Report prepared in support of implementing the IAS regulation in Belgium

Authors: Adriaens, T., Branquart, E., Gosse, D., Reniers, J., Vanderhoeven, S.

FEASIBILITY OF ERADICATION AND SPREAD LIMITATION FOR SPECIES OF UNION CONCERN SENSU THE EU IAS REGULATION (EU 1143/2014) IN BELGIUM

RESEARCH INSTITUTE NATURE AND FOREST

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Acknowledgements

We are grateful to Olaf Booy (UK Non-Native Species Secretariat), Peter Robertson and Aileen Mill (Newcastle University) for in-depth discussions on the manageability protocol, the sharing of information and their openness for collaboration. We thank Sander Devisscher for data handling and the production of the distribution maps and summary tables. We thank Hugo Verreycken, Luc Denys, Jo Packet and Pieter Boets for comments on some of the scenarios and strategies. Maxime Coupremanne assisted in gathering literature. We are grateful to the Belgian Committee on Invasive Alien Species for discussions and support. We thank INBO for financially supporting the workshop organization. We thank Sander Devisscher and Maxime Coupremanne for their practical help during the workshop, as well as Vincent Fiévet and Jim Casaer for the help they provided with the live translation during the workshop discussions.

We thank all of the assessors who willingly provided their assessments on the feasibility of management for the Union List species in Belgium (Annex 3): Adrien Latli, Alain De Vocht, Anne-Laure Jacquemart, Arnaud Monty, Bart Vandevoorde, Bram D'hondt, Denis Parkinson, Dido Gosse, Diederik Strubbe, Elena Tricarico, Etienne Branquart, Filip Verloove, Frank Huysentruyt, Gerald Louette, Hugo Verreycken, Iris Stiers, Jane Reniers, Jim Casaer, Jo Packet, Johan van Valkenburg, Koen van Roeyen, Luc Baufay, Luc Denys, Marijke Thoonen, Paul Stebbins, Pieter Boets, Quentin Groom, Quentin Rome, Sam Provoost, Sarah Descamps, Sonia Vanderhoeven, Tim Adriaens, Vinciane Schockert, Wouter Van Landuyt.

Lastly, we are grateful to all the invasion managers and experts who participated to the workshop for their feedback and active participation in the discussions: Adrien Latli, Alain De Vocht, Anja Goossens, Arnaud Monty, Benoit Garin, Bram D'hondt, Carole Van Roy, Céline Noulard, David Claeys, Dido Gosse, Diederik Strubbe, Elodie Nise, Emma Cartuyvels, Emmanuelle Sarat, Esmeralda Uskokovic, Etienne Branquart, Franck Minette, Frank Huysentruyt, Frédéric Mouchet, Henk de Jong, Hugo Verreycken, Iris Stiers, jean-philippe bizoux, Jelle Van den Berghe, Jim Casaer, Jo Packet, Johan De Beule, Johan Van Valkenburg, Johan Vander Heyden, Josse Gielen, Juan-Pablo Pertierra, Karel Van Moer, Katrien Hendrickx, Kenny Meganck, Koen Van Roeyen, Kris Schurmans, Luc Denys , Luc Baufay, Maarten Vangansbeke, Maarten Vanwesemael, Manou Pfeiffenschneider, Marielle Brasseur, Marijke Thoonen, Maxime Coupremanne, Myriam Dumortier, Nathalie Fonder, Olivier Beck, Paul Van Loon, Pauline Ducarme, Peter Staljanssens, Pierre Joye, Pieter Boets, Pieter Huybrechts, Pieter Van Dyck, Quentin Groom, Renaud Bocquet, Rik Puls, Ronny De Keer, Samuel Vander Linden, Sander Devisscher, Sarah Descamps, Sofie Standaert, Sonia Vanderhoeven, Spyridon Flevaris, Stéphan Adant, Thierry Sluyters, Tijl Schelfhout, Tim Adriaens, Ugolin Martin, Vincent Fiévet, Wim Dirckx, Wouter Van Landuyt, Xavier Rollin and Yasmine Verzelen.

How to cite this report:

Adriaens, T., Branquart, E., Gosse, D., Reniers, J., Vanderhoeven, S. 2019. Feasibility of eradication and spread limitation for species of Union concern sensu the EU IAS Regulation (EU 1143/2014) in Belgium. Report prepared in support of implementing the IAS Regulation in Belgium. Institute for Nature and Forest Research, Service Public de Wallonie, National Scientific Secretariat on Invasive Alien Species, Belgian Biodiversity Platform. DOI: https://doi.org/10.21436/17033333.

Depot number

D/2019/3241/285

Summary

Robust evidence is needed to ensure management of invasive alien species (IAS) is feasible and resources are used effectively. Risk assessments are of limited use to decide on species management because the feasibility of different options is not considered. Risk management provides a structured evaluation of management options including an assessment of practical, resource, societal, ethical and legal constraints. We used this approach in Belgium to assess the feasibility of management for 43 species of Union Concern sensu the EU IAS Regulation (1143/2014) that came into force on January 2015 and urges member states to make decisions on species management. We organized an online participatory process involving more than 40 experts with experience in species management using an adaptation of the UK Non-Native Risk Management scheme (NNRM) (Booy et al. 2017). NNRM uses semi-quantitative response and confidence scores to assess key criteria linked with management feasibility: effectiveness, practicality, cost, impact, acceptability, window of opportunity and likelihood of re-invasion. The outcome of the assessment supports the Regulation implementation in Belgium, notably for the identification of a cost-effective management goals and techniques as required by Article 17 and 19 on IAS eradication and management, respectively. It provides an evidence base for Belgian management decisions through a transparent, standardized and repeatable process. The structured decision making and the participatory approach involving the Belgian expert community has added value in terms of engagement and support for the implementation of management action plans deriving from the risk management evaluation.

In this report, we present the invasion scenarios and management strategies for Belgium developed for this exercice, not only for assessing feasibility of species eradication but also their spread limitation. Scenario & strategy writing were performed by the Research Institute for Nature and Forest (INBO), National Scientific Secretariat on IAS (NSS), le Départment d'Etude du Milieu Naturel et Agricole - Service Public de Wallonie (DEMNA) and the Belgian Biodiversity Platform (BBPF). The species accounts present the current species distribution and summarize data on their invasion history and current management in Belgium (invasion scenario). For species that are not present in the territory, the scenario described is an imaginary but theoretically realistic invasion scenario taking into account pathways, entry points, habitat and detection threshold of the species. We then drafted realistic management strategies for eradication and spread limitation. Spread limitation strategies were categorized based on species distribution extent: limiting species presence to a single or a few patches, containment of populations in core area(s), elimination of the most dispersive populations or maintenance of pest free areas. We hope the invasion scenarios might provide topical information on the Union List species and their situation in Belgium.

Beside reporting on the Belgian manageability exercice, we hope the management strategies developed for Belgium could provide inspiration to practitioners and to other member states tackling invasive species of Union Concern.

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Executive summary

The EU IAS Regulation (1143/2014) requires Member States to prioritize species for eradication, containment and long term control. To support the decision making process and to ensure robust evidence is used to decide on suitable management options, we organized a participatory approach involving scientists and practitioners. First, we gathered all available information and data on the invasion, distribution and management of the Union List species in Belgium and used those to describe the *invasion scenario*. For species that are not present on the Belgian territory, the scenario described is an imaginary but theoretically realistic invasion scenario taking into account pathways, entry points, habitat and detection threshold of the species. We then drafted realistic management strategies for eradication and spread limitation based on the literature on best management practices. Spread limitation strategies were categorized based on species distribution extent: limiting species presence to a single or a few patches (option 1), containment of populations in core area(s) (option 2), elimination of the most dispersive populations (option 3) or maintenance of pest free areas (option 4). Importantly, the general obligations applying to Union List species through the EU Regulation such as bans, action plans for pathways and surveillance systems, are not part of the strategies but were considered to be in place for this exercise (table 3).

Second, more than 40 (Belgian as well as foreign) experts with experience in species management used an adaptation of the UK Non-Native Risk Management scheme (NNRM) (Booy et al. 2017) to score the feasibility of eradication and spread limitation. NNRM uses semi-quantitative response and confidence scores to assess key criteria linked with management feasibility: effectiveness, practicality, cost, impact, acceptability, window of opportunity and likelihood of re-invasion. These feasibility scores should be interpreted with caution as for some species the number of expert assessments was low (Annex 3), hence insufficient to detect significant differences between scenarios and criteria. However, the observed differences between expert assessments were still useful to initiate and guide the discussions. Therefore the feasibility scores were used to fuel a debate with the practitioner’s community on invasion management in Belgium during a participative workshop.

The aim of this workshop was to formulate a consensual management recommendation for Union List species in Belgium. The result of this exercise are summarized in Table 1. On top of this management recommendation, for some species additional requirements for successful implementation of the strategies were formulated (see individual species accounts).

The outcome of the full process supports the Regulation implementation in Belgium, notably for the identification of cost-effective management goals and techniques as required by Article 17 and 19 on IAS eradication and management, respectively. It provides an evidence base for Belgian management decisions through a transparent, standardized and repeatable process. The structured decision making and the participatory approach involving the Belgian expert community has added value in terms of engagement and support for the implementation of management action plans deriving from the risk management evaluation. Besides reporting on the Belgian manageability exercice, we hope the management strategies developed for Belgium and the process followed to support decisions on the management of IAS can provide inspiration to practitioners and other Member States tackling invasive species of Union Concern.

Table 1: Management recommendation for Union List IAS resulting from the manageability exercise. Further requirements for implementation of the strategies are mentioned in the full species accounts.

Species	Status in the wild in Belgium	Management recommendation
Vertebrates		
Alopochen aegyptiaca	Established	Consensus on **spread limitation option 3** - elimination of the most dispersive populations supplemented with basic long-term control throughout the whole Belgian territory
Corvus splendens	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium
Oxyura jamaicensis	Casual	Consensus on **eradication of all individuals** on the Belgian territory
Threskiornis aethiopicus	Casual	Consensus on **eradication of all individuals** on the Belgian territory
Callosciurus erythraeus	Casual	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present (or in this case eradicated) in Belgium.
Sciurus carolinensis	Casual	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium
Sciurus niger	Casual	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium

Tamias sibiricus	Established	Consensus on **spread limitation option 2** - containment of populations in the core area(s) of the Sonian forest. Populations outside this area are eradicated. The Sonian forest population is subjected to long term control to reduce numbers and reduce dispersal risk.
Muntiacus reevesii	Established	Consensus on prompt **eradication** as a management strategy. If this appears unfeasible for the Schoten population, spread limitation should be the preferred option here.
Myocastor coypus	Established	Consensus on a **mixed strategy** combining eradication in the Atlantic region, and spread limitation option 2 - containment of populations in core area(s) for the continental region in Belgium.
Procyon lotor	Established	Consensus on **spread limitation option 2** - containment of the population in the continental area with rapid eradication of raccoon in the Atlantic region. The population in the continental region is subject to long term control to mitigate impact and to reduce the risk of spread to neighboring areas.
Nyctereutes procyonoides	Unclear	Consensus on **eradication strategy** as a management recommendation for Belgium, including surveillance all over the country.
Ondatra zibethicus	Established	Consensus on **spread limitation option 2** - containment of the population in the continental area, with permanent removal from the Atlantic bioregion and increased population control in the continental bioregion both for impact mitigation and reducing the risk of spread to the Atlantic bioregion.
Insects		
Vespa velutina	Established	The species was not dealt with during the workshop. The eradication and spread limitation strategies were both scored low to medium by the experts.
Aquatic plants		
Cabomba caroliniana	Established	Consensus on **spread limitation option 2** - containment of populations in core area(s), limiting species presence to canals in Limburg and implementing improved surveillance all over the Belgian territory.
Elodea nuttallii	Established	No consensus on management strategy to recommend, but a majority of participants in favour of **long term population control.** Spread limitation was seen as an alternative by others .
Lagarosiphon major	Established	Consensus on **spread limitation option 1** - limiting species presence to a single or a few patches, including improved surveillance all over the Belgian territory.
Hydrocotyle ranunculoides	Established	No consensus on management strategy to recommend. Majority in favour of **eradication strategy**. Spread limitation was seen as an alternative by one participant.
Ludwigia grandiflora	Established	No consensus on management strategy to recommend. Majority in favour of **spread limitation option 2** - containment of population in core area(s), limiting species presence to the Nete and Gete river system. Eradication was seen as an alternative by others .
Ludwigia peploides	Established	Consensus on **eradication strategy** as a management recommendation for Belgium.
Myriophyllum aquaticum	Established	Consensus on **spread limitation option 3** - , elimination of the most dispersive populations located nearby the river systems.
Myriophyllum heterophyllum	Established	Consensus on **spread limitation option 2** - containment of populations in core area(s), including increased surveillance all over the Belgian territory.
Terrestrial plants		
Impatiens glandulifera	Established	**Consensus on spread limitation option 4** - , maintenance of pest free areas. The option recommended is to identify and maintain pest free areas of high conservation value in the upstream zones in rivers basins.
Asclepias syriaca	Established	Consensus on **eradication strategy**, including increased surveillance all over the Belgian territory.
Baccharis halimifolia	Established	Consensus on **eradication strategy** as a management recommendation for Belgium.
Gunnera tinctoria	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium.
Heracleum	Established	No consensus on management strategy to recommend. Majority in favour of

mantegazzianum		**eradication strategy**. Long term control for mitigating impact was seen as an alternative by others.
Heracleum persicum	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium.
Heracleum sosnowskyi	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium.
Lysichiton americanus	Established	Consensus on **eradication strategy** as a management recommendation for Belgium, including plant destruction in parks and gardens.
Microstegium vimineum	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium, including increased surveillance all over the country..
Persicaria perfoliata	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium, including increased surveillance all over the country.
Aquatic animals		
Perccottus glenii	Not present	Consensus on eradication as a guiding principle of the EU Regulation for species not yet present in Belgium.
Pseudorasbora parva	Established	Consensus on **long term control** as a management recommendation. Eradication measures could be implemented at local level on a case by case basis where relevant.
Lithobates catesbeianus	Established	Consensus on **spread limitation option 2** - containment of populations in core area(s), limiting species presence to the Nete valley.
Trachemys scripta	Casual	Consensus on **long term control** as a management recommendation.
Eriocheir sinensis	Established	Consensus on **long term control** as a management recommendation, with a suggestion to focus on the tributaries of the Scheldt. Knowledge gaps on management need to be closed.
Orconectes limosus	Established	Consensus on **spread limitation option 4** - maintenance of pest free areas in the vicinity of sites occupied by native *Astacus astacus* populations.
Orconectes virilis	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium.
Pacifastacus leniusculus	Established	Consensus on **spread limitation option 2 - containment of population in the continental region** and eradication of any new population in the Atlantic region. In the continental region long term control is implemented.
Procambarus clarkii	Established	No consensus on management strategy to recommend. The majority was in favour of an adapted **spread limitation option 2 - containment of population in core area(s)**, including surveillance all over the country. Increased knowledge is needed to adequately identify these core areas. .
Procambarus fallax	Not present	Consensus on **eradication strategy** as a guiding principle of the EU Regulation for species not yet present in Belgium.

1. Introduction

Ensuring a robust and transparent process underpinning decisions on invasive alien species (IAS) management is a crucial element in evidence-based conservation (Essl et al. 2016). Risk assessments, such as the ones performed with the Belgian Harmonia+ protocol (D'hondt et al. 2015), are commonly used to prioritise IAS, but are of limited use to decide on management of species because the feasibility of different options is not considered (Booy et al. 2017). Moreover, effective management requires clear objectives and rigorous monitoring of outcomes (Foxcroft et al. 2019). Managers, policy makers and scientists need to agree on achievable management goals.

Risk management (RM) (Figure 1) provides a structured evaluation of management options. So far, RM options have only been described qualitatively for a number of species for which a full risk assessment was conducted in Belgium (http://ias.biodiversity.be/species/risk). These assessments were largely based on (1) the relative importance of intentional/non-intentional introduction pathways and (2) a qualitative assessment of potential eradication/containment actions.

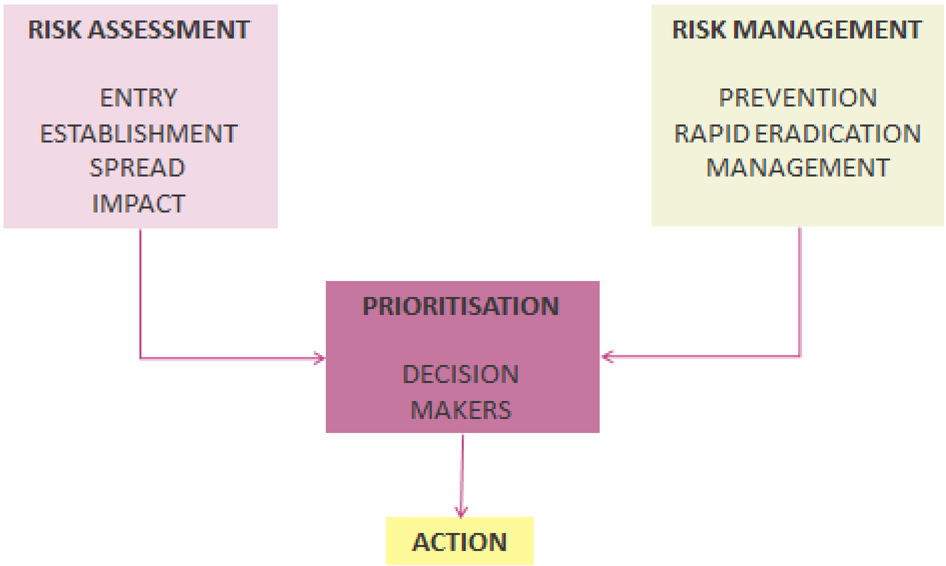


Figure 1: Risk assessment, risk management and risk communication form the three pillars of risk analysis (European Food Safety Authority 2012; IPPC 1997; Maijala 2006; OiE 2015).

1.1 Context of the manageability assessment

1.1.1 Determining management options for the EU Regulation 1143/2014

Regulation (EU) 1143/2014 on IAS entered into force on 1 January 2015. It provides for a set of measures to be taken across the EU in relation to IAS included on a list of Invasive Alien Species of Union concern. The first list of Invasive alien species of Union Concern came into force on 3 August 2016 and comprised 37 species. A first update, in force since 2 August 2017, added 12 species to the Union List.

Three types of measures are envisaged, which follow an internationally agreed hierarchical approach to combating IAS: 1) Prevention: a number of measures aimed at preventing IAS of Union concern from entering the EU, either intentionally or unintentionally; 2) Early detection and rapid eradication: Member States must put in place a surveillance system to detect the presence of IAS of Union concern as early as possible and take rapid eradication measures to prevent them from establishing; 3) Management: some IAS of Union concern are already well-established in certain Member States and concerted management action is needed so that they do not spread any further and to minimize the harm they cause.

For species of EU concern, Member States have to take a decision on the management options. These options are outlined in Articles 17 (Rapid eradication at an early stage of invasion), 18 (Derogations from the obligation of rapid eradication) and 19 (Management measures of invasive alien species that are widely spread) of the Regulation.

The Regulation requires Member States to develop rapid eradication actions for the species of EU concern (Art 17). However, Member States may decide, based on scientific evidence, not to apply eradication measures if (Art 18) at least one of the following conditions is met: *(a) eradication is demonstrated to be technically unfeasible because the eradication methods available cannot be applied in the environment where the invasive alien species is established; (b) a cost-benefit analysis demonstrates on the basis of the available data with reasonable certainty that the costs will, in the long term, be exceptionally high and disproportionate to the benefits of eradication; (c) eradication methods are not available or are available but have very serious adverse impact on human health, the environment or other species*. In principle, with every formal notification of a species of EU concern in Belgium, decisions not to rapidly eradicate should be formally based on robust evidence. The risk management assessment performed here, although not formally applying cost-benefit analysis (sensu Reyns et al. 2018), includes elements outlined in Article 18 (e.g. effectiveness, practicality, cost, non-target impact).

The management of widely spread species is another requirement of the EU Regulation (Art 19). *Within 18 months of an IAS being included on the Union list, Member States shall have in place effective management measures for those IAS of Union concern which the Member States have found to be widely spread on their territory, so that their impact on biodiversity, the related ecosystem services, and, where applicable, on human health or the economy are minimised. Those management measures shall be proportionate to the impact on the environment and appropriate to the specific circumstances of the Member States.*

The European Commission indicated *widely spread* should be interpreted in the broadest sense. Hence, the following Union list species are covered by Article 19: (1) Union List IAS which already had a population in Belgium before entry into force of the list and (2) Union List IAS which establish populations after entry into force but where eradication (Article 17) is not possible and where Article 18 (derogation) is consequently applied. As such, apart from long term control as a management strategy (e.g. aimed at impact mitigation or at reducing the species' density in Belgium), eradication of an existing population from the Belgian territory can also be a management option to consider within Article 19.

1.1.2 Providing an evidence base for decision on management options and derogations

Invasion scientists and practitioners have developed robust scoring protocols to assess the manageability of species in relation to various management options (Booy et al. 2015, 2017). These protocols are mostly based on the species distribution and abundance, and expert knowledge on the probability of reinvasion, the effectiveness of management options, the prevailing legislation and public acceptance of the eradication or management measures. Given the range of species on the EU list such scheme should be broadly applicable to any taxa and, given large numbers of species involved, should be efficient to apply (Andersen et al. 2004). It should be possible to complete the scheme even where data are lacking, with uncertainty taken into account, documented and justified (Leung et al. 2012). The Booy et al. (2017) scheme accounts for that.

1.2 Objective

The objective of the Belgian Manageability assessment is to **evaluate the feasibility of management for the species of EU concern** applying and adapting an existing risk management scheme, the Non-Native Risk Management scheme (NNRM) (Booy et al. 2015, 2017) (https://link.springer.com/article/10.1007/s10530-017-1451-z/fulltext.html). This scheme will be applied to the invasive species of EU concern (1^{st} and 2^{nd} batch) sensu the EU IAS Regulation 1143/2014. The undertaking of this assessment was agreed upon and formalized at the joint thematic meeting of the Belgian IAS Scientific Council & IAS Committee (February 14th 2017). This assessment will:

- Support the EU Regulation implementation in Belgium;
- Provide an evidence base for derogations on the rapid response obligation (Art 18) so this has not to be decided upon on a case by case basis;
- Provide a sound evidence base for decisions on IAS management through a transparent, repeatable process (Vanderhoeven et al. 2017);

- Provide a means of structured decision making (i.e. the collaborative and facilitated application of multiple objective decision making and group deliberation methods cf. Gregory et al. 2012) for IAS management through a participatory approach of the Belgian expert community on IAS and their management.

As with many impact assessment e.g. using ISEIA (Branquart 2007; Vanderhoeven et al. 2015) or risk assessment schemes, the NNRM uses <u>semi-quantitative response and confidence scores</u> to assess seven key criteria linked with management feasibility of an invasive species: *Effectiveness*, *Practicality*, *Cost*, *Impact*, *Acceptability*, *Window of opportunity* and *Likelihood of re-invasion* (**Annex 1**).

The approach was adapted to the fit the needs of the Belgian assessment (e.g. uncertainty framework in line with Harmonia+) (**Annex 2**). To ensure transparency, the aim was to apply consensus-building methods using on-line expert elicitation tools.

1.3 Species considered

The manageability assessment considers 43 Union list species (1st and 2nd batch) sensu the EU IAS Regulation 1143/2014 (Table 1).

