, shades submersed aquatic vegetation, and is inhospitable for fish and aquatic invertebrates.

B/ Predation/herbivory

Not applicable.

C/ Genetic effects and hybridization

L. peploides (including all subspecies) is a diploid species with 16 chromosomes (2n). Zardini *et al.* (1991) report that nearly all species in sect. *Oligospermum* can hybridize and produce vigorous offspring. The species has demonstrated a high degree of phenotypic plasticity (see chapter 2.1.4.B) which can be considered as an advantage towards other species and allows development in a wider range of ecological conditions.

D/ Pathogen pollution

No cases of pathogen pollution are reported for *L. peploides*.

E/ Effects on ecosystem functions

Impacts on the local environment by *L. peploides* can be devastating. Besides the allelopathic activity of *L. peploides* (see chapter 2.2.1.A), the species can also cause severe hypoxia and sometimes anoxia during the summer. Hence it can also lead to lower sulphate and nitrate levels and increased sulphide and phosphate concentrations. These combined effects have the capability of triggering what Dandelot *et al.* (2005) refer to as "a dystrophic crisis" and an intoxicated ecosystem. The plant has been reported to outcompete native *Myriophyllum* and *Potamogeton* species in France, which translates to a reduction in macroinvertebrate habitat (Dutartre, 1986; CEH, 2007).

L. peploides can double its biomass in 15 to 20 days in slow flowing water (EPPO, 2004), and the resulting vegetation mats can drastically reduce water flow (Dandelot *et al.*, 2008). Along with the closely related *Ludwigia grandiflora*, *L. peploides* is considered by some to cause the most damage in aquatic systems across many regions of France, blocking slow-moving waterways, and impacting irrigation and drainage in lakes, ponds and ditches (Ruaux *et al.*, 2009). The plant can also cause hyper-sedimentation and silting (Dandelot *et al.*, 2008).

ENVIRONMENTAL IMPACTS
In suitable conditions *L. peploides* tends towards invasiveness. Rapid development of dense mat of stems and leaves, cause competitive exclusion, declines in native biodiversity (affecting particularly native flora, invertebrates, and fish) and chemical alteration of the environment. Heavy infestation causes hypoxia, alters water chemistry and reduces and/or blocks slow-moving waterways (impacting irrigation, drainage in lakes, ponds and ditches, and also cause hyper-sedimentation and silting).

2.2.2 Other impacts

A/ Economic impacts

Describe the expected or observed direct costs of the introduced species on sectorial activities (e.g. damages to crops, forests, livestock, aquaculture, tourism or infrastructures).

There has been some study regarding the use of this plant in the treatment of wastewater. It is capable of producing large amounts of biomass in the presence of elevated nitrogen levels (Rejmánková, 1992). However, other studies have concluded that many other species are preferable to *L. peploides* in wastewater processing. Little information is available regarding other beneficial social uses of the plant.

In case of heavy infestation by *L. peploides*, negative effect on local economy may occur by clogging of drainage ditches or floodgates (see photo 1), navigation impeded by floating mats and by reducing recreational (or fishing) potential of streams, ponds or lakes. In France, displacement of native wetland grasses that serve for livestock has been observed (CEH, 2007).

Photo 1: Clogged floodgate by *Ludwigia peploides* in France.
Source: Environment Agency Media Team (http://www.environment-agency.gov.uk/)

B/ Social impacts

Describe the expected or observed effects of the introduced species on human health and well-being, recreation activities and aesthetic values.

- Positive impact:

Water garden enthusiasts may have an aesthetic appreciation of this species.

- Negative impact:

This plant can grow very densely, impeding navigation and interfering with hunting, fishing and other recreational activities (CEH, 2007). Dense mats also provide excellent mosquito habitat, primarily because of the exclusion of fish that prey on the larvae.

STAGE 3 : RISK MANAGEMENT

The decision to be made in the risk management process will be based on the information collected during the two preceding stages, e.g. reasons for initiating the process, estimation of probability of introduction and evaluation of potential consequences of introduction in Belgium. If the risk is found to be unacceptable, then possible preventive and control actions should be identified to mitigate the impact of the non-native organism and reduce the risk below an acceptable level. Specify the efficiency of potential measures for risk reduction.