Table 1: Union List species sensu the EU Regulation with their status and their extent of occurrence (definition: IUCN 2001, Burgman & Fox 2002) (EOO) and area of occupancy (AOO) in Belgian bioregions (ATL: Atlantic bioregion, CONT: Continental bioregion) at the time of the assessment.

Species	Status (2017)	EOO (km^2)			AOO (km^2)		
		ATL	CONT	TOTAL	ATL	CONT	TOTAL
Alopochen aegyptiaca	Established	16489	9076	25565	13082.46	3295.91	16378.37
Asclepias syriaca	Established	400	0	400	16.01	0.00	16.01
Baccharis halimifolia	Established	570	0	570	136.11	0.00	136.11
Cabomba caroliniana	Established	-	-	-	8.00	0.00	8.00
Callosciurus erythraeus	Eradicated	29	0	29	20.00	0.00	20.00
Elodea nuttallii	Established	7741	10008	17749	1408.55	234.60	1643.15
Eriocheir sinensis	Established	3829	0	3829	984.57	4.00	988.57
Heracleum mantegazzianum	Established	16124	6580	22704	5458.75	2358.60	7817.34
Hydrocotyle ranunculoides	Established	10135	1809	11944	620.34	20.00	640.34
Impatiens glandulifera	Established	14945	8433	23378	6310.98	2893.99	9204.98
Lagarosiphon major	Established	4459	2509	6968	40.02	36.00	76.02
Lithobates catesbeianus	Established	2538	195	2733	292.11	16.01	308.12
Ludwigia grandiflora	Established	5652	4441	10093	500.22	28.00	528.22
Ludwigia peploides	Established	3896	0	3896	76.05	0.00	76.05
Lysichiton americanus	Established	386	1716	2102	12.00	28.00	40.00
Muntiacus reevesi	Established	3477	0	3477	76.03	8.00	84.03
Myocastor coypus	Established	4822	1263	6085	104.02	64.02	168.03
Myriophyllum aquaticum	Established	5728	3889	9617	1092.49	64.01	1156.50
Myriophyllum heterophyllum	Established	5728	3889	9617	72.04	4.00	76.04
Nyctereutes procyonoides	Casual	9624	1292	10916	52.02	12.00	64.02
Ondatra zibethicus	Established	15612	8156	23768	2141.17	962.30	3103.47
Orconectes limosus	Established	9160	7247	16407	856.34	380.08	1236.42
Oxyura jamaicensis	Established	8523	2321	10844	540.29	56.01	596.30
Pacifastacus leniusculus	Established	1961	9282	11243	40.01	1041.05	1081.06
Procambarus clarkii	Established	3626	254	3880	144.08	28.01	172.09
Procyon lotor	Established	13246	5859	19105	272.12	2142.10	2414.21
Pseudorasbora parva	Established	11244	2925	14169	2072.99	87.52	2160.51
Sciurus carolinensis	Casual	3517	0	3517	28.02	0.00	28.02
Sciurus niger	Casual	-	-	-	4.00	0.00	4.00
Tamias sibiricus	Established	2151	0	2151	232.13	0.00	232.13
Threskiornis aethiopicus	Casual	8762	6616	15378	540.24	28.00	568.24
Trachemys scripta	Casual	12729	4974	17703	1028.51	319.21	1347.72
Vespa velutina	Established	-	-	-	4.00	0.00	4.00

Six Union list species were not considered in the manageability because their establishment potential in Belgium is reported to be very limited. The status of these species in Belgium and the reasons for not taking these species into account for the manageability assessment can be found in Table 2.

Table 2: Union List species sensu the EU Regulation excluded from the risk management assessment with justification.

Species	**Status in Belgium**	**Justification**
Small Indian mongoose *Herpestes javanicus*	Absent	Established in Croatia. Suitable climatic conditions are mostly present in Mediterranean countries (European PRA).
Coati *Nasua nasua*	Casual with 2 escaped animals caught in 2007 (Vanden Berge 2008; Vanden Berge & Gouwy 2009)	Native to South-America and only naturalized on Mallorca (Mayol et al, 2009). It is a particular risk for the Mediterranean. Coati are (sub)tropical and live in relatively stable temperature climes, minimum 3°C to maximum 29°C with an average of 18°C -20°C (Beisiegel 2001)
Water hyacint *Eichhornia crassipes*	Casual in Belgium probably mostly a mere garden throw-out or relic of cultivation (Verloove 2016).	Very sensitive to frost and unlikely to become naturalized in the near future in Belgium (EPPO PRA). Single plants may possibly survive mild winters in our climate (Verloove 2016). Optimal growth occurs at temperatures of 28-30°C (air temperatures) while growth ceases when water temperatures drop below 10°C. Prolonged cold temperatures, below 5°C, result in death of the plants (Gopal 1987, Owens and Madsen 1995).
Kudzu *Pueraria Montana*	Absent	Native to eastern Asia, only established in Italy and it has the potential to spread in areas with high rainfall and mild winters.
Parthenium weed *Parthenium hysterophorus*	Casual, exceptional and ephemeral in Belgium (Verloove 2016).	Especially relevant for the Mediterranean (EPPO PRA). In contrast to its behaviour under the warm, summer-wet climates, it is not able to complete more than one life cycle per year in colder regions (Reddy & Bryson, 2005).
crimson fountaingrass *Pennisetum setaceum*	Absent	Spreading and colonising many areas in Canary, Balearic Islands and semi-arid areas of the Iberian Peninsula (Gonzàlez-Rodriguez et al. 2010). Could be invasive in could be invasive in the warm temperate and dry and hot summer zone (Csa).

1.4 From feasibility scores to actual management in the field

The outcome of the present manageability assessment provides **support to the decision making process**. The outcome of the assessment are species-specific feasibility scores for the specific scenario's and management strategies defined. These scores do <u>not</u> translate directly into a decision on the preferred management option in Belgium, nor do they directly result in a decision on management options sensu the EU IAS Regulation (Art 17/Art 19) because (1) the assessment only considered eradication and spread limitation and not long-term control – however, species with a low scores on the feasibility of eradication and a low score on spread limitation, are candidates for a long term control programme sensu Art 19 (2) for the purpose of the assessment, we standardized and homogenized spread limitation strategies but intermediate strategies are possible (cf. the hierarchy in management objectives in Robertson et al. 2016) (3) in reality the concept of adaptive management (Gregory et al. 2012) can be applied taking into account inherent uncertainty of outcome. Furthermore, the feasibility scores should be interpreted with caution as for some species the number of expert assessments was low (Annex 3), hence insufficient to detect significant differences between scenarios and criteria defined. However, the observed differences between expert assessments were still useful to initiate and guide the discussions.

A final choice of management option in Belgium requires further consultation with stakeholders and requires many other considerations:

- Alternative strategies considered, including the pooling of management for various species;
- Cost-benefit analysis;
- The ecosystem context (cf. Zavaleta et al. 2001):

- Available budget and human resources, stakeholder support, opinion and involvement, community engagement, political and public support etc.

Also, after a decision on management, further work is needed to refine and implement the scenarios in the field by drafting concrete **management plans**. Several guidances and standards are available for running eradication and management programmes see e.g. Keitt et al. (2015) and references therein. Eradication is a fundamental tool for protecting biodiversity from the negative effects of IAS (Howald et al. 2007; Robertson et al. 2017). If removal actions do not obtain the expected result, the risk is to move on to a continuous control. Therefore, careful planning is necessary to evaluate the effort needed for eradication. Modelling procedures can be used to evaluate the timeframe of a campaign, the effectiveness of different techniques or management options and the amount of effort needed for effective eradication (e.g. Tattoni et al. 2006).

Also, for rapid response to new introductions, **contingency plans** should be drafted. Such plans indicate what needs to be done when IAS are found for the first time; it is therefore the step before a detailed management plan. It indicates the organisational structures, procedures and arrangements. The plan describes roles and competences, and how the response is aligned with the regulations and other organisations. This plan should, as a minimum, mention the stakeholders and experts who should be contacted when more concrete actions are taken, but above all should outline the competences of different bodies and organisations and the concrete procedures to be followed (Adriaens et al. 2015).

Lastly, the most important reasons why management measures for biological invasions fail are:

- Lack of clear management objectives
- Inadequate or missing medium-term planning
- Uncertain funding streams
- Lack of monitoring of outcome of the measures

Regardless the outcome of management feasibility assessment presented here, which contributes to the definition of clear management goals defined both by scientists and practitioners, planning, budget and monitoring have to be addressed in the final management strategy.

2. Scenarios and strategies

2.1 Invasion scenarios

Invasion scenarios consist of factual description of the historic and current distribution and spread of the species. For IAS that are already established in Belgium, the scenario describes is the current extent of the species. For non-established species the scenario represents a probable invasion scenario that takes into account the probable pathway of introduction, the most likely entry point in the wild and the most likely extent of the species in Belgium at the point detection based on existing surveillance. The scenario includes:

- **Invasion situation and history in Belgium**: brief account of the species invasion history and current invasion extent based on published information and data.
- **Reliability of the Belgian distribution**: representativeness of the distribution, identification of knowledge gaps in relation to ease of identification of the species and coverage of the species range by the current monitoring systems.
- **Current management practice** is mentioned when available with differences between bioregions.
- **Invasion situation in neighbouring countries**: this information is primarily relevant for assessing the likelihood of reintroduction from neighbouring countries.
- **Distribution map**: based on validated distribution data from different regions as reported for the EASIN baseline (Tsiamis et al. 2017). This distribution map has a specific purpose and used specific date cut-offs with reference period 2000-2015 (Adriaens et al. 2017). Hence, the current distribution of the species can deviate from the map: the species can be underreported/underestimated (e.g. because of poor detectability, difficult identification of insufficient monitoring) or the distribution map can overestimate the actual distribution of a species, especially when it is under management. In this case, this is clearly explained in the scenario. In addition, for some species, the distribution map shows occurrence gaps.
- **Quantification of invasion extent**: a table is presented containing the number of 10 km, 5km and 1km squares where the species was recorded in each bioregion (Atlantic/Continental) during the reference period 2000-2015. It also shows the percentage of 1km square in Natura2000 areas (% 1km SAC) to provide an idea of its occurrence in protected areas. Furthermore, because this information is relevant to assess practicality, clustering index (CI, nearest neighbor index) was calculated which represents the level of clustering between the observations (using the average nearest neighbour tool from ESRI Arcgis). If the index is < 1, the distribution pattern exhibits clustering. An index > 1 indicated a more scattered distribution pattern.

2.2 Management strategies

Suitable and realistic management strategies were drafted by the authors of this report (**Annex 3**) for both eradication and spread limitation. These were derived from the full risk assessments for Belgium if available (see Vanderhoeven et al. 2015; Adriaens et al., 2013; Baiwy & Schockert, 2013; Baiwy et al., 2012a, 2012b; Lafontaine et al., 2013a, 2013b; Robert et al., 2013a, 2013b, 2013c, 2013d; Schockert, 2012; Schockert et al., 2012; Vanderhoeven, 2013; Verreycken, 2013; Verloove & Groom, 2013; Verloove, 2002, 2006), as well as published literature on management methods and their effectiveness.

Two risk management strategies were considered for Belgium:

1. *Eradication* : the complete and permanent removal of a population of invasive alien species by lethal or nonlethal means (definition of EU Regulation 1143/2014).

2. *Limiting spread* : any management scenario aimed at halting/limiting the spread of an IAS. In accordance with the stand-still principle of many legislative biodiversity instruments in Belgium, this is further specified as a management scenario aiming at a *status quo* in the current (T0) baseline distribution of an IAS of EU concern as reported to the European Alien Species Information Network (EASIN) (Adriaens et al. 2017; Tsiamis et al. 2017). Note the notion of limiting spread refers to the entire Belgian population and should therefore be considered broader than containment, which involves any action aimed at creating barriers which minimizes the risk of a population of an invasive alien species dispersing and spreading beyond the invaded area (definition of EU Regulation 1143/2014). Often, the strategy is different from the eradication

strategy in the spatial scale at which the populations are considered. The following spread limitation options have been identified for the EU list species:

- **Option 1. Stand-still principle with a single or a few patches.** This strategy aims at limiting the presence of a species in Belgium to a single or a few patches where it is described in the invasion scenario. This is done primarily by implementing procedures to eradicate any new populations, measures to create dispersal barriers (e.g. fencing, making areas inaccessible to species or vectors) or management methods aimed at avoiding the production of propagules that might result in dispersion (e.g. mowing before seed setting, measures aimed at reducing the population density). This strategy also includes methods to rapidly eradicate any new patches discovered outside the known patches.
- **Option 2. Stand-still principle with core area(s).** This strategy aims at limiting a species within a given core area where it is more widely distributed by implementing management measures aimed at avoiding any further spread or establishment outside this area. This includes management measures aimed at avoiding the production of propagules that might result in dispersion (e.g. mowing before seed setting) as well as methods to rapidly eradicate any new patches discovered outside the known core area(s). As dispersal is often influenced by population density, the strategy can also include management measures aimed at reducing the population density within the core area.
- **Option 3. Progressive elimination of the most dispersive populations** (widespread species with uninvaded areas in the distribution). This strategy aims at eradicating the dispersive segment of the total population in order to reach a stand-still of its current distribution. For plant species, this includes differentiated management measures for patches that are the source of new propagules for dispersal and measures to limit propagule pressure in other places. For widely spread animal species, this this can include the breeding part of the population.
- **Option 4. Maintenance of pest free areas** for widespread species. The spread limitation strategy aims at managing uninvaded areas as free areas. These areas are subjected to (i) dedicated biosecurity measures, (ii) management actions aiming to increase habitat resistance to invasion, (iii) an increased surveillance effort and (iv) rapid eradication actions after detection.

Although the manageability assessment only considered eradication and spread limitation as management strategies, species with low scores on the feasibility of eradication as well as a low score on spread limitation can be considered candidates for a long term control programme sensu Art 19.

The time frame for eradication and spread limitation is important to assess the different risk management criteria. If a specific timeframe is envisaged, it is mentioned in the strategies. If no specific timeframe is mentioned in the strategies, eradication is considered to take as long as is necessary to achieve permanent removal during in a time-limited campaign (Bomford and O'Brien 1995), whereas spread limitation should be considered an ongoing activity.

2.3 General provisions not part of the management strategies

When assessing the strategies' feasibility, assessors should assume the general Regulation obligations and bans are fulfilled:

- **Trade bans** are effectively installed, border inspection services are up and running;
- **Action plans for unintentional pathways** of introduction are implemented;
- **Surveillance** including both the current general surveillance activities (citizen science recording and professional WFD & N2000 monitoring) as well as dedicated surveillance for Union List species. Surveillance can be considered at two levels:
    - **General surveillance**: non-targeted screening of the entire territory for new observations of IAS of Union concern. This often requires the adaptation or expansion of existing monitoring systems for various species (groups) or habitats. An example for Belgium is the general surveillance through the online citizen science recording system www.waarnemingen.be/exoten and https://observations.be/invasive_alert_view.php and the use of dedicated smarphone apps for reporting (Adriaens et al. 2015a,b).
    - **Dedicated surveillance**: targeted surveillance, risk oriented surveillance and inspection programs aimed at specific locations where invasive exotics can be detected, often with specific methods and with greater frequency of sampling or field visits. Examples are the surveillance for Asian hornet at beehives or the use of wildlife camera trap networks to detect nocturnal mammals. Targeted surveillance can be performed in

areas with biodiversity present that is particularly vulnerable to invasions by specific IAS, such as Natura 2000 sites, nature reserves and other protected areas, biodiversity hotspots, vulnerable water bodies and river basins, or in areas where new invasions may be expected on the basis of the distribution pattern or specific pathways of introduction (cf. Adriaens 2016).

These general measures are not explicitly mentioned in the strategies because they are an inherent part of any strategy. The strategies only comprise such activities in case they are explicitly required for implementing the strategy e.g. surveillance activities that exceed the general and dedicated surveillance that should be set up for the species, dedicated biosecurity measures that exceed the general provisions but that are required for the spread limitation strategies.

These measures are often necessary conditions to run eradication or management campaigns. Assessors should consider the surveillance in place when scoring the feasibility of the different management strategies for species, here, we present further information on surveillance needed for some species (groups) (Table 3).

Table 3: Some general recommendations for a number of Union List species (group) linking to the obligations in the EU Regulation on bans (prevention), action plans for pathways (e.g. biosecurity) and surveillance that are not part of the strategies but should be considered to be in place while scoring the management feasibilty.

Species	Surveillance	Prevention & biosecurity
Baccharis halimifolia	A survey should be conducted to determine the full extent of the B. halimifolia distribution, using the existing species monitoring (PINK, BEK) of natural areas and N2000 areas along the coast (Provoost et al., 2012) but adding dedicated surveillance at likely places of introduction of *B. halimifolia*, especially along roadsides, on brownfields with bare soil and along canals. Increased attention for the species is required in the Polder area, especially in areas with halophytic grasslands. The most appropriate time for surveillance is during the flowering period (mostly June-August). *Baccharis halimifolia* has a very high seed production and is dispersed by wind and water, which ensures a good colonization capacity (Fried et al., 2016). Suitable habitat (moist soils with high organic content, poorly drained saline soils) is present further east in the Atlantic bioregion (e.g. along the river Scheldt and in natural areas around the port of Antwerp) and is well within range of its wind dispersed fruits.	Preventive measures include the prohibition of selling, growing, transporting, introducing *Baccharis*. The species should not be planted anymore along the coast in gardens, public greenery, roadside verges or roundabouts. Public authorities are stimulated to remove current *Baccharis* stands through an awareness raising campaign.
Ludwigia grandiflora & *L. peploides*	The strategies should be based on (i) a systematic survey of Ludwigia populations in Belgium coordinated and animated by regional public authorities, with the support of local managers, naturalists, plant experts, etc. and (ii) mandatory notification by land owners/managers. Monitoring is concentrated on areas that are most vulnerable to invasion, i.e. in nutrient-rich water bodies and slow flowing watercourses. Due to the very high likelihood of plant spread by water current, systematic inventories of upstream and downstream areas adjacent to known infestations are conducted by dedicated personnel. Surveillance is also intensified near border areas due to high risk of plant recolonization from populations established in neighbouring countries, especially along transboundary watercourses and waterbodies with Netherlands and Northern France that are strongly invaded.	Preventive measures include the prohibition of growing, transporting, introducing and trading of *Ludwigia* spp. A communication and biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas. Biosecurity mainly focuses on checking boats and equipment and removing any *Ludwigia* material before use and moving from invaded to uninfected areas.
Cabomba caroliniana	See *Ludwigia* spp.	Public information is provided to villagers about *Cabomba*, its impact and the actions performed, through targeted communication (leaflets for the surrounding villas, announcement in the local village newsletter, website of municipal council, social media, fora of aquarists). The surrounding villagers are informed through an information session in the town hall. Before the action is undertaken, it is approved by the town council who decides on a budget. Additional funding is sought and obtained from the provincial water management services.

Lagarosiphon major	See *Ludwigia* spp.	Public information is provided to stakeholders involved (boaters, aquarists) about L. major, its impact and the actions performed, through targeted communication.
Elodea nuttallii	To plan the management surveillance is performed. This is achieved by general surveillance using naturalists, dedicated macrophyte sampling and an increased number of sites monitored within the framework of the reporting for the Water Framework Directive in suitable habitats. Eradication or spread limitation needs to be well planned and coordinated as it involves many stakeholders, private people and water managers.	See *Lagarosiphon major*
Heracleum mantegazzianum	Management strategies should be accompanied by (i) a systematic survey of giant hogweed populations in Belgium coordinated and animated by regional public authorities, with the support of local managers, naturalists, etc. and (ii) mandatory notification by land owners/managers. Monitoring is concentrated on areas that are most vulnerable to invasion (abandoned grassland, fringes along watercourses, woodlands, roads and railways, nature conservation areas) and on sites susceptible to colonization (e.g. nearby areas where giant hogweed has been used for apiculture or gardens where it is cultivated). Due to the very high likelihood of seed spread by water current, systematic inventories of upstream and downstream areas adjacent to known infestations are conducted by dedicated personnel. Surveillance is also intensified near border areas due to high risk of plant recolonization from populations established in France, Germany and Netherlands, especially along transboundary watercourses and waterbodies.	Preventive measures include the prohibition of growing, transporting, introducing and trading of Ludwigia spp. An awareness campaign is launched with garden owners to prevent translocations and garden escapes. Also, a communication campaign is launched towards beekeepers to prevent the species from being introduced.
Threskiornis aethiopicus	The current general surveillance and early warning tool through observations.be is used and every bird reported receives appropriate response and follow-up. With the very active bird-watching community and the relative rarity of the species, any free-flying sacred ibis will quickly be detected and reported. Also, heron and spoonbill colonies are monitored and the coverage of birders is good. Early warning alone is not sufficient as the eradication approach requires interpreting multiple observations, bird's behaviour and whereabouts etc. Therefore, the general surveillance is supplemented with increased agility for sacred ibis presence within the monitoring of heron and spoonbill colonies and any other risk areas for breeding.	Increased compliance with the prohibition on introduction and keeping through training of nature and zoo inspectors, awareness raising with stakeholders (e.g. owners of private bird collections and their stakeholder organisations) and an active policy towards phasing out the captive population (e.g. by actively stimulating zoos and collections to dispose of their animals, sterilize and contain them, promptly verbalizing such institutions/persons in case any birds shot originate from captive populations in Belgium) in order to prevent new introductions.
Oxyura jamaicensis	Birds are located using the general	See *Threskiornis aethiopicus*

	surveillance and early warning system observations.be, supplemented with monitoring data from the wintering waterbird census and dedicated surveys at locations where birds are known to breed.	
Squirrels (*Callosciurus erythraeus, Tamias sibiricus, Sciurus carolinensis, S. niger*)	To locate squirrels, general surveillance using waarnemingen.be/observations.be (Adriaens et al., 2015b; Adriaens et al., 2017a) is combined with dedicated surveillance using a network of the same camera traps and hair tubes (Verbeylen, 2012) in a 2km buffer zone around the managed populations. Action need to be well planned and prepared, including an initial survey to determine the extent of the population, to delimit the management areas (e.g. natural barriers to squirrel dispersal, zones of sympatric occurrence with native red squirrel) and to roughly assess squirrel densities in order to assess the density of traps and the required surveillance effort. Agreement of site owners, regional and local authorities is acquired and budget is secured, including for post-eradication monitoring.	Increased compliance with the prohibition on introduction and keeping through training of nature and zoo inspectors, awareness raising with stakeholders (e.g. pet owners and the public) and an active policy towards phasing out the captive population (e.g. by actively stimulating zoos and collections to dispose of their animals and to cover the costs for humane killing of pets through a veterinarian) to prevent new introductions.
Lithobates catesbeianus	Surveillance is carried out using waarnemingen.be, accompanied by inventories using e-DNA, and is focused in priority zones for population expansion. Control is carried out by trained professionals (e.g. social economy companies, agency people) in a long-term dedicated project (e.g. a Life+ project) with appropriate human and other resources at the initiative of both government agencies and conservation ngo's. An intensive early warning and rapid response campaign for the Nete Valley population with the aims of rapidly intervening in case of further spread. To this end, a volunteer network is set up and coordinated where trained volunteers adopt km squares around the Nete population nucleus and actively perform field surveys in the right season to detect calling males or juveniles.	Increased compliance with the prohibition on introduction through training of nature inspectors and awareness raising with stakeholders (e.g. owners of private fish ponds, the public) to prevent new introductions.
Muntiacus reevesi	A dedicated network of camera traps is set up and maintained in high risk areas of muntjak occurrence or points of entry e.g. along the border with the Netherlands. In parallel, residents, hunters, nature lovers and the general public are informed about the presence of muntjak in the area and are stimulated to rapidly report any observations using online recording with www.waarnemingen.be or through one of the available apps (Adriaens et al., 2015c). This is done using simple flyers, explanations during guided walks, posters, leaflets and television interviews.	Increased compliance with the prohibition on introduction and keeping through training of nature and zoo inspectors and an active policy towards phasing out the captive Belgian population (e.g. by actively stimulating zoos and collections to dispose of their animals and to cover the costs for humane killing of pets by a veterinarian). Second hand websites offering pets for sale and hunting forums are monitored. To prevent new introductions, an awareness raising programme is launched targeted towards hunters in cooperation with the hunting societies, to increase awareness on the impact of this (non-game) species on biodiversity and hunting assets (notably roe

		deer), and to stimulate rapid action by volunteer hunters when new muntjak individuals pop up.
Eriocheir sinensis	Surveillance is organized by a network of fyke traps in the areas concerned. Careful planning is necessary to identify suitable locations to install traps taking into account the local site conditions and migration barriers where the animals could amass during upstream migration. Additionally, surveillance of standing waters (lakes, ponds etc.) is organized through dedicated samplings using adapted crayfish traps and using e-DNA.	
Pseudorasbora parva	Dedicated monitoring of streams and water bodies is necessary to detect presence of topmouth gudgeon and to.	To prevent further spread and new introductions, a prohibition on using the species as live bait (or a general prohibition on the use of live fish as live bait) is issued and enforced in Flanders (in Wallonia, this is already in place). Also, stringent procedures are put in place to check fish stocking material imported for fish farms and for stocking open water for contamination with P. parva. As dispersal from (former) aquaculture facilities represents a key factor in the spread of P. parva (and other small bodied non-native fish) (Davies & Britton, 2016), additional biosecurity measures should be applied at infected sites, for example, fine mesh screens on all outlets to minimize escapees contaminating connected water bodies and, where feasible, eradication, using appropriate methods.
Myocastor coypus	Surveillance consists of (i) an active and systematic survey of coypu populations in Belgium coordinated and animated by regional public authorities, with the support of river managers, hunters, anglers, naturalists, etc. and (ii) mandatory notification by land owners/managers. Monitoring effort is increased in wetlands situated in transboundary river catchments where coypu presence is already confirmed (Chiers, Meuse, Sambre, Semois, etc.). Professional hunters commissioned by regional authorities are hired to detect specific signs of presence of the species through a systematic survey in those areas, including night inventory campaigns.	Preventive measures include the prohibition of trading, rearing and holding *M. coypus*. Coypu feeding is prohibited in urbanised areas.
Lysichiton americanus	Surveillance consists of (i) a systematic survey of American skunk cabbage populations in Belgium (incl. hybrids) coordinated and animated by regional public authorities, with the support of local managers, naturalists, plant experts, etc. and (ii) mandatory notification by land owners/managers, including gardeners. Information sheets are produced to avoid any confusion of young stages with related taxa like the eastern skunk cabbage (*Symplocarpus foetidus*),	Preventive measures include the prohibition of growing, transporting, introducing and trading of L. americanus. A communication and biosecurity campaign is organised targeted at park managers, pond owners and gardeners. Care is taken to avoid any movement of seeds with contaminated soils and garden waste.

	another Araceae native to North America. Monitoring is concentrated on areas that are most vulnerable to invasion, i.e. near ponds, wells and watercourses. Due to the very high likelihood of plant spread by water current, systematic inventories of downstream areas adjacent to known infestations are conducted by dedicated personnel.	
Invasive crayfish (*Orconectes limosus, Procambarus clarkii, Pacifastacus leniusculus*)	Surveillance consists of (i) a systematic survey of crayfish populations in Belgium coordinated and animated by regional public authorities, with the support of local managers, anglers, naturalists and crayfish specialists and (ii) mandatory notification by land owners/managers. This is supplemented in low-density areas with e-DNA samplings. Monitoring is concentrated in areas that are most vulnerable to invasion, i.e. artificial fish ponds. Due to the very high likelihood of crayfish spread by water current, systematic inventories of upstream and downstream areas adjacent to known infestations are conducted by dedicated personnel. Surveillance is also intensified near border areas where known crayfish populations are established due to a high risk of recolonization from them.	Preventive measures include the strict prohibition of growing, transporting, introducing and trading of crayfish. Leisure and commercial fishing is also forbidden. A communication and biosecurity campaign is organised targeted at aquarium industry, pet owners and also pond and river users, especially fishermen. A special care is taken (i) to avoid any accidental introduction via fish stocking operations and (ii) to avoid any accidental spread of the crayfish plague by managers towards native crayfish populations. In parallel, the public should be made aware of the problems associated with non-native crayfish introductions, which is done through involving them in management actions and surveillance programmes using citizen science (e.g. reporting apps for anglers), awareness campaigns towards all users of water bodies, pond owners etc. Thorough enforcement of the prohibition on introductions in nature is necessary at risk locations for introductions e.g. restaurants dumping live waste, aquaculture or other breeding facilities. As a restoration measure, a reintroduction programme for native noble crayfish *A. astacus* could form an integral part of the strategy. This requires a feasibility study to identify suitable areas for reintroduction, rearing programmes, monitoring and follow-up.

2.4 Workshop on Management of IAS of Union Concern

Without clear objectives and rigorous monitoring of outcomes, an effective system of adaptive management for invasive alien species will remain difficult (Foxcroft et al. 2019). Managers, policy makers and scientists need therefore to agree on achievable management goals. To achieve this, we took the approach as proposed by Metzger et al. (2017) which involved drafting various management scenario's and capturing the aspirations of multiple stakeholders (in this case decision makers, practitioners and scientists). The aim of this participatory approach was to have the different perspectives correctly represented. Beyond providing a correct evidence base for decisions on management of IAS in Belgium, this approach also stimulates co-production and co-ownership of knowledge (Fujitani et al. 2017) and can hopefully lead to more support for the management measures proposed. It also contributes to closing the knowing-doing gap in invasion management (Roux et al. 2006; Esler et a. 2010; Matzek et al. 2014) and to reinforce the IAS community of practice (sensu Wenger 1998, 2002).

On 19 December 2018 a workshop was held in Brussels jointly organized by the Research Institute for Nature and Forest (INBO), the Belgian Biodiversity Platform, the Département d'Etude du Milieu Naturel et Agricole (Service Public de Wallonie - DEMNA) and the National Scientific Secretariat on Invasive Alien Species. The workshop, which was built around the results of the manageability assessments, brought together a number of experts who performed the assessments of management feasibility (Annex 3) with field practitioners who manage invasions in Belgium. The purpose of this workshop was to gather the opinions of managers on the proposed objectives and management strategies to be put in place in support of the of the IAS Regulation in Belgium, as a straightforward management recommendation from the practitioner's community.

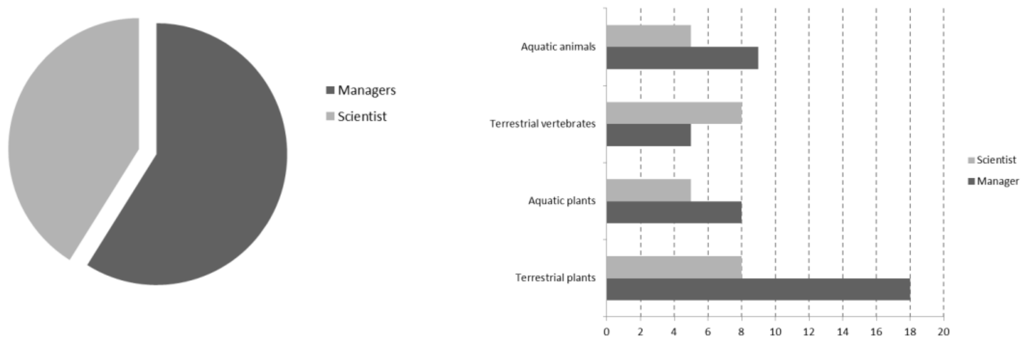


Figure 1: General profile of attendants (left) and split out per thematic group (right) attending the Workshop on Management of IAS of Union Concern in Belgium (12 December 2018, Brussels).

The workshop was attended by 78 people, of which 61% had a field manager profile and 39% had a scientific profile (figure 1). A number of introductory talks explained the purpose of the workshop and the methodology to the participants. Break-out groups were organized for four thematic species groups: aquatic plants (8 species), terrestrial plants (9 species), aquatic animals (10 species) and terrestrial vertebrates (13 species). Asian hornet (*Vespa velutina*) was not considered during the workshop. These were moderated by Etienne Branquart, Sonia Vanderhoeven, Dido Gosse and Tim Adriaens respectively. Discussions in the break-out groups were standardized across thematic groups. First, per species, the invasion scenario and the proposed management strategies were quickly revisited with the aim of focusing the discussion and getting information on completeness of the scenario. Second, the overall result of the management feasibility assessment for eradication and spread limitation were presented, followed by a breakdown of scores and standard deviations over the different criteria assessed (see species accounts). For the purpose of the workshop, we used the standard deviation around the mean as a measure of variation around the feasibility scores. Revisiting the scores across strategies and criteria, a moderated discussion was then held with the participants around the management strategy to recommend for the species (eradication, spread limitation or any alternative strategies), and a consensual management recommendation was formulated. In case there was no agreement amongst participants about the scenario to recommend, this disagreement was documented and a voting was organized.

After the workshop, a survey was sent around with the notes of the discussion outcomes per species on which workshop attendants provided further comments. The aim was to ensure these notes provide an accurate representation of the discussion outcome or if anything is missing and to gain any other comments followed. This supplemental feedback was screened by the workshop organizers and added to the notes if deemed relevant. The management recommendations from the workshop are supplemented to the scenario's, strategies and outcomes of the expert's assessments in this report (see species accounts). This way, both the scientific expert's and the field manager's opinion can be taken into account by the competent authorities in Belgium in the decision-making process on the management of IAS of Union concern in Belgium.

3. Results

3.1 Vertebrates

3.1.1 Egyptian goose *Alopochen aegyptiacus* (nijlgans, ouette d'Egypte)

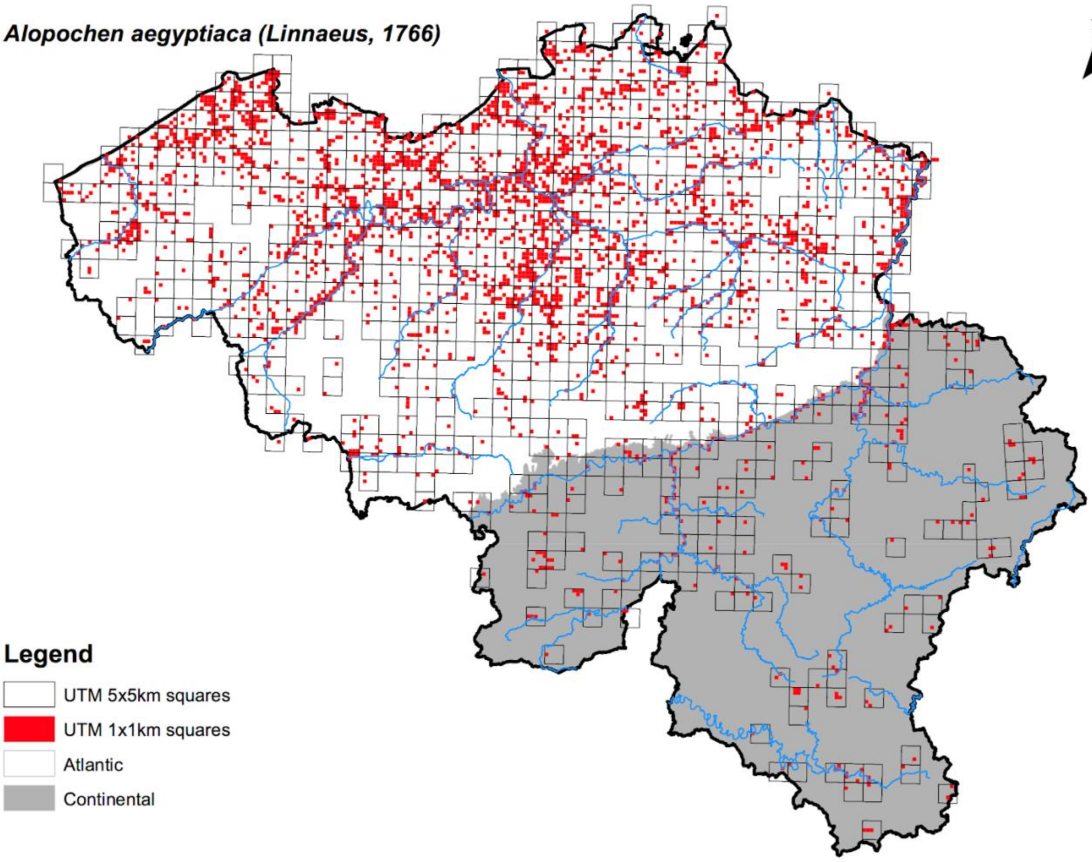
©Karel Van Moer

Invasion scenario

- Invasion situation and history in Belgium: Egyptian goose was reported in Belgium in the wild in 1984, started breeding in the early nineties and is now widely established in the country. The Belgian breeding population originated from escaped geese from the ornamental bird collection of the Royal Domain (Laken) (Vangeluwe, 2010; Vangeluwe & Roggeman, 2000) and has expanded rapidly since the 1990s (Gyimesi & Lensink, 2012; Vangeluwe & Roggeman, 2002; Vermeersch et al., 2004). Census data on the wintering population show a similar increase since the mid-1990s. According to the common bird monitoring scheme in the Atlantic bioregion, which now includes Egyptian goose, the species is still significantly increasing (>5% increase in the number of $1km^2$ squares per year). Strongholds in the Atlantic bioregion are the Brabant, the northern Hainaut and Campine areas, central Limburg and the gravel extraction pits in the Meuse area (Limburg). The species is less abundant in the continental bioregion; it is rather common in the Condroz and Famenne but much more rare in the Ardenne and Lorraine areas. There is no detailed information available on the current number of breeding pairs in the Atlantic bioregion, but presumably the number of breeding pairs is over 2000. In winter, in the Atlantic bioregion, the average winter maximum (2010-2015) is quite stable since 2007 with 3500 birds and maxima of about 4000 birds (Adriaens et al., 2011, 2012; Anselin & Devos, 2005; Devos & Onkelinx, 2013). In the winter of 2016-2017 the maximum number was 5630 (INBO, waterbird census). There is no information on the importance of the influx of escaped birds from collections in the population built-up. In Belgium, Egyptian geese are culled through hunting (yet without obligatory reporting), are captured on breeding grounds and also egg destruction is practiced locally.

- Reliability of the BE distribution: Despite lack of detailed data on the breeding population, species distribution is considered as representative as the species is easy to recognize and the coverage of birders is good. It is the most reported alien bird species on the citizen science platform waarnemingen.be/observations.be

- Invasion situation in neighbouring countries: Some breeding areas in Flanders (e.g. Meuse valley) were colonized from The Netherlands where a large breeding population is present (>10.000 breeding pairs, >50.000 birds) (Benmergui 2011; Hustings & Koffijberg, 2015). In The Netherlands, numbers show a stabilisation since 2010 and (local) decrease since 2012-2013. Ringing data primarily show exchanges with Zeeland/Zuid-Holland and Limburg but also with western Germany (North Rhine Westphalia). In France, the number of breeding pairs is still rather limited (150-200 pairs in 2009) but the birds are concentrated along the Belgian border (Alsace, Lorraine) and the population is expanding (Benmergui 2011). In Germany it is widespread with over 2.200-2.600 breeding pairs (Südbeck et al. 2007). In Luxemburg, the species is widespread and the population is estimated at about 40 breeding pairs (Bastian 2016).



	ATL	CONT
UTM 10km	226	94
UTM 5km	800	270
UTM 1km	7039	919
% 1km SAC	26	81
Clustering index	1.06	0.68

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy consists of culling birds through a combination of shooting and capturing. Shooting is the principal method used to control Egyptian geese. Birds can be shot when at or when flying into night roosts, at feeding sites and on breeding territories. Actions can be targeted towards single breeding pairs, but can also be aimed at shooting geese in numbers when they aggregate in groups (autumn & winter). Disturbance should be kept to a minimum especially with autumn and winter aggregations to prevent induced dispersal (e.g. when shooting). In summer, birds tend to be more dispersed. Shooting is mostly performed using short range shotguns, small caliber long rifles with silencer or a powerful air rifle. This would allow to shoot multiple animal at roost sites (cf. actions on ruddy duck and sacred ibis). Shooting would be supplemented with trapping where required, e.g. at sites were shooting is not possible because of safety or disturbance issues, such as parklands, nature reserves, urban areas and private land. Trapping is performed year-round using a land-placed multi-capture Larsen trap with live decoy. Operating such traps requires daily checking for captured birds and checking on the condition and food of the decoy birds. Traps can be transported on a trailer and can be operated by one or two people. A Belgian case study (19 locations, max distance between two sites < 120 km) employed 2 FTE field control officers (Adriaens & Huysentruyt, 2014). It can be assumed that if capture sites are not spread out too widely, a single person can manage about 10 Larsen trap inspections/day. Initial surveillance would be required to identify roosting, feeding sites and breeding territories, safe lines of fire for marksmen and if required suitable locations for traps. The effectiveness of these traps has not been assessed, but when used to target couples at the onset of breeding, potentially they are very effective at preventing breeding thus taking out the reproductive segment of the population.

Egyptian geese experience a full primary moult leaving them flightless, but are, due to their excellent diving capacities (they are shellducks, not geese), not susceptible to the moult trapping systems applied for other species such as greater Canada or greylag goose (Adriaens & Huysentruyt, 2014; Adriaens et al., 2012, 2013, 2014a,b; Huysentruyt et al., 2013; Reyns et al. 2018; Van Daele et al., 2012). The species does not generally nest in colonies and regularly uses nesting sites in trees, making the nests less accessible for fertility control through egg pricking or oiling with liquid paraffin (Baker et al., 1993). Fertility control through nest destruction, pricking or oiling eggs has also been shown ineffective at population level (Klok et al., 2010). Floating Larsen traps have been tested in Belgium (Adriaens & Huysentruyt, 2014) but are more difficult to operate and more labour intensive. Trials with clap nets have largely been proven unsuccessful for capturing large flocks of Egyptian geese. Therefore, these methods are <u>not</u> part of the eradication strategy.

- <u>Post-intervention verification</u>: no specific post intervention measures are applied apart from monitoring for the occurrence of birds and breeding pairs. Birds shot should be removed from the environment if possible.

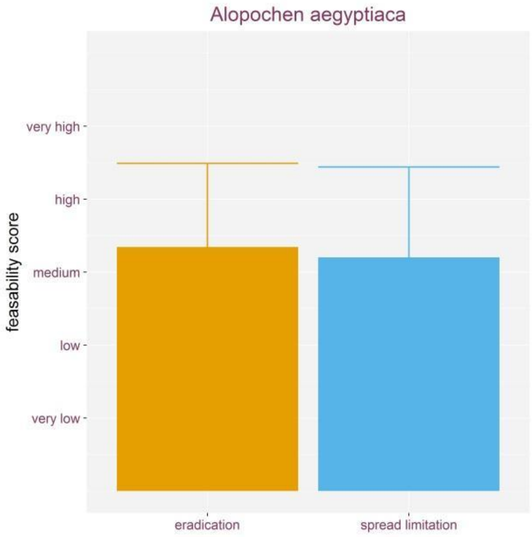
1. *Management strategy – spread limitation*

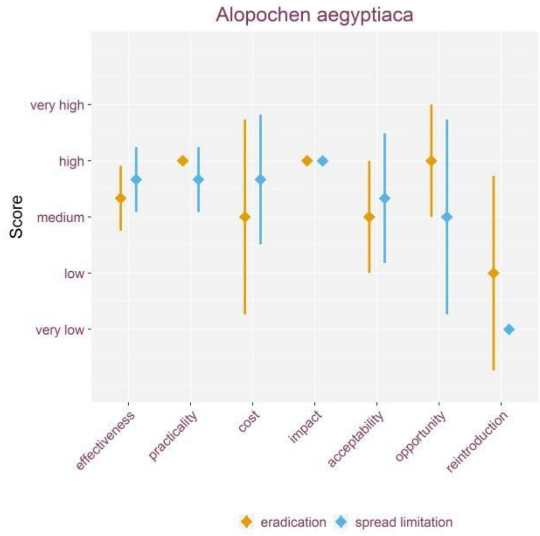
- <u>Aim</u>: *Option 3 - Progressive elimination of the most dispersive populations*
  As the whole Belgian territory is invaded by Egyptian goose and the species has good dispersal capacities, the strategy is to perform control of dispersive nuclei under the assumption that this might prevent dispersal to a certain extent. The spread limitation strategy therefore aims at eradicating dispersive nuclei of Egyptian geese, i.e. areas where large flocks and breeding concentrations occur. This coincides with the parks and surroundings of Brussels, Mechelen and Klein-Brabant, the northern Campine area, central Limburg and the gravel extraction pits in the Meuse area.

- <u>Methods and techniques</u>: Techniques similar to those used in the eradication strategy are applied to the most dispersive populations. This involves culling birds through a combination of shooting and capturing with Larsen traps.

- <u>Post-intervention verification</u>: no specific post intervention measures are applied apart from monitoring for the occurrence of birds and breeding pairs. Birds shot should be removed from the environment if possible.

Assessment results





The feasibility for both strategies was scored between medium and high by the experts, with similar variation around scores. This is reflected in comparable scores across criteria. Practicality and non-target impact were scored high for both strategies. Effectiveness and cost scored between medium and high. Acceptibility was scored between medium and high but with a degree of variation around the average. Reintroduction was scored low and very low for eradication and spread limitation respectively. There was more variation around the scores for cost, window of opportunity and the probability of reintroduction.

Outcome from the workshop

1. General considerations

The fact that the biggest population nuclei in Wallonia are found in Fouron where the Meuse enters Wallonia should be added in the scenario. The high scores for practicality are counterintuitive in light of the complexity of trapping as a control method for this species. The group remarked that this feasibility score was probably influenced by the combination of trapping and shooting in the strategy. Also, Window of Opportunity is giving counterintuitive results. Some remarks were made on the similarity between both strategies. However, for spread limitation the focus is on the distribution and therefore, big nuclei/groups of birds should be targeted. In practice, this can also be seen as ‘progressive’ elimination.

2. Recommendations for management

The group concluded that for Egyptian goose, the proposed spread limitation (scenario 3) should be recommended but supplemented with basic control throughout the whole Belgian territory. The strategy should include provisions to stimulate volunteer hunting, but part of the control should be professionalised using professional control agents. The management efforts need to target big concentrations but also smaller nuclei that are equally responsible for spread.

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3.1.2 House crow *Corvus splendens* (huiskraai, corbeau familier)

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Invasion scenario

- Invasion situation and history in Belgium: not currently established in the wild in Belgium. The scenario is, at the point of detection, a few house crows (max 10 birds) reported in a built-up area in the vicinity of Antwerp harbour that arrived as stowaways on a ship from Egypt cf. the case of Hoek van Holland, Netherlands (Vane and Runhaar 2016).

- Reliability of the BE distribution: the coverage of the Belgian territory by birders is good so probably new arrivals would be detected fairly easily.