3.1 RELATIVE IMPORTANCE OF PATHWAYS FOR INVASIVE SPECIES ENTRY IN BELGIUM

The relative importance of intentional and unintentional introduction pathways mediated by human activities should be compared with the natural spread of the organism. Make use e.g. of information used to answer to question 2.1.3.

Ludwigia peploides is introduced as an ornamental aquatic plant. There are very few data available on the accurate quantity imported, but the species is still sold in Belgium (see Halford *et al.,* 2011), as in many of the EPPO countries. This represents the main pathway of entry of *L. peploides* in Belgium. Attention is drawn to the fact that in most cases the species is sold under misapplied names such as *Jussiaea* or *Ludwigia grandiflora* (Dandelot, 2004).

Although natural dispersal from neighboring countries should not be neglected, it can be considered as a secondary pathway of entry in Belgium.

3.2 PREVENTIVE ACTIONS

Which preventive measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially (i) the restrictions on importation and trade and (ii) the use of specific holding conditions and effect of prohibition of organism introduction into the wild.

(i) Prohibition of organism importation, trade and holding

Several actions can be undertaken in order to limit introduction of *Ludwigia* spp. in non-native countries:

- **Action 1: Amend existing legislation**
  Legislation should be strengthened to ensure a total ban on import and trade of potential invasive species such as *L. peploides* and closely related species.

- **Action 2: Highlight, support and promote Invasive Species Codes of Practice**
  A priority action to prevent the spread and release of invasive species such as *L. peploides* is to promote wide use and implementation of the Invasive Species Codes of Practice (ISCP, see table 1) and to support these with literature and information leaflets for both the horticultural sector and the general public. *L. peploides* is valued as an ornamental plant, therefore educational programs must be directed to educate the public about the dangers this plant poses outside its native range. Teaching water managers how to clean equipment in a way that decreases the chance of transmission is one way to lessen the prevalence of human-mediated transport. Additionally, information should be disseminated regarding responsible propagation and cultivation of this species if it remains to be sold (which is an undesired

scenario). In Belgium, a large information campaign was promoted by AlterIAS (http://www.alterias.be). Such initiatives enhance awareness of the risks caused by invasive species such as *L. peploides* , facilitate early warning and correct identification and provide valuable measures for careful culture and manipulation, as well as trade reduction, by proposing alternative garden plants through detailed Invasive Species Codes of Conduct (table 1), targeting the public at large as well as retailers. As the species is still widely available, there is an opportunity for education to at various points along the horticultural trade pathway from distributor to introduction.

ISCP for horticultural professionals	ISCP for the general public
1.Be informed about the Belgian alien species list	1.Be informed about the Belgian alien species list
2.Stop selling and/or planting invasive alien species	2.Avoid buying and planting alien species
3.Spread information about invasive alien species to customers and the general public	3.Choose non-invasive native plants as an alternative to alien species
4. Promote the use of alternative, non-invasive plants	4.Do not dump vegetal residues in nature
5. Take part in early invasive alien species detection actions	5. Share your knowledge and awareness about invasive plants and issues related to their introduction

Table 1. Invasive Species Codes of Practice for the industry and the general public
Source: http://www.alterias.be/fr/que-pouvons-nous-fairen/les-codes-de-conduite-sur-les-plantes-invasives

- **Action 3: Public sector bodies adopt Invasive Species Codes of Practice**
  All public sector organizations should lead by example and adopt the Invasive Species Codes of Practice in their relevant work areas. This is key to the success of both existing codes (for professionals in horticulture and for general public). Government agencies should also incorporate the philosophy of the codes into tenders and procurement procedures and ensure that suppliers and contractors for public works are abiding the codes.

(ii) Use of specific holding conditions and effect of prohibition of organism introduction into the wild

The plant is listed as a noxious weed in Washington State, USA (INVADERS, 2009; Peconic Estuary Program, 2009), South Africa, and was added to the EPPO Alert List in 2004.

Information on trade of *L. peploides* into some EPPO countries is as follows:

- In the Netherlands a Code of conduct has been signed by the “Unie van Waterschappen” on behalf of all 26 local water boards, the Ministry of Agriculture, Nature and Food safety, as well as umbrella organisations and various associations representing producers, importers, retailers and garden centres such as DIBEVO, Tuinbranche Nederland, De Nederlandse Bond van Boomkwekers, De Vereniging van Vasteplantenkwekers. Several individual importers and producers of aquatic plants also signed the Code of conduct. The signatories have agreed to refrain from selling several invasive aquatic plants (incl. *L. grandiflora* and *L. peploides*) in the Netherlands as of January 1st 2011. Before the implementation of this Code of conduct, *L. grandiflora* and *L. peploides* could be found in almost every garden centre (J. van Valkenburg, Plant Protection Service, The Netherlands, pers. comm., 2010 in EPPO PRA *L. peploides*).