- Invasion situation in neighbouring countries: the only reported population in neighbouring countries was a population in Hoek van Holland (Netherlands) which originated from a ship-assisted introduction of two birds in 1994. By 2012 23 house crows were present and at most 30 birds were reported (Slaterus et al. 2009; de Baerdemaeker and Klaassen 2012). A strongly contested eradication campaign was launched in 2014 after a juridical battle. Meanwhile, this population was eradicated. The eradication was initially performed by capturing, but later by shooting as birds grew shy fast. The campaign has cost the Ministry +/- 23.600 euros for 26 crows, about 15.000 euros cheaper than capturing and replacing the birds in zoos (Tweede Kamer der Staten-Generaal 2015).

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy is to cull all birds applying shooting as the principal method (Verwaijen 2016). Birds can be shot when at or when flying into roosts and at feeding and nesting sites depending on their locations (no shooting is allowed in Belgium within 150m of homes). Initial surveillance will be required to identify roosting, feeding and nesting sites and safe lines of fire. Because the control measures will take place in suburban areas, sufficient information should be provided for residents and passers-by. Birds shot should be removed from the environment if possible.
  Trapping using nets and cages has proven successful in the beginning but insufficient to remove the last birds (CABI, 2017). This was also the case in Hoek van Holland (Vane and Runhaar 2016) where birds grew shy very fast. Fertility control will not remove the population in the short-term. Chemical methods such as the use of starlicide are not permitted in Belgium, not humane and have non-target effects on native avifauna. Chemical sterilization such as the use of OvoControl (nicarbazin) which is commonly used to control feral pigeons is currently not permitted in Belgium and has non-target effects on native avifauna. Therefore these methods are not part of the eradication strategy.

- Post-intervention verification: monitoring for the occurrence of crows and breeding pairs on the site and dedicated surveillance in an area of 2km around it for at least two breeding seasons after the removal actions.

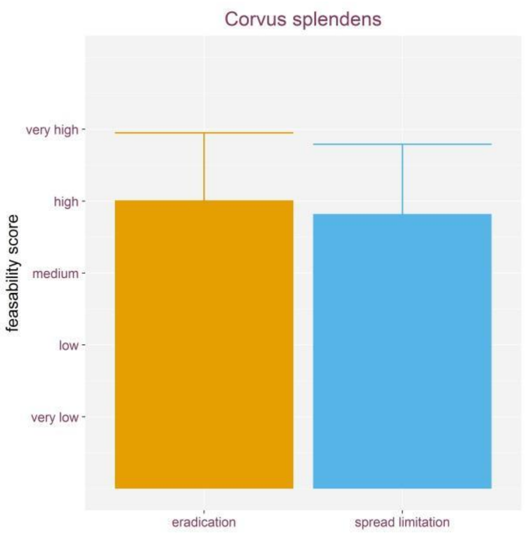
1. *Management strategy – spread limitation*

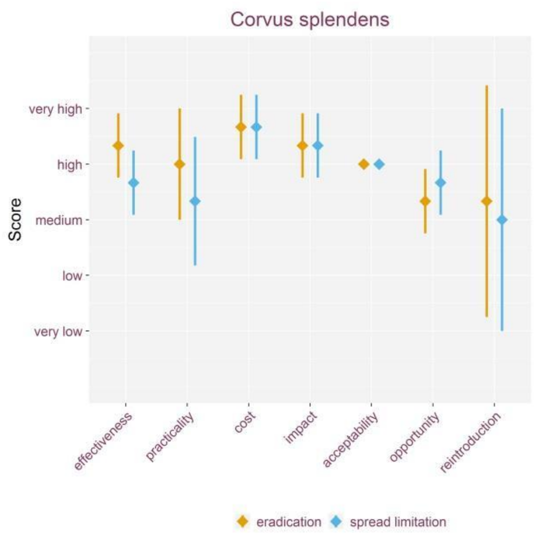
- Aim: *Option 1 stand-still principle with a single or a few patches.*
  The spread limitation strategy aims at limiting the presence of *Corvus splendens* to the area and maintaining the current population level.

- Methods and techniques: The technique is to cull birds that occur outside the harbour area using the method described in the eradication strategy (shooting). Furthermore, to maintain the current population level, nest destruction is applied on the site which for corvids is commonly performed by shooting the nest with a shotgun. This way, nests with eggs or young are destroyed. This requires continuous monitoring of the population and locating of the nests. In parallel, actions are undertaken to limit the breeding success by limiting anthropogenic food sources for the birds, sealing off dumpsters and informing the public not to leave any food waste on site.
  Chemical sterilization such as the use of OvoControl (nicarbazin) which is commonly used to control feral pigeons are currently not permitted in Belgium and have non-target effects on native avifauna. Therefore this can not be part of the spread limitation strategy.

- Post-intervention verification: detailed monitoring of the nests and the breeding success (at least number of nests, number of eggs and hatching success) is necessary to assess whether fertility reduction effectively prevented offspring. Where house crow were removed outside the breeding area, follow up monitoring is performed for at least one season to ensure all birds were removed.

Assessment results





The eradication strategy was scored high on average, the spread limitation was scored marginally lower. Effectiveness, practicality, cost, impact and acceptability scored high on average, with effectiveness and practicality scoring a bit lower for the spread limitation strategy. Window of opportunity and likelihood of reintroduction scored lower between medium and high. Reintroduction had considerable variation around the average score.

Outcome from the workshop

1. General considerations

The eradication and spread limitation strategy were more or less scored the same by experts. The group noted this was counterintuitive and hypothesized that probably assessors did not understand very well that spread limitation requires continuous investment in surveillance and rapid response, whereas the cost for eradication can initially be higher but in the end cheaper.

2. Recommendations for management

The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.1.3 Ruddy duck *Oxyura jamaicensis* (rosse stekelstaart, érismature rousse)

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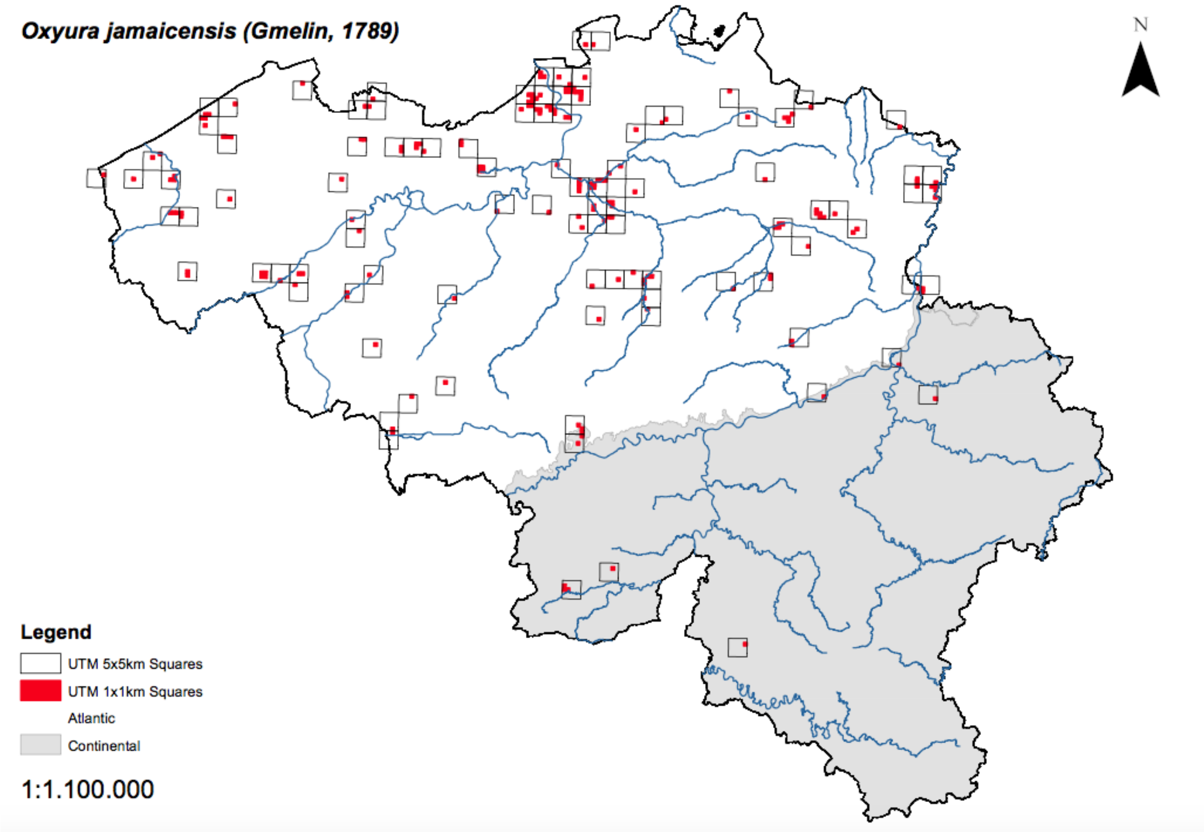
Invasion scenario

- Invasion situation and history in Belgium: Irregular breeder in the Atlantic bioregion. The current invasion scenario is one breeding attempt or breeding pair per year in the Atlantic bioregion (mostly Antwerp harbour area, Groot Rietveld and vicinity, Kalmthoutse Heide, sometimes Bospolder Ekeren or Blokkersdijk), representing about 10 wintering birds (on 10-15 different locations) or 20-30 birds present in summer (>20 locations) (Adriaens et al., 2011; Demolder et al., 2016). Breeding areas are mostly nature reserves and water bodies under public or conservation-NGO authority (Spanoghe et al., 2010). Only a few casual data are reported from the Continental bioregion, representing a maximum of 2 wintering birds per year. The source of birds are escaped/released individuals as well as spill-over from a more extensive breeding population in The Netherlands and possibly also France. The species is under coordinated management since 2011 (in the period 2009-2016, 69 birds have been shot) (Adriaens & D'hondt, 2017; Robertson et al., 2015).

- Reliability of the BE distribution: Species distribution is considered as representative. With the very active bird-watching community and the relative rarity of the species, ruddy ducks are quickly detected and reported. Furthermore, good monitoring data are available from the wintering waterbird census and monitoring in Natura2000 areas where birds are known to breed (e.g. Antwerp harbour).

- Invasion situation in neighbouring countries: In The Netherlands 60-80 wintering birds are present which represents 12-16 breeding pairs. About 5 birds are shot per year on average since 2013 in The Netherlands (Ruks 2017). In France, the population is currently stable at about 200 wintering birds (representing 40 breeding pairs) thanks to control actions (Hall 2016; pers. comm. J.-B. Mouronval). The largest concentration occurs around the Lac de Grand Lieu (Nantes) where a dedicated Life project is planned. The numbers in UK have dropped since the eradication campaign and currently only a few birds are present on a few sites (pers. comm. I. Henderson).



	ATL	CONT
Utm 10km	71	9
Utm 5km	90	9
Utm 1km	176	15
% 1km SAC	34 %	33 %
Clustering index	0.47	0.77

1. *Management strategy – eradication*

- Methods and techniques: The strategy (currently applied) consists of culling every individual bird present on the Belgian territory through shooting. When multiple birds are present (or parent with fledglings), the female is shot first. Birds are culled through shooting (up to a distance of 200 meters) in the period march-october, accompanied by good surveillance through citizen science. Shooting is performed using rifles (.223 caliber with ballistic tip bullets to prevent ricochet on the water surface) although sometimes shotguns (with pellets) are used when birds (e.g. breeding couples with fledglings approached by wading the reed marsh or using a boat) can be approached more easily at shorter distances. Care is taken to limit the frequency of shots - ideally, sound moderated rifles would be used - and to prevent the use of boats so as not to disturb native breeding birds and waterfowl. Playing sound (the male call) is used to attract birds from cover. This works best during breeding and at the onset of breeding (april-august). Sound works

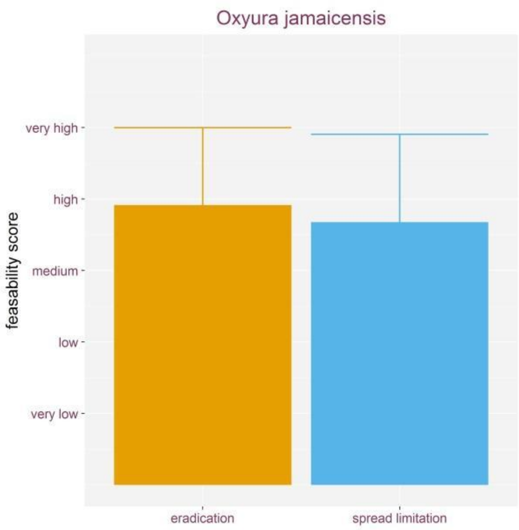
well on males but females follow frequently and can also be attracted using male sounds when they are solitary (pers. comm. I. Henderson). A plastic decoy is sometimes used to guide ruddy ducks to the place where they can be shot. Shooting can be performed by a volunteer hunter, such as in Flanders, supplemented with professional agents.
Alternative control methods such as live trapping using cages with a live decoy, baited dive-in traps (Whitworth et al. 2007), mirror traps (Savard, 1985), submerged mist nets (Breault & Cheng, 1990), drive-by netting (Caudell and Conover, 2007), night-lighting (Cummings en Hewitt 1964), or gill netting are considered unpractical and create too much disturbance. Therefore they are not part of the eradication strategy.

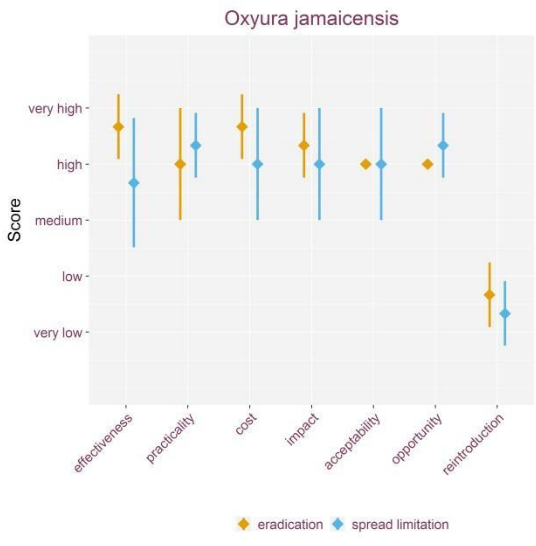
- Post-intervention verification: no specific post intervention measures are applied apart from monitoring for the occurrence of birds and breeding pairs. Birds shot should be removed from the environment if possible.

1. *Management strategy – spread limitation*

- Aim: *Option 3 - Progressive elimination of the most dispersive populations with nesting birds as dispersive populations* The spread limitation strategy consists of only removing nesting birds or birds suspected of breeding that could represent a source of further dispersal.
- Methods and techniques: The technique is similar to the one used in the eradication strategy but applied only to remove nesting birds. Birds are shot with rifles or shotguns, taking precautions to prevent ricochet and disturbance.
- Post-intervention verification: no specific post intervention measures are applied apart from monitoring for the occurrence of breeding pairs. Birds shot should be removed from the environment if possible.

Assessment results





The eradication strategy scored marginally higher than the spread limitation strategy but both strategies scored between medium and high. All the criteria, except likelihood of reintroduction, scored high to very high for eradication. The same was true for spread limitation, yet effectiveness was scored somewhat lower between medium and high.

Outcome from the workshop

1. General considerations

Participants confirmed that indeed the likelihood of reintroduction is still a high since France and Netherlands are still tackling their populations. This should however improve at least for France as a life project has started which already culled a lot of birds. Also, the Netherlands developed some actions in Markiezaat which is probably the provenance of many Belgian birds. –

The acceptability score is logically high because of the low number of animals which limits the potential for problems with public support.

2. Recommendations for management

As the species is currently not really established but present (and an irregular breeder in Flanders), the workshop participants agreed on the eradication of all individuals on the Belgian territory as a management recommendation.

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3.1.4 Sacred ibis *Threskiornis aethiopicus* (heilige ibis, ibis sacré)

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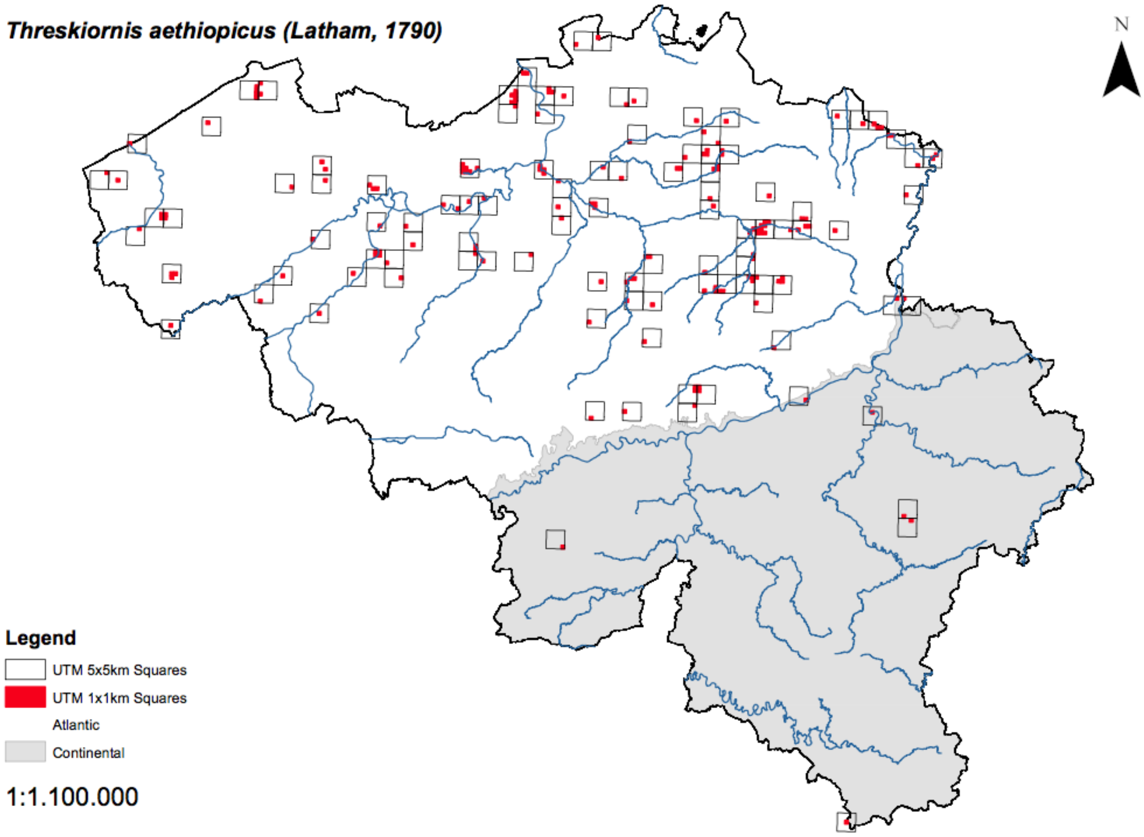
Invasion scenario

- Invasion situation and history in Belgium: The species is currently not established in Belgium in the wild but sightings of wandering and vagrant sacred ibis are regular in the Atlantic bioregion (Robert et al., 2013). The same is true, to a lesser extent, for the continental region. No breeding colonies are currently known so the observed birds either originate from escapes (zoos that often have free roaming birds in collection, but also private collections) or originate from breeding colonies in western France. Some individual birds are known to roam around specific areas, mostly wetlands, for longer periods of time (e.g. Mechels Broek, Verrebroekse Plassen). More rarely, individual birds are reported to disturb breeding spoonbills in the Antwerp harbour area. This was the case in 2016 when a bird was continuously present in and around the single Flemish spoonbill colony present on an artificial island and was observed predating/destroying spoonbill eggs (Beveren, Verrebroekse Plassen). This bird was shot in 2017 during a ruddy duck eradication action in the same area. Risk areas for breeding are heron colonies, islands in lakes in wetlands and marshes, and coastal areas and marshes (Zwin, Zeebrugge harbour area, Harchies marshes). Breeding is facilitated by the presence of other heron species or spoonbills.

- Reliability of the BE distribution: Species distribution is considered as representative. With the very active bird-watching community and the relative rarity of the species, any free-flying sacred ibis will quickly be detected and reported. Also, heron and spoonbill colonies are monitored and the coverage of birders is good.

- Invasion situation in neighbouring countries: In the Netherlands 12 nesting pairs were reported on three locations in 2007, but these birds were caught in 2009 and no breeding was reported in the period 2010-2014 (website SOVON). In 2015 one breeding pair was observed in De Wieden and furthermore some solitary birds are present, presumably spill-over from the French populations, new escapees or birds arriving from Germany (NVWA 2016; Yésou et al. 2017). In western France (Loire-Atlantique, Morbihan) 155 breeding pairs were reported in 2016 on 4 sites. Based on winter counts at roosting sites, 500-550 birds are present in total in Morbihan, Pays de la Loire and Charente-Maritime (Maillard and Barbotin 2017). The population is under management (shooting and egg destruction in Grand-Lieu by ONCFS agents and the reserve manager) since 2006 (Clergeau & Yésou, 2006; Marion, 2006; Yésou & Clergeau, 2005). In 2017, it is estimated that 250-300 birds remain around the Atlantic coast in western France (Yésou 2014; Yésou et al. 2017). Not reported for Luxemburg nor Germany (Tsiamis et al. 2017).



	ATL	CONT
Utm 10km	71	8
Utm 5km	98	8
Utm 1km	168	8
% 1km SAC	49 %	63 %
Clustering index	0.52	1.32

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy consists of culling every bird on the Belgian territory by shooting. Birds can be shot when on the ground at feeding sites, when flying to and from foraging areas at or when flying into night roosts. This can be performed using powerful air rifles, ideally equipped with a sound moderator or alternatively with a rifle (.223 caliber). When shooting around water, ballistic tip bullets need to be used to prevent ricochet on the water surface. Birds are shot from vehicles, from hides or from open grounds using a simple tripod. Decoys can be used to attract sacred ibises to ideal sites for culling operations (Yésou et al. 2017). For every intervention, initial surveillance will be required to identify roosting and feeding sites and a clear and safe line of fire for the marksmen. Trapping is not considered as there is no information to be found on its effectiveness. Fertility reduction through egg sterilisation, such as it was practiced in the sacred ibis colony at Banc du Bilho (Loire estuary) and currently at Lac du

Grand Lieu (twice a year during the breeding season, ensuring the vast majority of initial and replacement clutches do not hatch), only stabilizes or reduces recruitment and will not remove the population in the short/mid-term. Spraying corn oil on the eggs or removing fledglings from the nest, as was practiced in a colony at Guandu mangrove wetland in Taipei, was also insufficient to remove the population (Hung et al. 2013). Therefore, these methods are not part of the eradication strategy.

- Post-intervention verification: no specific post intervention measures are applied apart from surveillance for new occurrence of birds and breeding pairs. Birds shot should be removed from the environment if possible.

1. Management strategy – spread limitation

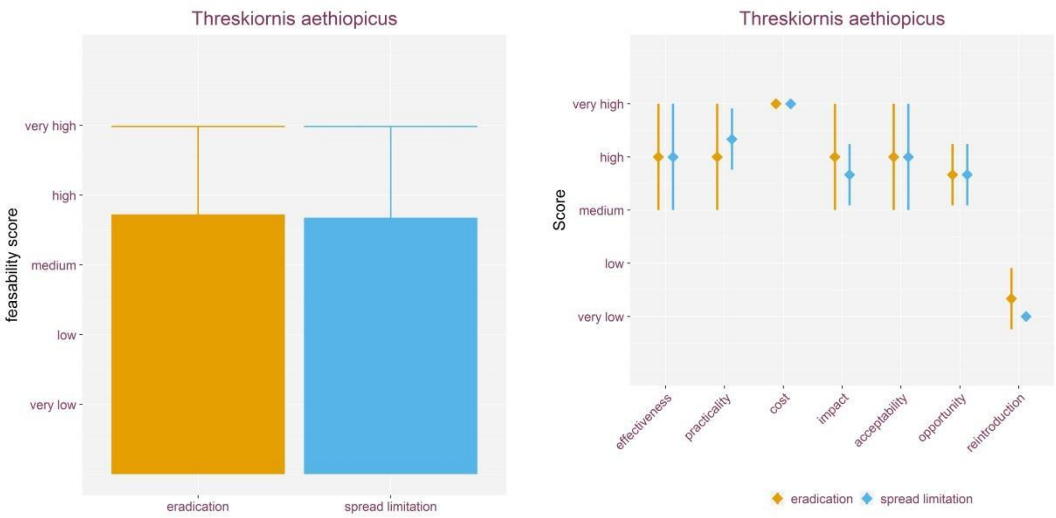
- Aim: *Option 3 - Progressive elimination of the most dispersive populations with nesting birds as dispersive populations*

The spread limitation strategy consists of only removing nesting birds or birds suspected of breeding that could represent a source of further dispersal. Special attention is given to ibis roaming risk areas for breeding (islands in lakes in wetlands and marshes, coastal areas and marshes) for a longer period of time, birds suspected of breeding or displaying direct interaction with native herons and/or spoonbills.

- Methods and techniques: The technique is similar to the one used in the eradication strategy but applied only to remove nesting birds. Birds are shot when at or flying into night roosts and also at feeding sites using powerful air rifles or alternatively with rifles.

- Post-intervention verification: no specific post intervention measures are applied apart from dedicated surveillance for new occurrence of birds and breeding pairs (e.g. in suitable breeding habitats and heron colonies). Birds shot should be removed from the environment if possible.

Assessment results



Both the eradication and spread limitation strategy were assessed medium to high feasibility with equal average scores and variation. For eradication, all criteria scored high except cost, which was assessed very high, and likelihood of reintroduction which scored between very low and low. The same was true for spread limitation, yet practicality scored somewhat higher and impact somewhat lower.

Outcome from the workshop

1. General considerations

Some of the workshop participants noted that only tackling breeding pairs as a proposed strategy is not really eradication, but could indeed have positive effects on acceptability. The criterium cost was scored very high, probably because the strategy was based on volunteer involvement cf. ruddy duck eradication.

2. Recommendations for management

As the species is currently not really established but present, the workshop participants agreed on the eradication of all individuals on the Belgian territory as a management recommendation.

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3.1.5 Pallas's squirrel *Callosciurus erythraeus* (Pallas' eekhoorn, écureuil de Pallas)

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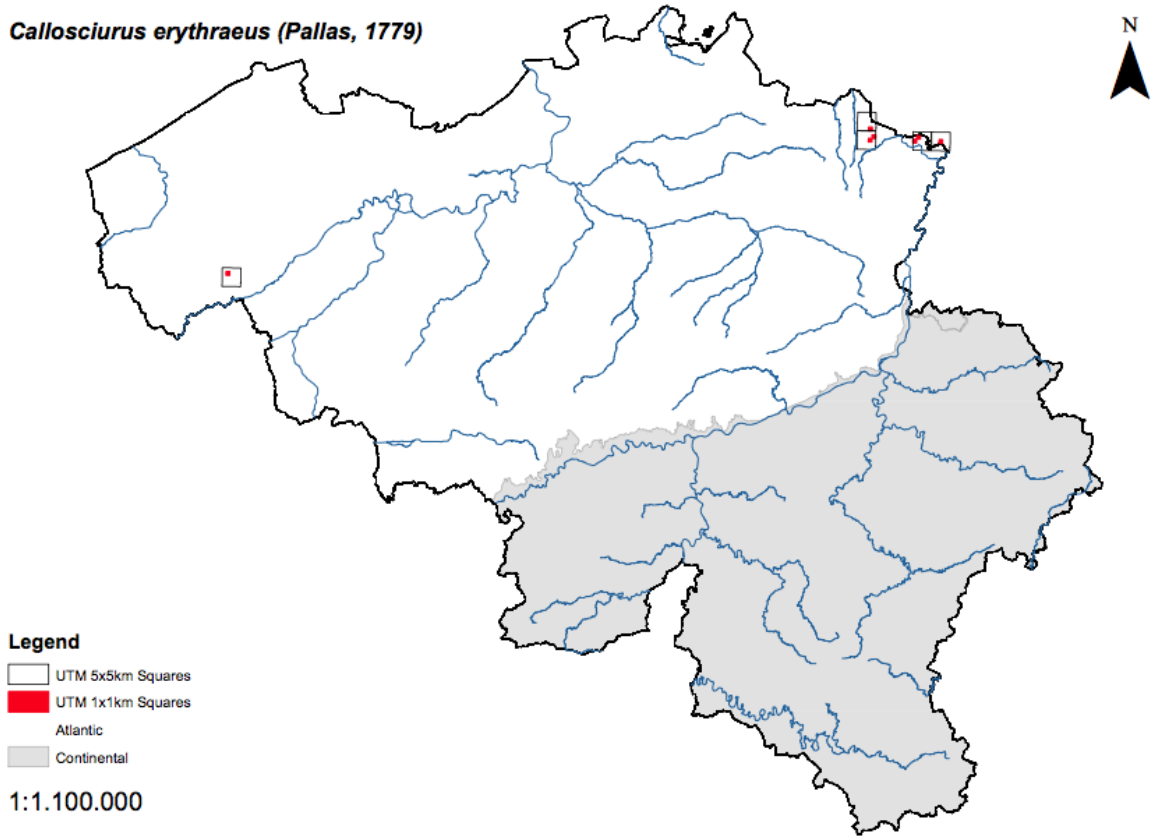
Invasion scenario

- Invasion situation and history in Belgium: Currently not established in the wild in Belgium. In the Atlantic bioregion, Dadizele (western Flanders), a population was eradicated with a dedicated campaign (2005-2011) at a theoretical cost of 200.000 euros (Stuyck et al., 2013; Adriaens et al., 2015a; Adriaens et al., 2017b). Animals on the Belgian side in the border region with the Netherlands (Limburg), were also eradicated during the Weert campaign (Dijkstra and La Haye 2017). The scenario is based on an hypothetical new outbreak similar to the Weert case (Dijkstra & La Haye 2017), and consists of a single population originating from unsterilized individuals escaped from a private collection in the Atlantic bioregion in a forested suburban context (e.g. park or public forest) with villas around, in a residential setting with big private gardens. Despite squirrels being obviously well known to the public, they were not readily identified to species level cf. the Dadizele case (Adriaens et al., 2015a). The presence of squirrels was first suspected by the occurrence of damages (cable gnawing and bark stripping). By the time the population is detected, about 40-50 squirrels are present. The animals regularly roam private gardens around their core habitat to look for food and shelter.

- Reliability of the BE distribution: the distribution is considered representative.

- Invasion situation in neighbouring countries: A population originating from a pet shop escape in 1998 was present in the Netherlands (Weert) but is meanwhile eradicated using live trapping (2012-2013) (Dijkstra et al. 2009; Dijkstra 2012,2013). Trapped animals were sterilized and replaced in zoos and animal rescue centers (Vane & Runhaar, 2016). In 2017 a newly escaped animal was reported in Noord-Limburg (Meerdaal America), probably originating from a cage in a holiday resort where sterilized squirrels were housed from the first capture campaign in Dadizele (Dijkstra and La Haye 2017). In France, bigger populations are present in the south (Bouche du Rhône, Antibes) that are under management (Chapuis et al. 2014).



	ATL	CONT
Utm 10km	3	0
Utm 5km	5	0
Utm 1km	7	0
% 1km SAC	43 %	-
Clustering index	3.97	-

1. *Management strategy – eradication*

- Methods and techniques: The strategy to eradicate Pallas's squirrel would be year-round live trapping using low-tech baited (hazel nuts, walnuts) traps (e.g. Sherman traps 25x8x8 or self-made traps) as described in the Dadizele case (Adriaens et al., 2015a). Prebaiting is an essential part of the strategy to increase trapping success (Mazzamuto et al. 2015; Dutton, 2016; Shuttleworth et al., 2016). To reduce cost, baiting stations are equipped with state-of-the-art Reconyx high performance wildlife cameras (trigger speed 0,2s or faster, adapted to small agile squirrels) mounted in security boxes and with a lock. Traps are set only upon squirrel detection by cameras and are moved around the area regularly. Trapping effort and trap density are kept sufficiently high (on average 10 traps/hectare), but the effort is spread throughout the season and is most intensive during the months before squirrel reproduction. Cameras have integrated SIM card to reduce costs of human resources and transport to and from the site. Bycatch is released on site. Trapped squirrels are humanely killed in a mobile field unit with an overdose of CO_2 using an isoflurane evaporator or are sterilized and put in zoos. Trapping is executed by professional trappers supplemented with

dedicated and trained volunteers to reduce costs. To ensure perseverance of the trapping effort during consecutive years of trapping (cf. Dadizele case), follow-up is organized through a Belgian scientific institute or university.
To supplement live trapping with air rifle shooting (e.g. 22LR with scope, sound moderators and sub-sonic hollow point ammunition) at baiting stations is not part of the strategy since it is generally considered less effective than trapping (Shuttleworth et al., 2016). To apply lethal traps (e.g. fenn traps, kania traps) or to use sunflower seeds/hazel nut spread coated with oral contraceptives (DiazaConTM, GonaConTM) are not part of the strategy since these methods are not selective and could also impact native red squirrel.

- Post-intervention verification: 1.5 years of post-eradication surveying is maintained on and around (5 km radius) the site in suitable habitat, using a combination of citizen science reporting (e.g. observations of squirrels in garden on bird feeders, early warning with waarnemingen.be), a network of camera traps and hair tubes (Verbeylen, 2012).

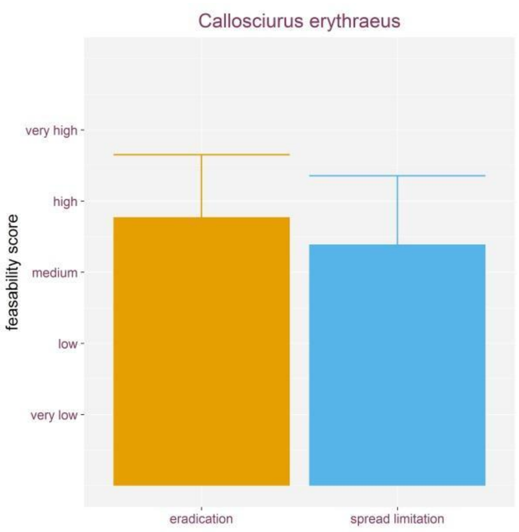
1. Management strategy – spread limitation

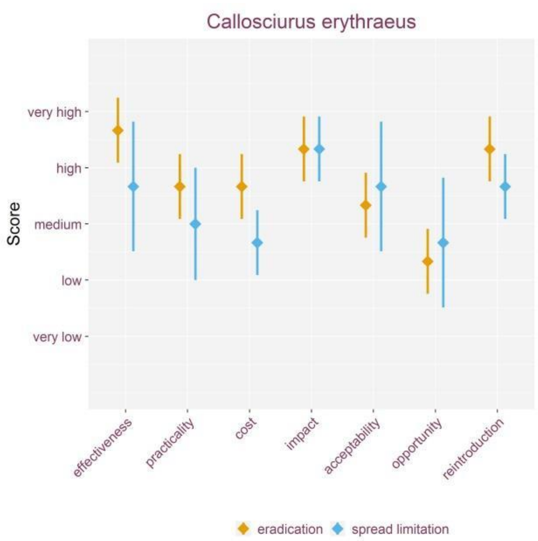
- Aim: *Option 1 Stand-still principle with a single or a few patches.*
  The spread limitation strategy consists of keeping the current population in check by preventing its spread.

- Methods and techniques: increased surveillance around the population using a network of camera traps (Adriaens et al. 2015b), interviews with garden owners and a citizen science early warning network (Adriaens et al. 2014) in a buffer zone around the current population. This surveillance is targeted towards potential habitat of the species nearby, taking into account landscape features that could act as barriers (cf. the A8 motorway that initially represented a barrier to the spread of the Cap d'Antibes (France) population (Chapuis et al. 2011)). In case new squirrels establish outside this area, they are rapidly eradicated using the eradication methods described in the eradication strategy i.e. pre-baited live traps supported by wildlife cameras. The low perceptual range of Pallas's squirrel limits their ability to cross gaps in fragmented landscapes with low densities of connective features (Bridgman et al. 2012). However, long distance dispersal (>5km) has been observed (Adriaens et al. 2015a). Therefore, the removal of trees to prevent squirrel dispersal is not considered a viable part of the spread limitation strategy.

- Post-intervention verification: on sites where new squirrels were detected and removed, 1.5 years of post-eradication surveying is maintained using the same monitoring techniques as for the eradication strategy i.e. early warning with waarnemingen.be, a network of camera traps and hair tubes.

Assessment results





The feasibility of eradication scored between medium and high. The feasibility of spread limitation was scored somewhat lower but with similar variation around the average score. Effectiveness, impact and likelihood of reintroduction scored between high and very high for the eradication strategy, but were scored lower in the spread limitation strategy. Cost was scored between medium and high for eradication, but low to medium for spread limitation. Acceptibility was scored between medium and high . There was more variation on the scores for the different criteria in the spread limitation strategy than for the eradication strategy.

Outcome from the workshop

1. General considerations

The workshop partipants noted that since the invasion scenario is based on the Weert case (The Netherlands), in a forested area with private gardens, any strategy requires dealing with the public and access to private property. This is more challenging than the insular Dadizele case with only a single site owner and could have an influence on acceptability. Eradication should be community-based.

2. Recommendations for management

The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.1.6 Grey squirrel *Sciurus carolinensis* (grijze eekhoorn, écureuil gris)

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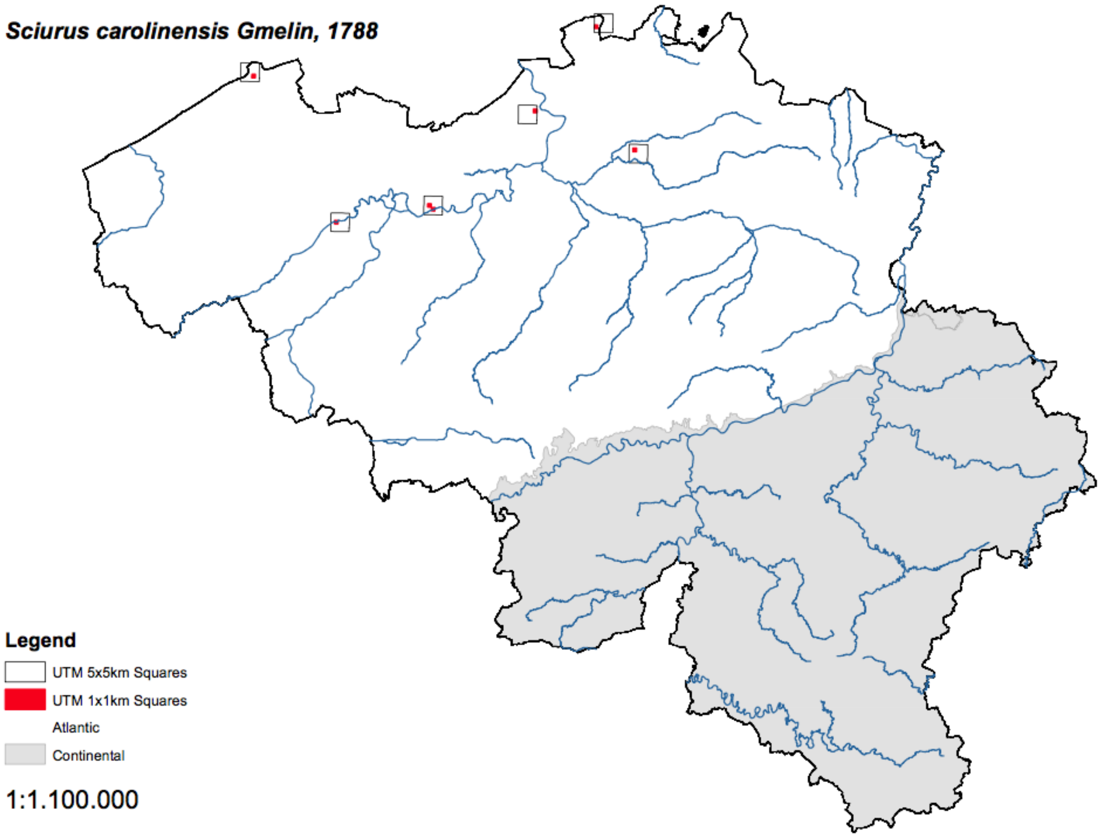
Invasion scenario

- Invasion situation and history in Belgium: Currently not established in Belgium. There have been several casual observations of grey squirrels (including some roadkill) in the Atlantic bioregion in recent years (Zeebrugge, Kallo). Authorities attempted capture of the Kallo animal but the animal was not resighted. The scenario to consider is a single population originating from unsterilized individuals escaped from a private collection in the Atlantic bioregion in a forested suburban context (e.g. park or public forest) with villas around, in a residential setting with big private gardens. By the time the animals are detected, the population already consists of a several tens of individuals. The animals regularly roam private gardens around their core habitat to look for food and shelter.

- Reliability of the BE distribution: the distribution is considered representative.

- Invasion situation in neighbouring countries: no established populations are reported in neighbouring countries. In The Netherlands, casual observations are reported almost yearly (12 individuals in the period 2005-2013) (Dijkstra 2015, 2017).



1. *Management strategy – eradication*

- Methods and techniques: The strategy to eradicate grey squirrel would be year-round live trapping using low-tech baited (hazel nuts, walnuts) traps (e.g. Sherman traps 25x8x8 or self-made traps) as described in the Dadizele case for Pallas's squirrel (Adriaens et al., 2015a). Prebaiting is an essential part of the strategy to increase trapping success (Dutton, 2016; Shuttleworth et al., 2016). To reduce cost, baiting stations are equipped with state-of-the-art Reconyx high performance wildlife cameras (trigger speed 0,2s or faster, adapted to small agile squirrels) mounted in security boxes and with a lock. Traps are set only upon squirrel detection by cameras and are moved around the area regularly. Trapping effort and trap density are kept sufficiently high (on average 10 traps/hectare), but the effort is spread throughout the season and is most intensive during early spring, when there is food scarcity. Thus, the attractivity of baits is stronger and grey squirrels are easier to catch (Mayle 2004). Cameras have integrated SIM card to reduce costs of human resources and transport to and from the site. Bycatch is released on site. Trapped squirrels are humanely killed in a mobile field unit with an overdose of CO_2 using an isoflurane evaporator or are sterilized and put in zoos. Trapping is executed by professional trappers supplemented with dedicated and trained volunteers to reduce costs. To ensure perseverance of the trapping effort during consecutive years of trapping (cf. Dadizele case), follow-up is organized through a Belgian scientific institute or university.
  To supplement live trapping with air rifle shooting (e.g. 22LR with scope, sound moderators and sub-sonic hollow point ammunition) at baiting stations is not part of the strategy since it is generally considered less effective than trapping (Shuttleworth et al., 2016). To apply lethal traps (e.g. fenn traps, kania traps), poison (Palmer et al. 2007), or to use sunflower seeds/hazel nut spread coated with oral contraceptives (DiazaConTM, GonaConTM) are not part of the strategy since these methods are not selective and could also impact native red squirrel.

- Post-intervention verification: 1.5 years of post-eradication surveying is maintained on and around (5 km radius) the site in suitable habitat, using a combination of citizen science reporting (e.g. observations of squirrels in garden on bird feeders, early warning with waarnemingen.be), a network of camera traps and hair tubes (Verbeylen, 2012).

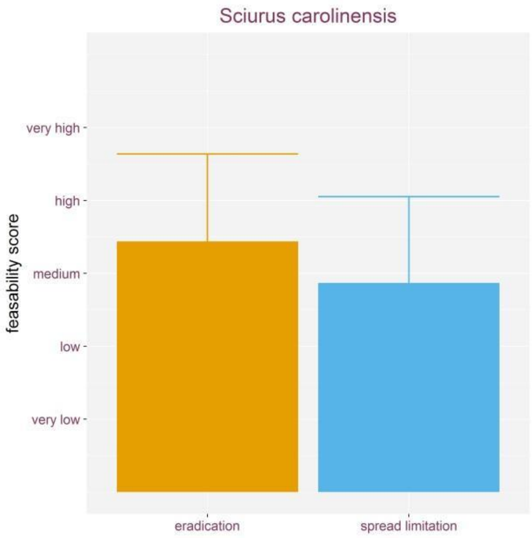
1. *Management strategy – spread limitation*

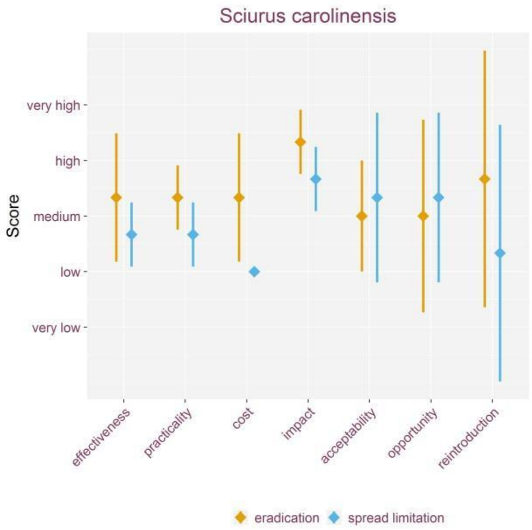
- Aim: *Option 1 Stand-still principle with a single or a few patches.*
  The spread limitation strategy consists of keeping the current population in check by preventing its spread.

- Methods and techniques: increased surveillance around the population using a network of camera traps, interviews with garden owners and a citizen science early warning network in a buffer zone around the current population. This surveillance is targeted towards potential habitat of the species nearby, taking into account landscape features that could act as barriers (cf. the A8 motorway that initially represented a barrier to the spread of the Cap d' Antibes (France) population (Chapuis et al. 2011)). In case new squirrels establish outside this area, they are rapidly eradicated using the eradication methods described in the eradication strategy i.e. pre-baited live traps supported by wildlife cameras.

- Post-intervention verification: on sites where new squirrels were detected and removed, 1.5 years of post-eradication surveying is maintained using the same monitoring techniques as for the eradication strategy i.e. early warning with waarnemingen.be, a network of camera traps and hair tubes.

Assessment results





The feasibility of eradication was assessed between medium and high. The feasibility of spread limitation was assessed lower, between low and medium. This difference was due to a low score for cost and scores between low and medium for effectiveness and practicality in the spread limitation strategy, whereas these criteria were scored higher for eradication. There was considerable variation on the scores for almost all criteria but especially so for acceptability, window of opportunity and likelihood of reintroduction.

Outcome from the workshop

1. General considerations

No general considerations were raised during the workshop.