- In France, sale of *L. peploides* is forbidden, and the EWG could not find retailers through an internet search, but the species could be traded under different names.
- In Germany, although sale is not banned, the plant is not widely available in trade.
- In the UK, all sales of *Ludwigia* spp. for outdoor use are labeled as either *L. grandiflora* or *J. grandiflora*. However, sales of *L. peploides* under these names cannot be excluded (J. Newman, Waterland Management Ltd, United Kingdom, pers. comm., 2010 in EPPO PRA *L. peploides*).

Since *L. peploides* is introduced intentionally as an ornamental plant and is still for sale in Belgian garden centres (Halford *et al.,* 2011) as well as in other European countries, the probability of spread to areas where it is currently not present is high. Exchanges of plants between gardeners and deliberate transplantation by human activity also increase *L. peploides*'s colonization potential. Where it is already present, the probability of short distance spread is very high as vegetative dispersal is very effective for local colonization. Human activity is mostly responsible for long distance spread.

Hussner et al. 2010 consider that the increase in species number and abundance of aquatic plants is probably caused by enhanced trading and increased invasibility of waters by eutrophication ⁄ re-oligotrophication and climate change. They made proposal of a trading ban for highly invasive non-indigenous aquatic plants with which we agree. This will not stop their natural spread, but should reduce the risk of further unintended entry and thus can be a major control factor.

3.3 CONTROL AND ERADICATION ACTIONS

Which management measures have been identified to reduce the risk of introduction of the organism? Do they reduce the risk to an acceptable level and are they considered as cost-effective? Specify if the proposed measures have undesirable social or environmental consequences. Consider especially the following questions.

(i) Can the species be easily detected at early stages of invasion (early detection)?

L. peploides is a rather conspicuous and "eye-catching" plant. It can therefore fairly easily be detected even at early stage of development. However, growth rate is fast and new populations can develop from a single node of the plant (transported at sometimes long distances by human, water current or animals). Time before the population reaches an incontrollable dimension is therefore relatively short.

(ii) Are there some best practices available for organism local eradication?

The side effect of chemicals and even biological control means can often be as detrimental or even worse for the environment at large, native species and human health.

The precautionary principle should be applied as a general rule.

Several types of methods are available in order to control *L. peploides* invasions:

- **Physical/Mechanical Control**

A number of physical control measures including hand-pulling, rotovation[6], and mechanical harvesting may be used to control *L. peploides*; however, all fragments and roots must be removed to prevent re-establishment and further spread (CEH, 2007). It is likely that mechanical treatment of large populations would provide only temporary nuisance relief.

- **Movement Control**

Plants can spread locally when seeds and fragments drift in water currents or are carried to new areas by animals, but most attention should be given to different forms of human-mediated transport. The availability of this plant as an ornamental, and its ability to spread vegetatively from small amounts of material indicate that controlling human behaviour and increasing awareness might be the most effective way to reduce introductions of *L. peploides.*

- **Biological Control**

Sterile grass carp (*Ctenopharyngodon idella*) have been used to control *L. peploides* (Manuel, 1989). However, grass carp are non-selective herbivores that will harm native species (sometimes more attractive than the target species). Some studies of native biological control measures yielded promising results of using highly specific herbivores to control the plant, although caveats regarding the introduction of a non-native control agent remain.

The water primrose beetle, *Lysathia ludoviciana* has been observed to selectively feed on *L. peploides* (Campbell and Clark, 1983). The beetle is native to the southern USA and Caribbean region; its USA distribution has been reported to include Texas, Georgia, South Carolina, Ohio and Alabama (Habeck and Wilkerson, 1980). Several species of insect

[6] Rotovators is a floating machinery equipped with underwater rototiller-like blades used to uproot invasive aquatic plants. The rotating blades churn seven to nine inches deep into the lake or river bottom to dislodge plant root. The plants and roots may then be removed from the water using a weed rake attachment to a rototiller head, by harvester or by manual collection.