2. Recommendations for management

The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.1.7 American fox squirrel *Sciurus niger* (Amerikaanse voseekhoorn, écureuil fauve)

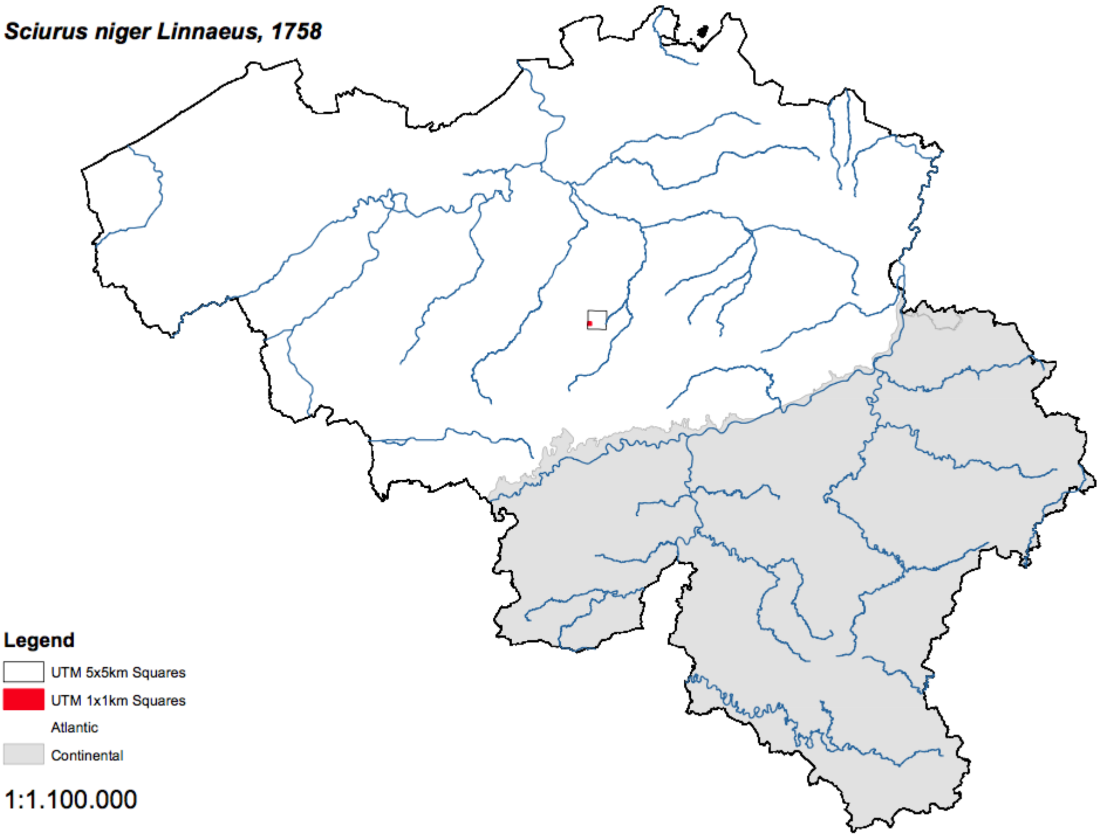
©Stargazer

Invasion scenario

- Invasion situation and history in Belgium: Currently not established in Belgium. *Sciurus niger* has been casually observed in Belgium (2016) in La Hulpe (Atlantic bioregion) but was not resighted since. The scenario to consider is a small population in a largely forested area cf. the La Hulpe occurrence in the Atlantic bioregion. By the time the animals are detected, the population already consists of a several tens of individuals in a large, publicly managed forest. Considering the preferred habitat of the species, the animals are mostly observed in open, mature pine/oak habitat and the ecotones between pine and other vegetation types (Weigl 1989). The squirrels are observed along forest edges, outside the forest in open woodlands with scattered trees and an open understory, prairies and parkland, especially where there is human disturbance (Allen 1982).

- Reliability of the BE distribution: the distribution is considered representative.

- Invasion situation in neighbouring countries: no established populations are reported in neighbouring countries. Three isolated individuals were already observed in the Netherlands in 2011 (Dijkstra 2015).



1. *Management strategy – eradication*

- Methods and techniques: The strategy to eradicate grey squirrel would be year-round live trapping using low-tech baited (hazel nuts, walnuts) traps (e.g. Sherman traps 25x8x8 or self-made traps) as described in the Dadizele case for Pallas's squirrel (Adriaens et al., 2015a). Prebaiting is an essential part of the strategy to increase trapping success (Dutton, 2016; Shuttleworth et al., 2016). To reduce cost, baiting stations are equipped with state-of-the-art Reconyx high performance wildlife cameras (trigger speed 0,2s or faster, adapted to small agile squirrels) mounted in security boxes and with a lock. Traps are set only upon squirrel detection by cameras and are moved around the area regularly. Trapping effort and trap density are kept sufficiently high (on average 10 traps/hectare), but the effort is spread throughout the season and is most intensive during the months before squirrel reproduction. Cameras have integrated SIM card to reduce costs of human resources and transport to and from the site. Bycatch is released on site. Trapped squirrels are humanely killed in a mobile field unit with an overdose of CO_2 using an isoflurane evaporator or are sterilized and put in zoos. Trapping is executed by professional trappers supplemented with dedicated and trained volunteers to reduce costs. To ensure perseverance of the trapping effort during consecutive years of trapping (cf. Dadizele case), follow-up is organized through a Belgian scientific institute or university.
  To supplement live trapping with air rifle shooting (e.g. 22LR with scope, sound moderators and sub-sonic hollow point ammunition) at baiting stations is not part of the strategy since it is generally considered less effective than trapping (Shuttleworth et al., 2016). To apply lethal traps (e.g. fenn traps, kania traps) or to use sunflower seeds/hazel nut spread coated with oral contraceptives (DiazaConTM, GonaConTM) are not part of the strategy since these methods are not selective and could also impact native red squirrel.

- Post-intervention verification: 1.5 years of post-eradication surveying is maintained on and around (3 km radius) the site in suitable habitat, using a combination of citizen science reporting (e.g. observations of squirrels in garden on bird feeders, early warning with waarnemingen.be), a network of camera traps and hair tubes (Verbeylen, 2012).

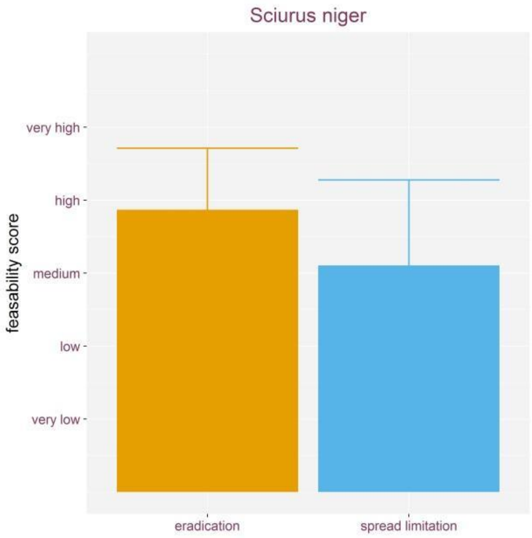
1. *Management strategy – spread limitation*

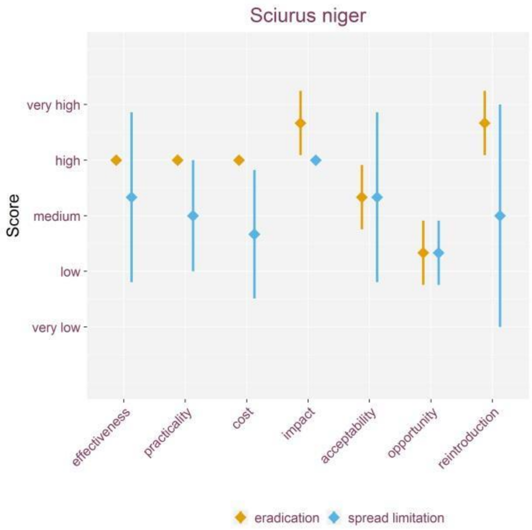
- Aim: *Option 1 Limiting species presence to a single or a few patches.*
  The spread limitation strategy consists of keeping the current population in check by preventing its spread.

- Methods and techniques: dedicated surveillance in a 3km buffer zone (Koprowski 1996) around the population using a network of camera traps, interviews with garden owners and a citizen science early warning network in a buffer zone around the current population. This surveillance is targeted towards potential habitat of the species nearby. Fox squirrels mostly move as juveniles and subadults during April and May or July through October in search of a new home range (Koprowski 1996). In case new squirrels establish outside this area, they are rapidly eradicated using the eradication methods described in the eradication strategy i.e. pre-baited live traps supported by wildlife cameras. This increased surveillance and response outside the core patch is supplemented with active low-intensity trapping within the patch to reduce population density and prevent dispersal.

- Post-intervention verification: on sites where new squirrels were detected and removed, 1.5 years of post-eradication surveying is maintained using the same monitoring techniques as for the eradication strategy i.e. early warning with waarnemingen.be, a network of camera traps and hair tubes.

Assessment results





The average scores for feasibility of eradication and spread limitation compared favourably to the scores for grey squirrel. Eradication scored between medium and high, spread limitation scored lower between low and medium. This difference can be related to lower scores for effectiveness, practicality, cost and likelihood of reintroduction in the spread limitation strategy. There was however considerable variation on all scores but impact in the spread limitation strategy.

Outcome from the workshop

1. General considerations

No general considerations were raised during the workshop.

2. Recommendations for management

The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.1.8 Siberian Chipmunk *Tamias sibiricus* (tamia de Sibérie, Siberische grondeekhoorn)

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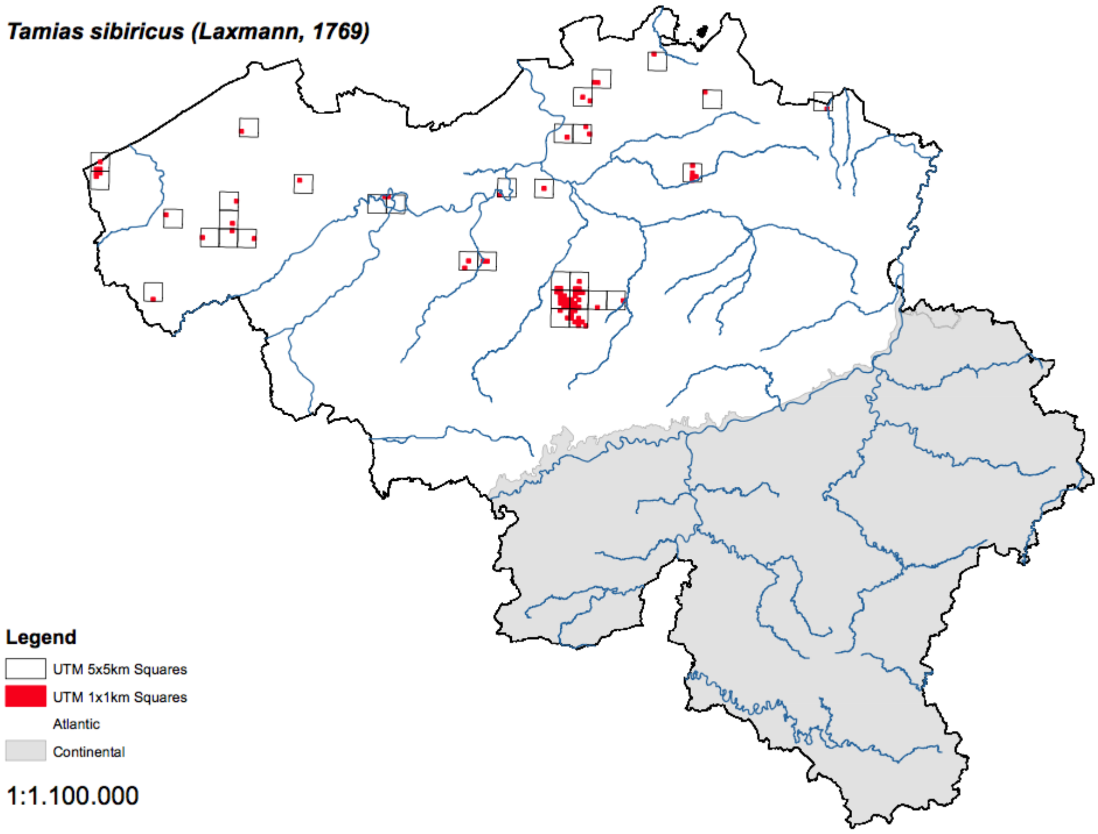
Invasion scenario

- Invasion situation and history in Belgium: The invasion scenario is two small and one large established population in the Atlantic bioregion with regular casual sightings of escapes outside these areas in the same bioregion. In the 4200 ha Sonian forest, managed jointly by ANB, Leefmilieu Brussel and DNF, the species is sympatric with red squirrel. Siberian ground squirrels were released here in the 1960s-1970s and the population grew exponentially to more than 7,500 animals by 1998 (Verkem et al., 2003). There is no recent population estimate available (2000 individuals, website BIM) but there are probably a few thousand squirrels present that occupy several core areas of the forest (La Hulpe, Groenendaal, Watermael-Bosvoorde, Bois de la Cambre, Auderghem-Tervuren). A small population exists since 1976 and is still present in De Panne (Calmeynbos, 66ha), a public poplar-elder dune forest currently managed by the Agency for Nature and Forest (Verbeylen & Matthysen 1998). Here, native red squirrel is absent in the whole region. In years with good reproduction, individual squirrels are reported to disperse towards neighbouring dune reserves such as Houtsaegherduinen (<3km) and Oosthoekduinen (1km) but this has not happened since 2000. This population, which existed of a few hundred squirrels in 1998-2001, has naturally crashed a few years later and now probably consists of less than 30 animals at either sides of the De Pannelaan and close to the nature education center De Nachtegaal (pers. comm. K. Verschoore). The animals are prone to roam sun-exposed areas with dead wood and forest edges. In the deciduous forest De Beeltjens-De Kwarekken (Westerlo, Antwerp, 127 ha), a small population is present existing of only a few individuals. This forest is managed by the municipality, Kempens Landschap vzw and ANB.

- Reliability of the BE distribution: the distribution is considered representative.

- Invasion situation in neighbouring countries: In the Netherlands, two populations are known, in Tilburg (since 1972) and Weert (Dijkstra 2015, 2017). Outside these areas, there are numerous casual observations in other provinces Noord-Brabant, Limburg, Gelderland, Overijssel, Utrecht, Noord-Holland, Zuid-Holland, Zeeland en Drenthe and local reproduction cannot be ruled out (NVWA 2016). In France, at least 11 populations are known, 8 of which are localised in the Ile-de-France region within a 30 km radius around Paris, in suburban deciduous forests or urban parks. The three other populations are found in deciduous forest 40 km north of Paris, and one in the Baie de Somme approximately 120 km north (Chapuis et al. 2011; Pisanu et al. 2013; http://ecureuils.mnhn.fr). Not in Luxemburg (neobiota.lu).



	ATL	CONT
Utm 10km	26	0
Utm 5km	33	0
Utm 1km	80	0
% 1km SAC	61 %	-
Clustering index	0.54	-

1. *Management strategy – eradication*

- Methods and techniques: The strategy to eradicate Siberian chipmunk would be a combination of (year-round) live trapping using low-tech baited (hazel nuts, walnuts) traps (e.g. Sherman traps 25x8x8 or self-made traps) (pers. comm. J.-L. Chapuis). Prebaiting is an essential part of the strategy to increase trapping success (Dutton, 2016; Shuttleworth et al., 2016). To reduce cost, baiting stations are equipped with state-of-the-art Reconyx high performance wildlife cameras (trigger speed 0,2s or faster, adapted to small agile squirrels) mounted in security boxes and with a lock. Traps are set only upon squirrel detection by cameras. Trapping effort and trap density are kept sufficiently high (on average 10 traps/hectare), but the effort is spread throughout the season and is most intensive during the two months (march-april and july-august) before ground squirrel reproduction. Cameras have integrated SIM card and send images to the coordinator/trappers smartphone/ipad so as to reduce the number of hours spent in the field. Bycatch is released on site. Trapped squirrels are humanely killed in a mobile field unit with an overdose of CO_2 using an isoflurane evaporator or are sterilized and put in zoos. To locate squirrels, general surveillance using waarnemingen.be/observations.be (Adriaens et al., 2015b; Adriaens et al., 2017a) is combined with dedicated surveillance using a network of the same camera traps and hair tubes in a 2km buffer zone around the managed populations. Eradication needs to be well planned and prepared, including an initial survey to determine the extent of the population, to delimit the management areas (e.g. natural barriers to squirrel dispersal, zones of sympatric occurrence with native red squirrel) and to roughly assess squirrel densities in order to assess the density of traps and the required surveillance effort. Prior to the eradication, agreement of site owners, regional and local authorities is acquired and budget is secured, including for post-eradication monitoring. The management programme is coordinated by one full time equivalent who is also responsible for communication and training of volunteers. Trapping is executed by two professional trappers supplemented with dedicated and trained volunteers. Follow-up is organized through a Belgian scientific institute or university.

To supplement live trapping with air rifle shooting (e.g. 22LR with scope, sound moderators and sub-sonic hollow point ammunition) (e.g. Barnes) at baiting stations is not part of the strategy since it is generally considered less effective than trapping (Shuttleworth et al., 2016). To apply lethal traps (e.g. fenn traps, kania traps) or to use sunflower seeds/hazelnut spread coated with oral contraceptives (DiazaCon™, GonaCon™) are not part of the strategy since these methods are not selective and could also impact native red squirrel.

- Post-intervention verification: 1.5 years of post-eradication surveying is maintained on and around (5 km radius) the sites in suitable habitat, using a combination of citizen science reporting (e.g. observations of squirrels in garden on bird feeders, early warning with waarnemingen.be), a network of camera traps and hair tubes (Verbeylen, 2012).

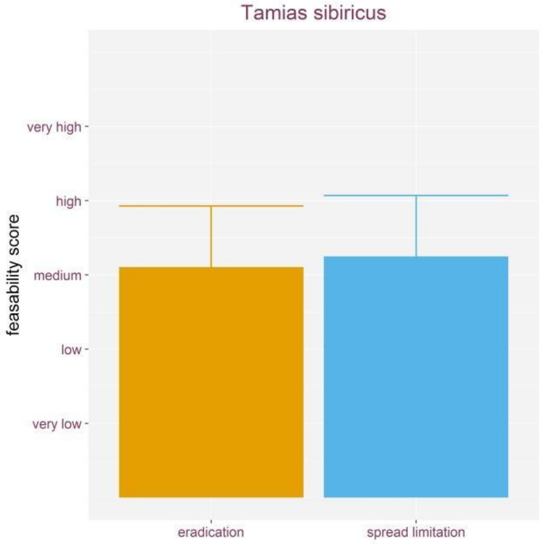
1. Management strategy – spread limitation

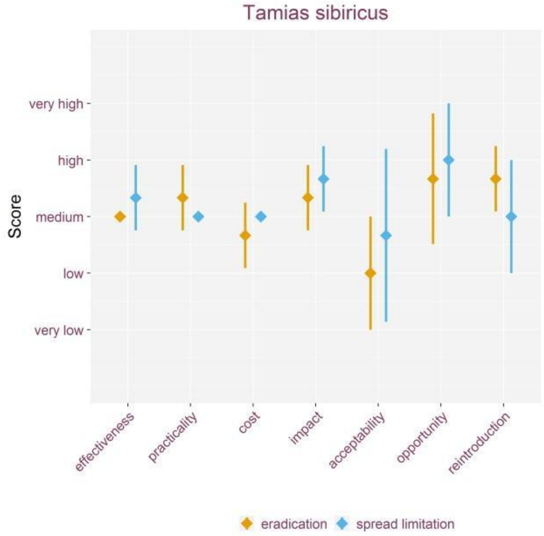
- Aim: *Option 2 Stand-still principle with populations in core areas.*
  The spread limitation strategy consists of keeping the current population within the core area by preventing its dispersal to other areas (Sonian Forest). The two other small populations (De Panne, Westerlo) would be eradicated.

- Methods and techniques: The strategy used to contain Siberian chipmunk would be eradication of the two small populations in De Panne and Westerlo using the methods described for eradication but taking into account a more limited capture campaign and reduced costs for running the programme. Here, trapping would be organized and executed by the local site managers. The Sonian forest population is kept in check by setting up a surveillance network around the forest. This is done by installing a network of camera traps, performing interviews with garden/park owners and citizen science early warning network in a buffer zone around the current population. Surveillance is targeted towards potential habitat of the species nearby, taking into account landscape features that could act as barriers. In case new squirrel populations establish outside this area, these are rapidly eradicated using the eradication methods described (active live trapping).

- Post-intervention verification: on sites where new squirrels were detected and removed, 1.5 years of post-eradication surveying (two reproductive seasons) is maintained using the same monitoring techniques as for the eradication strategy i.e. early warning with waarnemingen.be, a network of camera traps and hair tubes.

Assessment results





The eradication strategy scored medium feasibility. The spread limitation strategy was assessed slightly more feasible between medium and high. The criteria had comparable scores, with most of them scoring between medium and high in both strategies except acceptability which was scored between low and medium. Non-target impact and acceptability were scored slightly higher in the spread limitation strategy.

Outcome from the workshop

1. General considerations

Participants noted that the cost of surveillance is probably going to outweigh the cost of eradication in the long term. Surveillance should be set up in a buffer zone and capacity developed to tackle any dispersing squirrels. Dispersal to surrounding gardens could be complicated to control because of restrictions with access to private property.

2. Recommendations for management

The group agreed that eradication of all populations on the Belgian territory with the exception of Sonian forest should be the management recommendation for this species. In Sonian, long term control should be implemented to reduce numbers and reduce dispersal risk to other areas, with surveillance installed to prevent the species from spreading further.

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3.1.9 Chinese muntjak *Muntiacus reevesi* (Chinese muntjak, muntjac)

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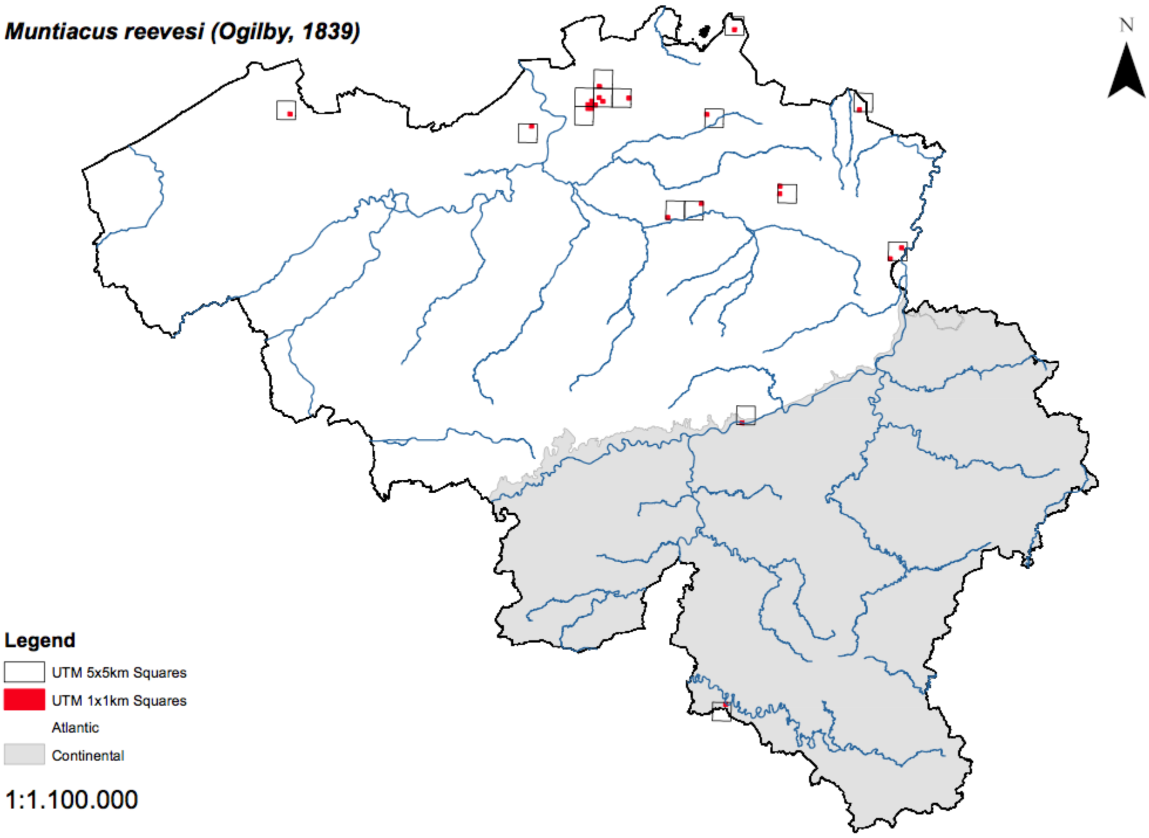
Invasion scenario

- Invasion situation and history in Belgium: The invasion scenario is a Chinese muntjak population introduced around 2000 and halfway its lag time in the Belgian Atlantic bioregion which is starting to reproduce and spread. Until 2014, about 10 observations were known in the vicinity of Schoten-Brasschaat (Peerdsbos, Park van Brasschaat, De Zeurt, Park Vordenstein, Botermelk-La Garenne), of live animals as well as roadkill (Elshoutsebaan). The animals originate from a private estate which kept muntjak. Currently, a limited population with only two/a few reproductive nuclei (Vordenstein park Schoten, potentially another nucleus in Limburg) is present in the Atlantic region (Casaer et al., 2015). In one of those, Vordenstein park, muntjak is under management since 2014 (shooting during the day from high seats) under coordination of ANB. Several (<10) animals were shot since, mostly bucks but also a pregnant doe. Muntjak regularly pop up in the surrounding gardens, urban and natural areas (e.g. the military area Groot Schietveld) and reproduction has been confirmed through autopsies and observations of juvenile muntjak. Outside these areas, casual escaped muntjak are regularly observed in all Flemish provinces, mostly in gardens or as traffic victims (Vercayie 2016). Since 2008 there have been numerous isolated sightings (Baiwy et al., 2012). In the continental bioregion, two dead individuals were found in the vicinity of Andenne in the summer of 2015, after which a warning was sent to nature volunteers and hunters, but without further observations since. Furthermore, there are recent observations of a muntjak pair in a suburban area in Brabant (Bousval) (not shown on map).

- Reliability of the BE distribution: Currently the distribution of muntjak is considered representative. However, the animals are very secretive and can be confused with roe deer so it is possible it has been overlooked or at least their abundance is underestimated.

- Invasion situation in neighbouring countries: Confirmed sightings of single and multiple free-roaming muntjac deer are reported from the Netherlands since 2005 resulting from release or escape events (Baiwy et al. 2012). A population possibly still occurs on the estate *de Utrecht* (Noord-Brabant) at 1 km from the Belgian border. Although in 2014 a female with young was observed, this population is now estimated at no more than a few individuals (Hollander 2016a,b). In France, muntjak is not believed to be established, but the *réseau ongulés sauvages* of ONCFS reports two muntjak in 2012, one roadkill in côtes d'Armor (Bretagne) and one shot in l'Indre (Réseau Ongulés Sauvages 2013). Not in Luxemburg.



	ATL	CONT
Utm 10km	12	2
Utm 5km	14	2
Utm 1km	21	2
% 1km SAC	0 %	100 %
Clustering index	0.96	551.62

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy involves a combination of year-round shooting from temporary high seets using a long rifle with a minimum kaliber .243 WIN or the like, nightly muntjak hunting and trapping in baited cages to promptly remove the Vordenstein population and any free roaming muntjak around that area (Casaer et al., 2015). Firearms such as air rifles with muzzle energy below 980 joule/100 meters are not used. Also, shooting with pellets is not done for animal welfare reasons. Details of this method are described in the best management practice by Casaer et al. (2015). Shooting is performed during the day, but is supplemented wherever possible with hunting at dawn, dusk and night. A buttolo call is used to attract muntjak from cover. This is performed with a light source mounted on the rifle and from vehicles patrolling the area. Nightly shooting involves additional safety hazards and requires necessary care to avoid causing inconvenience or disturbance to local residents. A good communication strategy for residents is set up to avoid any problems. Nightly hunting is performed by hired professionals in the field of muntjak eradication under strict coordination of ANB. Shooting from high seats is done with trained volunteer hunters. To reduce cost, in the core area, state-of-the-art Reconyx high performance wildlife cameras (range 10m, trigger speed 1s or faster, infrared light) are mounted at appropriate height for muntjak in security boxes and with a lock. The traps used are equipped with cameras that have integrated SIM card and send images to the coordinator/trappers smartphone/ipad so as to reduce the number of hours spent in the field. Bycatch (e.g. red fox, roe deer) is released on site. Caught animals are humanely killed by a veterinarian. To increase the chances of detection, cameras or traps are (pre)baited with common ivy or corn (The Deer Initiative, 2008 ; Smith-Jones, 2004). Sound moderators cannot be used currently because of legal restrictions. This would however be indispensable in order not to create a landscape of fear for the animals and reduce the risk of them spreading to other areas as a result of the actions.

- Post-intervention verification: Camera trapping has to be maintained in the area and suitable habitat nearby for at least 3 years after removal of the animals.

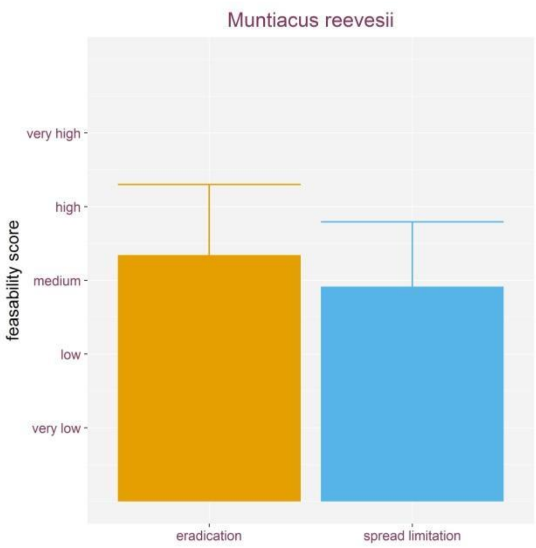
1. Management strategy – spread limitation

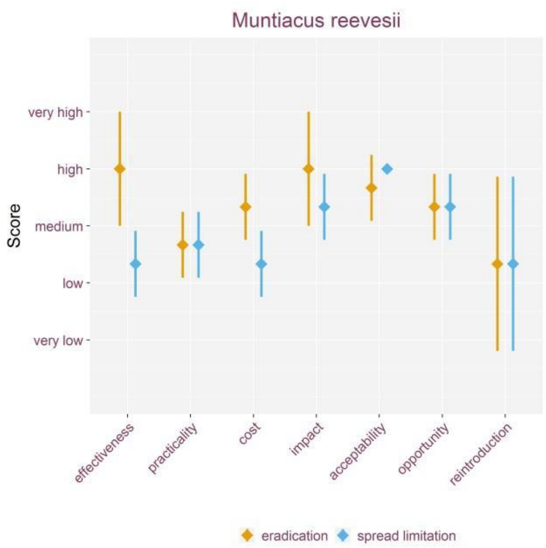
- Aim: *Option 1 Stand-still principle with a single or a few patches*
  The spread limitation strategy aims at containing the Schoten population within its core area (Vordenstein park) and avoid any further spread outside this area.

- Methods and techniques: Any new free-roaming muntjak (populations) outside the area are eradicated using the methods described in the eradication strategy. Also, the current population in Vordenstein is fenced, no hunting is allowed in the park and the habitat is kept as-is in order to keep providing muntjak habitat (food and shelter) and not to induce natural dispersal to other areas. Muntjak have no problem jumping fences of 1,2m height. A suitable fence for muntjak consists of wire mesh, dug into the soil for at least 15 cm and minimally 1,5 meters height. The mesh size is maximally 75 x 75 mm (Forestry Commission, 1999).

- Post-intervention verification: Camera trapping has to be maintained in areas where muntjak were removed and in suitable habitat nearby for at least 3 years after removal. The fence needs to be regularly inspected and maintained.

Assessment results





Eradication was scored between medium and high by the experts. The spread limitation strategy was scored somewhat lower between low and medium with a comparable variation around the average. The lower score for spread limitation is reflected in lower scores for effectiveness (low to medium), cost (low to medium) and non-target impact (medium to high). The probability of reintroduction was deemed relatively high by experts under both strategies, but not as high as other species such as muskrat, raccoon or coypu, hence a score between low and medium.

Outcome from the workshop

1. General considerations

Workshop participants noted that some known occurrences in Andennes, Bouillon and Bousval (Wallonia) are not mentioned in the invasion scenario. The proposed spread limitation strategy using enclosures is most probably unrealistic according to the experience of some with attempting to trap the species. It seems more useful to keep numbers as small as possible through active control. Muntjac are difficult to observe and monitoring should be intensive to be useful. Early detection needs to be implemented across the entire country. Action is especially urgent with muntjac and prompt eradication should be the goal. Some participants noted that removing the Schoten population will probably be unfeasible so spread limitation should be the preferred option here. In Wallonia, it seems feasible to try and eradicate so long as number are ten or less. The participants agreed the window of opportunity to successfully tackle muntjac in Belgium is very small and actions have to be undertaken immediately after detection. Some participants stated this window of opportunity was probably even scored too optimistic by the experts.

2. Recommendations for management

Consensus on prompt eradication as a management strategy for Belgium. If this appears unfeasible for the Schoten population, spread limitation should be the preferred option here but supplemented with prompt eradication everywhere else in the country (Atlantic and continental region). Active management is probably more useful in Schoten than installing exclosures. To successfully implement this strategy, legal barriers to nightly shooting need to be addressed and management needs to be performed by professionals as a condition.

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3.1.10 Coypu *Myocastor coypus* (beverrat, ragondin)

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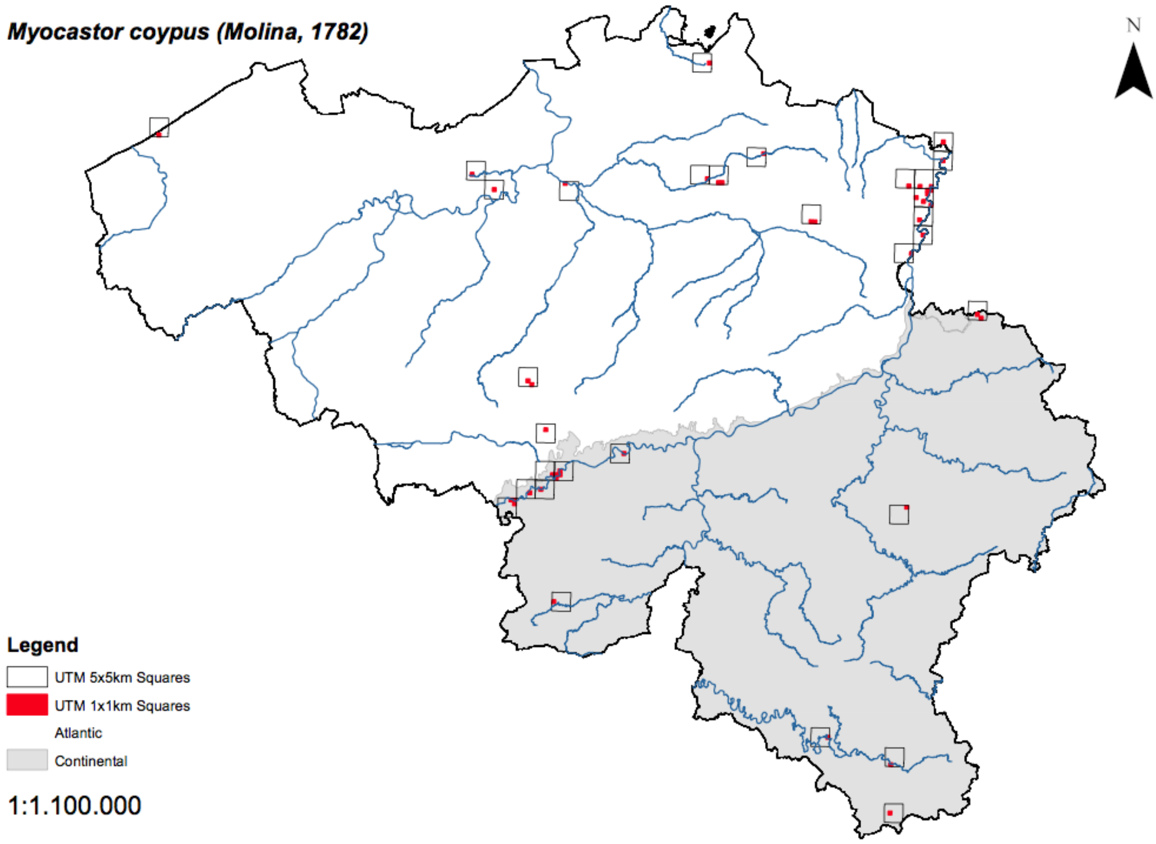
Invasion scenario

- Invasion situation and history in BE: *M. coypus* has been bred in captivity in Belgium since the 1930's and isolated feral populations have been observed since the early 1960's, suggesting regular escapes from captivity or deliberate releases into the wild. Local populations were however strongly reduced or even wiped out by severe winters (e.g. 1962-63 and 1978-79) (Libois, 2006). Although field observations of coypu are currently limited, the species is considered naturalised in the wetlands along the Upper Sambre but probably also in the Chiers and Semois catchments since recent years (Continental bioregion), due to immigration from core populations established in France. From September 2016 up to June 2017, more than 40 animals were destroyed by shooting and trapping along the Sambre river (Stephan Adant, pers. com.). So far, establishment in the Atlantic zone is avoided through frequent control actions by VMM services, e.g. near the Grensmaas when there is coypu influx via The Netherlands, to a lesser extent also in the Nete (2008-2009) and the Demer (2015) catchments; 1044 specimens were killed between 2001 and 2009 in the border Meuse area (Vlaamse Milieumaatschappij 2010).

- Reliability of the BE distribution: The current range of coypu is probably underestimated because it is a secretive animal more active at night which makes it hard to detect at an early stage of invasion. It is easier to detect when present at high densities through the presence of feeding routes, burrows and grazed vegetation (Quéré & Le Louarn, 2011). Recent sites colonised in the Chiers, Sambre and Semois catchments are not shown on the map.

- Invasion situation in neighbouring countries: Several core populations are established near the Belgian border, e.g. a large population in North Rhine-Westphalia and Lower Saxony (from which animals regularly emigrate towards Zuid Limburg in the Netherlands) and a growing population in Picardie. In The Netherlands coypu is under eradication but wandering animals are regularly reported near the german border.



	ATL	CONT
UTM 10km	16	10
UTM 5km	19	12
UTM 1km	28	18
% 1km SAC	50 %	94 %
Clustering index	0.61	0.61

Management strategy – eradication

- Methods and techniques: Coypu eradication is performed by professional and voluntary hunters with lethal (conibear 220, 18x18 cm) and live trapping set on floating rafts or on the water bank, complemented by animal shooting. Traps are baited with carrots and set at the entrance of burrows. Trapping is only performed when and where coypu presence is confirmed to reduce the amount of bycatch as recommended by the code of good practice for muskrat control; live trapping is favoured over conibears when there is a high risk of unintended capture of threatened species (beaver, otter, etc.). Trapped animals are humanely killed by a single shot to the head from a 0.22 calibre pistol (Baker & Clarke 1988, Verbeylen 2005, Baker 2006, Stuyck 2016). Shooting is performed in the evening or early in the morning, preferably in winter when ice prevents access to water and/or burrows are submerged with water. Animals are shot with a 22-caliber rifle or a shotgun No.2 (or larger), from the bank, an elevated platform or a boat when coypu are on the bank; shooting of submerged animals is avoided because it is poorly efficient (Burnam & Mengak

2007). The use of poisonous bait is not part of the strategy because of legal limitations and potential impact on non-target species.

- Post-intervention verification: A continuous census is performed during the whole control campaign to monitor its progress. An independent check on whether or not coypu is eradicated is implemented by scientists supplemented with volunteers for the last four years of the campaign using rafts baited with carrots that are regularly checked for droppings and teeth marks and/or automatic camera rafts. The success of the actions will be confirmed 24 months without any coypu being caught or found as for the UK eradication campaign (Baker 2006).

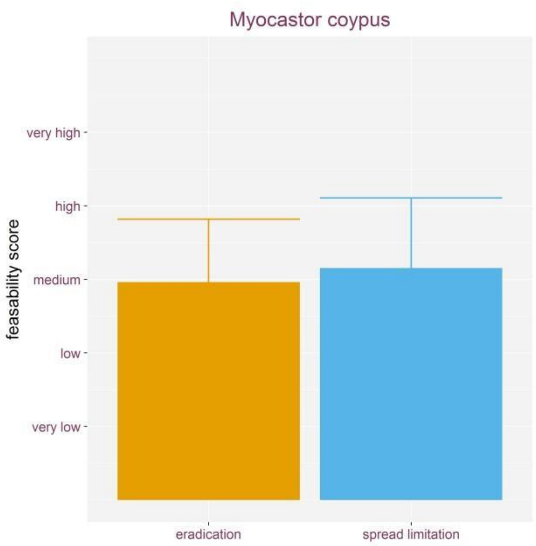
Management strategy – spread limitation

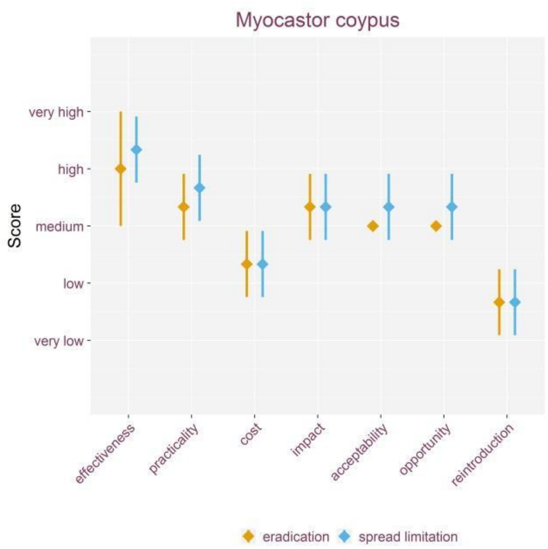
- Aim: *Option 2 Stand-still principle with populations in core areas.*
  The spread limitation strategy consists at containing *M. coypus* within the core area of the Upper Sambre, limiting spread and rapidly eliminating satellite populations discovered outside this zone.

- Methods and techniques: Satellite populations are eradicated using techniques similar to those described for the eradication strategy. A strong catch effort is implemented in wetlands in a buffer zone of 20 km around the Upper Sambre core area and along the border Meuse (to prevent any immigration in Belgium). Winter shooting by professional hunters is also implemented in the core area to reduce population density and reduce the risk of spread towards neighbouring areas.

- Post-intervention verification: Independent field surveys are performed during and after the control actions as in the eradication strategy.

Assessment results





The feasibility of eradication was scored medium, which is slightly lower than the score between medium and high for the spread limitation strategy. This can be related to slightly higher scores for effectiveness, practicality, acceptability and window of opportunity for the spread limitation strategy. Effectiveness was scored high, cost between low and medium. Assessors thought the species had a high probability to reinvade, hence reintroduction was consistently scored between very low and low for both strategies.

Outcome from the workshop

1. General considerations

Workshop participants noted that, despite the species being under control in Flanders through permanent removal, in Wallonia, waves of coypu are coming in from France. Because of this permanent influx eradication would probably be cumbersome. There is a practical/legal/support problem with the use of lethal raccoon traps for coypu in Wallonia. These traps could not be used because of supposed danger to the public hence it was impossible to use them on coypu. It was also stated that the success of actions will strongly depend on efforts in neighbouring countries. The Netherlands and France should be stimulated to take a stronger approach on this species.

2. Recommendations for management

The situation is very different in the Atlantic and continental region. The group agreed eradication (permanent removal) is the preferred option in the Atlantic region, whereas spread limitation (option 2) should be advocated for the continental region in Belgium.

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3.1.11 Raccoon *Procyon lotor* (wasbeer, raton laveur)

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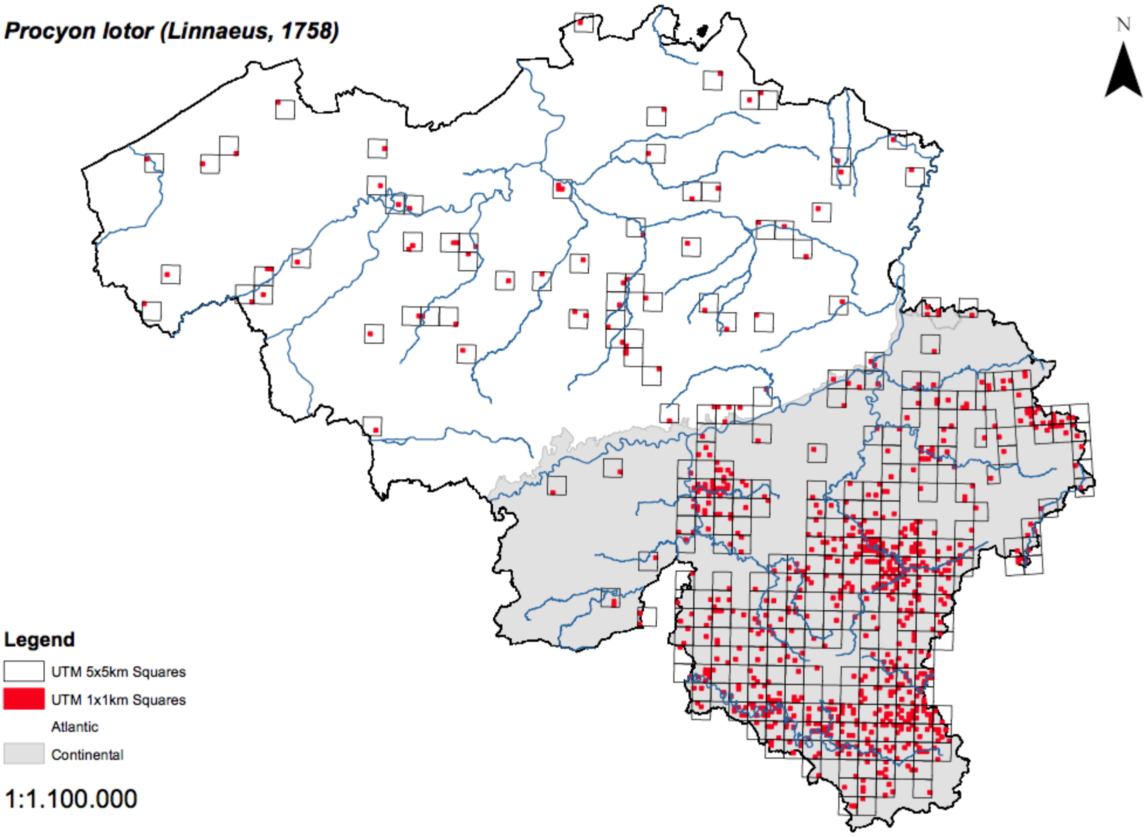
Invasion scenario

- Invasion situation and history in BE: Sporadic raccoon observations are reported in Belgium since the 80ies (Libois 1987). From 2005 onwards, evidences of reproduction are found (detection of juveniles) and the number of observations is rapidly increasing, mainly due to the natural expansion of the German population but also of the population established in Northern France (Aisne and Oise Departments). It is currently very abundant in the Continental bioregion (717 1 km squares). Since recent years, it is also increasingly observed in the Atlantic bioregion (74 1 km squares) and might be established in the Kempen and Brabant although it is unclear whether the species really has viable populations in this zone. So far, uncoordinated and local population control is performed through shooting and trapping, especially where socio-economic nuisances occur.