(*Curculionidae)* from Argentina (see chapter 2.1.4.E), including *Tyloderma* spp., *Auleutes bosqi*, *Onychylis* sp. nr. *nigrirostris* and *Lysathia flavipes* have been reported to have *L. peploides* as their only host (Cordo and DeLoach, 1982); however, the use of non-native biological control agents can be a risky endeavour.

- **Chemical Control**

Control of *L. peploides* is difficult. The plant has been used in the past to absorb herbicide residues in runoff water (CEH, 2007). Several herbicides have been used with success to eradicate *L. peploides*, including halosulfuron-methyl, glyphosate and triclopyr (CEH, 2007). The use chemical weed control in an aquatic environment is, however, extremely restricted in Belgium and its different regions. Practical control options should focus (with more efficiency and less negative impact on the environment) on prevention and integrated non-chemical methods.

(iii) Do eradication and control actions cause undesirable consequences on non-target species and on ecosystem services ?

Both mechanical and chemical management measures are non-specific means of control and will have negative effects on the environment. Either one of these actions will inevitably cause serious damage to local flora or fauna by intoxication (in case of chemical control), habitat disturbance and ecosystem service alteration.

- Mechanical control would remove a considerable number of invertebrates (Dawson *et al.*, 1991), and could also negatively impact native plants. Experiments in the UK concluded that the impact of mechanical control is severe on non-target organisms, but limited in time as recovery occurs by recolonization in a relatively short time (J Newman, pers. comm., in EPPO 2009).

- Chemical control of large stands can lead to the de-oxygenation of water due to decomposition of dead material (Barrett, 1978). Experiments in the UK concluded that the effects of chemical control on large volumes of plant biomass are restricted to de-oxygenation of the waterbody due to decomposition of treated plant material, not to direct toxicity of the herbicide. Partial mitigation of this effect can be achieved by removing the majority of the biomass prior to manual removal or targeted herbicide application to remaining inaccessible fragments (Newman, pers. comm., in EPPO 2009).

(iv) Could the species be effectively eradicated at early stage of invasion?

Small populations detected at ealy stage of development can effectively be controlled by hand pulling, prior to significant clonal expansion. It is indeed much easier and more effective to attempt to control this plant early in its introduction timeline. Eradication success depends thus on the population size and the accessibility of the infested water body (Grillas, 2004).

(v) If widespread, can the species be easily contained in a given area or limited under an acceptable population level?

With a high regeneration capacity and the ability to form new shoots from single nodes (Dandelot, 2004), eradication of *L. peploides* is considered very difficult or even impossible in water bodies with heavy infestation. Moreover, several actions often used to control aquatic weed could enhance further dispersion and new population establishment elsewhere. The accessibility of the water body being an extra issue when considering means of control (Grillas, 2004), the success of any action undertook for *L. peploides* eradication depends primarily of the size of the considered population (which is function of the moment of detection and time passed prior decision to eradicate the species).

RISK MANAGEMENT SUMMARY

In Belgium *L. peploides* is available in horticultural trade and subsequent accidental introduction into the wild is highly likely to occur. Spread from populations in neighbouring countries, though possible is considered as a minor pathway of entry in our country. Once established, small populations (if detected early enough) can be controlled with a relatively high chance of success. At later stages of invasion, control actions to keep the population to an acceptable level are considered as extremely difficult, laborious, costly or even "impossible".

Means of control include mechanical removing by rotovation (though not recommended for this species, see text above) or handpulling, introduction of a control agent (e.g. *Ctenopharyngodon idella* even if sometimes inefficient and even prohibited in some countries or several specific consumers of *L. peploides* such as *Curculionidae* spp.), and the use of chemicals such as halosulfuron-methyl, glyphosate and triclopyr based herbicide. Limitation of movement by increasing public awareness on risks in manipulating and buying *L. peploides* will, however, remain the most effective mean of control of this species. Moreover, it is important to note that the use chemical weed control in an aquatic environment is extremely restricted in Belgium and its different regions and because the results should be of practical use, the practical control options should focus on prevention and integrated non-chemical methods.

Preventive actions should lead to a total ban of *L. peploides* trade through amendments of existing legislation. Promoting, highlighting and supporting an "Invasive Species Code of Practice" (such as proposed by AlterIAS) to commercial sector bodies and to the great public could raise awareness on environmental risks caused by *L. peploides* introduction (and subsequent possible invasion).

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