- Reliability of the BE distribution: Raccoon is a nocturnal and rather secretive animal that is difficult to detect at early invasion stages. However, road traffic victims and typical footprints along rivers often help for animal detection (Van Den Berge & Gouwy 2009, Schockert 2017). It may be assumed that the map below is a rather good estimation of the invasion level in the Continental bioregion but probably underestimate species range in the the Atlantic bioregion, having e.g. in mind that recent data are not reported on the map (INBO - Marternieuws 22).

- Invasion situation in neighbouring countries: The species is widely spread and in constant increase in Germany (especially in Saxony, Hessen and Brandenburg) despite a high removal rate by hunting activities (yearly hunting bag increased from 9,000 to 71,000 animals between 2000 and 2011) (Fischer et al 2016) and now exceeds 120.000 animals per year (jagdverband.de). It is also widespread in Northern Luxembourg and well established and increasingly abundant in Picardie and Champagne-Ardennes (Schockert 2017). Frequent observations are also reported from Zuid-Limburg Province in the Netherlands which was suggested to be in line with growing numbers in Wallonia (Van der Grift et al 2016).



	ATL	CONT
UTM 10km	52	103
UTM 5km	65	246
UTM 1km	74	717
% 1km SAC	36	80
Clustering index	0.77	0.75

Management strategy – eradication

- <u>Methods and techniques</u>: An ambitious eradication campaign is organised combining different control techniques (trapping and shooting), local and central coordination and involving professional complemented by voluntary hunters. Actions are undertaken in the whole Continental bioregion and within areas where activity signs are found in the Atlantic bioregion. Clear targets are set for different catchments and progress is monitored using regular post-control monitoring to verify raccoon-free status of controlled areas. Specific types of traps and devices are allowed and certified for raccoon control in line with Regulation 3254/91 with maximum respect to animal welfare, i.e. live-capture wired cages and egg-traps (e.g. Austin et al 2004), but also lethal conibear device adapted to increase raccoon specificity. All traps are pre-baited for a few days before being set. Live-traps are equipped with cameras that have integrated SIM card and send images to the coordinator/trappers smartphone/ipad so as to reduce the number of hours spent in the field. Bycatch from cages is released on site. In rural sites, trapping is supplemented by intensive year-round animal shooting by professional hunters hired by regional authorities, including shooting at dawn, dusk and night wherever possible (performed with a light source mounted on the rifle and from vehicles patrolling the area). The use of biocides is not part of the eradication strategy because they cannot be applied legally, are not humane or may have a high impact on non-target animals like red fox or European badger (Schockert 2017).

- Post-intervention verification: Regular post-control monitoring, using transect inventories for signs of raccoon presence (e.g. footprints), is performed to verify raccoon-free status of controlled areas. The success of the eradication campaign will be confirmed 24 months without any raccoon being caught or found.

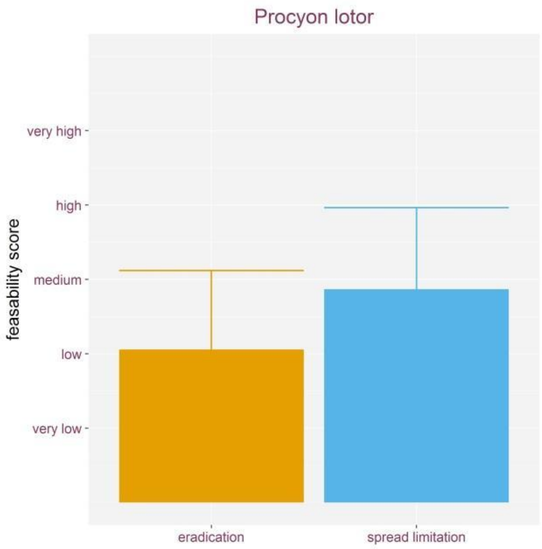
Management strategy – spread limitation

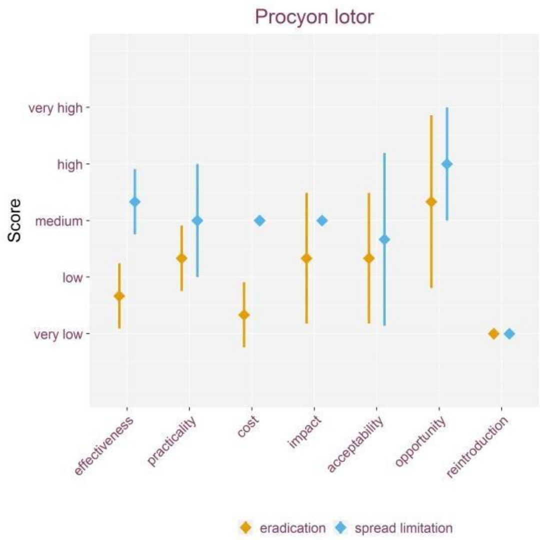
- Aim: *Option 2 Stand-still principle with core area(s).*
  The spread limitation strategy consists in limiting spread of *P. lotor* from the Continental zone towards the Atlantic zone and rapidly eliminating satellite populations discovered within the Atlantic zone.

- Methods and techniques: The strategy used would be the elimination of animals discovered north of the Sambre & Meuse borderline using similar device and techniques as those described for the eradication strategy. Active surveillance is implemented all over the area with a focus towards potential habitats of the species. Extensive shooting and trapping are also performed in the core area to reduce both raccoon density and the risk of emigration outside it.

- Post-intervention verification: Regular post-control monitoring, using transect inventories for signs of raccoon presence (e.g. footprints), is performed to verify raccoon-free status of controlled areas. The success of the eradication campaign will be confirmed 24 months without any raccoon being caught or found.

Assessment results





The feasibility of eradication as well as spread limitation was scored between low and medium by the experts. However, spread limitation scored higher. This is reflected in higher scores for all criteria except reintroduction, which was scored consistently very low for both strategies. Experts clearly thought spread limitation would be cheaper and more effective option, and raccoon is prone to reinvade Belgium from neighbouring countries.

Outcome from the workshop

1. General considerations

Eradication from the continental region was deemed impossible by workshop participants. The species has become very common, both around human habitations and in natural areas.

2. Recommendations for management

The workshop participants agreed active monitoring should be performed in the Atlantic region for effective early detection and rapid eradication by professionals. Under these conditions, eradication should be recommended. In the continental region hunting and trapping should be intensified to decrease raccoon impact and decrease numbers and to reduce the risk of spread. A more active management approach is needed in the continental region to achieve this.

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3.1.12 Raccoon dog *Nyctereutes procyonoides* (wasbeerhond, chien viverrin)

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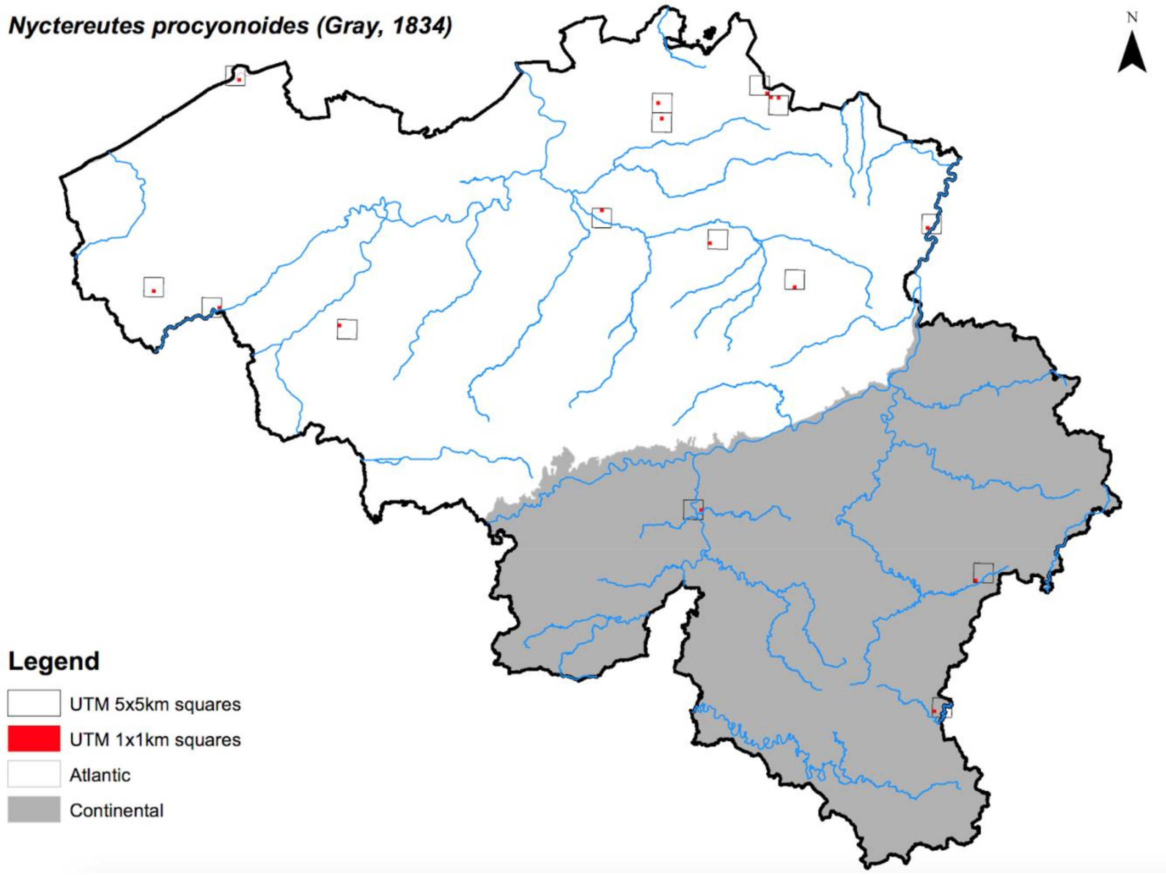
Invasion scenario

- Invasion situation and history in BE: So far, isolated observations of raccoon dogs were made in Belgium, most of them being collected as traffic casualties. No strong evidence of reproduction has been found so far (except 1 adult and 3-4 pups reported in 2010 near Libin). Until recent years, the species was not considered as really established in the country (Van Den Berge 2008, Baiwy et al 2013). However, repeated recent observations reported from the Semois catchment in South Luxembourg (not shown on the map) suggest that the species may become established in this area. In february 2017, in the vicinity of Bruges (not shown on map), a raccoon dog was observed on a wildlife camera at a badger hole.

- Reliability of the BE distribution: Raccoon dog is a nocturnal, secretive and highly mobile animal. It usually spends the day in burrows or reeds. It is sometimes confused with raccoon. Experience from northern Europe suggests that the species is difficult to detect in the wild at early stage of invasion (see references in Baiwy et al 2013) and that its range may therefore be strongly underestimated.

- Invasion situation in neighbouring countries: The species is widely spread in Germany, especially in the north-eastern part of the country where about 30,000 individuals are shot yearly since 2005. Observations are also increasingly reported from north-eastern France, Luxembourg and the Netherlands, but despite a report of successful reproduction in 2012 and 2013 in Drenthe (Mulder 2013a), firm evidence of the establishment of wild populations in these countries is still lacking (see references in Baiwy et al 2013, Mulder 2013b).



	ATL	CONT
UTM 10km	12	2
UTM 5km	12	2
UTM 1km	13	2
% 1km SAC	54%	50%
Clustering index	1.26	3.27

Management strategy – eradication

- Methods and techniques: The adopted eradication strategy is designed based on techniques and device tested through the north European cooperative raccoon dog management project (LIFE09 NAT/SE/000344) (Dahl & Ahlen 2017). Areas where sightings were confirmed so far are subjected to an intensive search for raccoon dogs, with a special focus on the province of Luxembourg from where most of the observations originate so far. Search is made using the establishment of a network of camera traps equipped with multimedia messaging (MMS) and/or latrine survey near bait/scent gland lures and badger holes (often used as den sites by raccoon dog) (Kauhala & Salonen 2012). In complement, sterilized Judas raccoon dogs equipped with transmitters are kept continuously in the area to help for the detection of unpaired animals. Once the presence of territorial raccoon dog is confirmed, they are captured using either trained hunting dogs accompanied by professional hunters or baited Nyborg cages (Dahl et al. 2010, Dahl & Ahlen 2017). Animal shooting is used as a complementary technique during the months with no dispersal and no reproduction (December – March). The use of biocides and killing traps are not part of the eradication strategy because they cannot be applied legally, are not humane or may have impact on non target animals like red fox or European badger (Mulder 2011).

- Post-intervention verification: An independent check on whether or not raccoon dog is eradicated is implemented by scientists using camera traps and track plates near badger holes (Wilson & Delahay 2001, Gompper et al 2006, Sidorovich & Vorobej 2013). The success of the eradication campaign will be confirmed 24 months without any raccoon dog being caught or found.

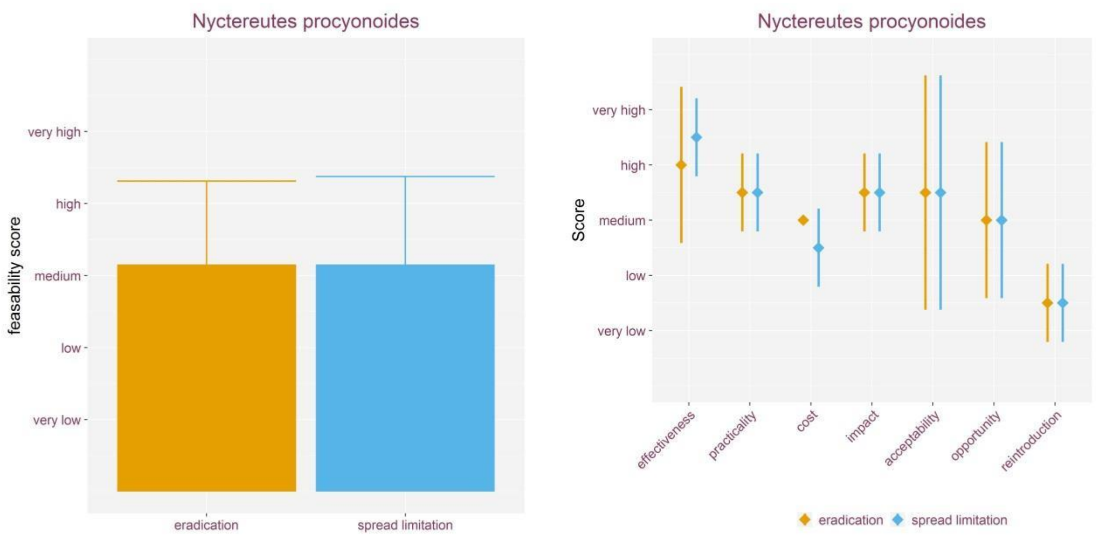
Management strategy – spread limitation

- Aim: *Option 2 Stand-still principle with core area.*
  The spread limitation strategy consists of containing *N. procyonoides* within the Semois River catchment, limiting spread and rapidly eliminating satellite populations discovered outside this zone.

- Methods and techniques: Satellite populations are eradicated using techniques similar to those described for the eradication strategy. Surveillance is performed outside the core area using a network of camera traps, citizen science reporting systems and use of Judas animals. Once detected, animals are caught or shot using the techniques described above. Trapping with Nyborg cages is also performed in the core area to reduce both raccoon dog density and the risk of emigration outside it.

- Post-intervention verification: Independent field surveys are performed after satellite populations have been controlled as in the eradication strategy.

Assessment results



The feasibility of eradication and spread limitation was scored medium with equal variation around the average. This is reflected in the scores and variation around them for the different criteria, which are almost identical. Effectiveness was scored high for eradication, high to very high for spread limitation. Practicality, impact and acceptability were scored between medium and high with lots of variation around acceptability. Assessors thought the species had a high probability to reinvade hence reintroduction was consistently scored very low to low for both strategies.

Outcome from the workshop

1. General considerations

The workshop participants confirmed that the species could already be established in Belgium without it being noticed because this nocturnal species is very hard to detect al low densities. There is no dedicated surveillance network for the species. Hence, knowledge on the exact status of the species in Belgium is lacking.

2. Recommendations for management

The group agreed on eradication as a management recommendation for Belgium, even despite the small detection threshold, because once it is firmly established it is very hard to control.

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3.1.13 Muskrat *Ondatra zibethicus* (muskusrat, rat musqué)

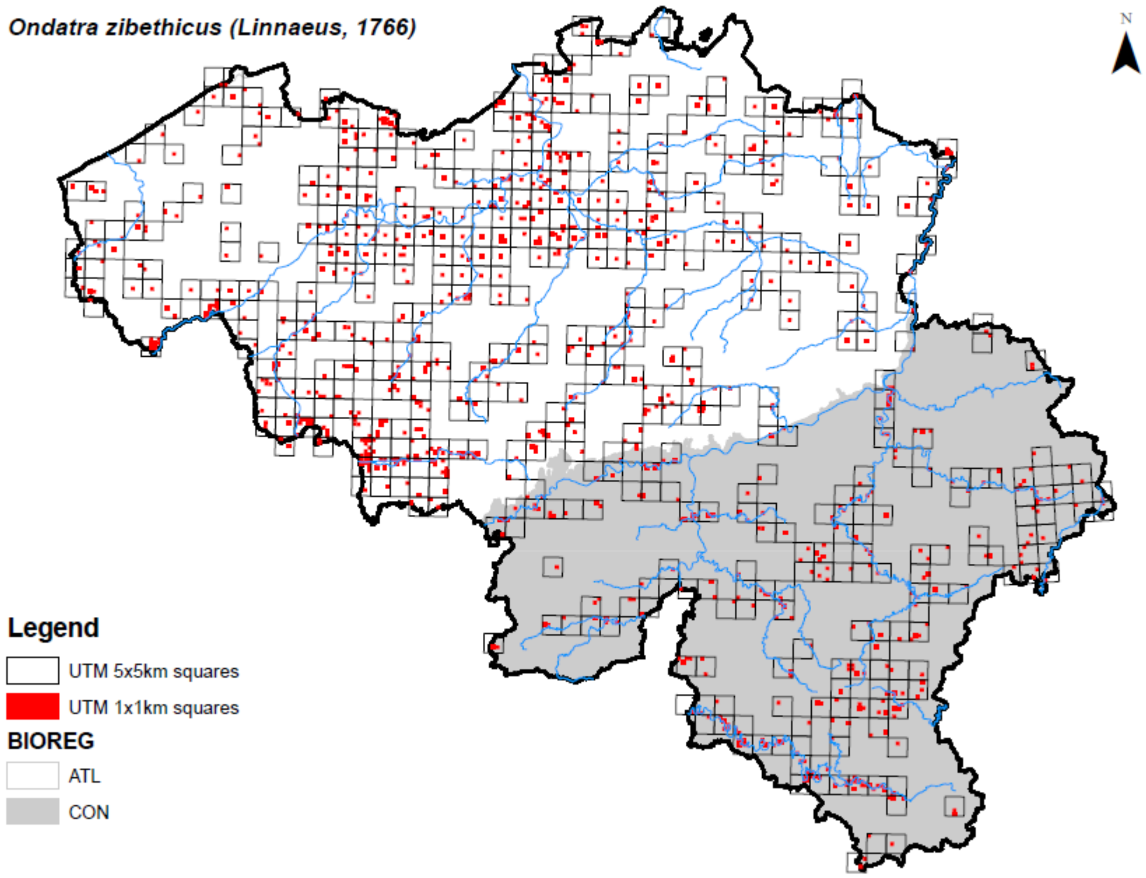
©Olivier Embise

Invasion scenario

- Invasion situation and history in Belgium: Although the distribution map (based on cumulative observations) suggests muskrat is widely spread, the species is subject to long standing control programmes in Flanders and in Wallonia. The number of muskrat strongly decreased within the Flemish part of the Atlantic bioregion thanks to a high trapping intensity and a reorganised control campaign but remains quite high in the Walloon part of it. Since a few years in some areas an increase in number is reported coinciding with a decrease in the intensity of control actions and lack of area-wide coverage. In the continental bioregion, muskrat is widespread but is distributed more sparsely, presumably at lower densities which may be a consequence of different landscape characteristics (more forested, higher grounds) and, generally, a more natural setting which could harbor more natural predators of muskrat. Muskrat commonly occupies wetlands, water courses, ponds and marshes. The species is found in areas with abundant vegetation such as reedbeds, rushes and *Typha latifolia* but also occurs in brackish and eutrophicated waters with almost no vegetation (Stuyck, 2003). Muskrat is subject to a control programme in Belgium since the fifties. As the control effort increased and rodenticides were applied, more rats were caught, with 100.000-150.000 captures reported yearly in the seventies-eighties (Geeraerts-Bracops, 1974). In Flanders, the numbers caught have decreased since 2000 (40-50.000 muskrat/year) and are currently relatively low (about 4000 muskrats /year) (VMM, 2010). In Wallonia, 15-20.000 muskrats are trapped yearly (S. Adant, com. pers.). Since 2000, the control of muskrat in Flanders is purely mechanical using various types of traps in a combination of passive control to protect the borders (i.e. traps laid out at fixed distances) and active control (i.e. only place traps where traces of muskrat presence are reported) (Verbeylen & Stuyck, 2002). In Wallonia, traps are used in combination with rodenticides. At the level of the Flemish region (VMM), the muskrat control programme is performed by about 65 full time equivalents in public service for which pure muskrat work represents about 20 full time equivalents. It is coordinated centrally as well as at catchment level (3 coordinators each responsible for 5-6 basins) (pers. comm. M. Vanderweeën). This is complemented with provincial and municipal rat catchers, Rattenbestrijding Oost-Vlaanderen (RATO vzw) and Polders and Wateringen. Despite this, the current eradication campaign still shows some gaps, especially in West and East Flanders, due to the fragmented water management competences and different ambitions at different levels (provinces, municipalities, polders). In Wallonia, 16 full time equivalents are involved in muskrat control for public services.

- Reliability of the BE distribution: The distribution on the map is overestimated since it is based on cumulative data over the reference period (2000-2015).

- Invasion situation in neighbouring countries: In Zeeuws-Vlaanderen (The Netherlands) in 2016 about 2200 muskrat were caught. High densities in Luxembourg (Pir and Schley 2015). High densities in Northern France along the Belgian border (Groupe ornithologique et naturaliste du Nord-Pas-de-Calais 2015).



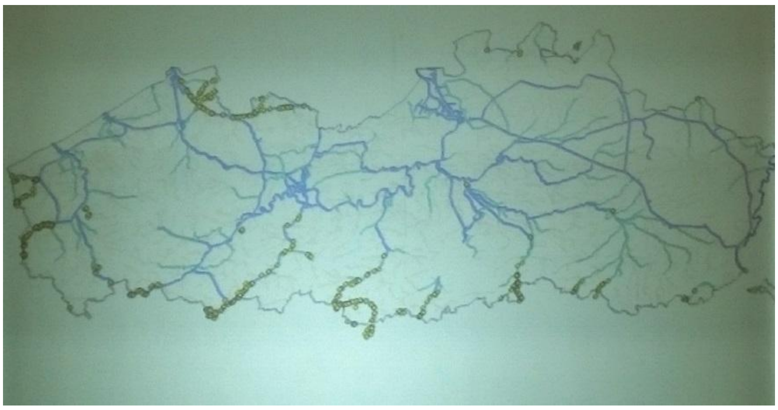


Figure 3: Geographic visualisation of muskrat traps placed in 2017 in Flanders (source: J. Stuyck)

	ATL	CONT
Utm 10km	171	69
Utm 5km	366	128
Utm 1km	642	248
% 1km SAC	35%	82%
Clustering index	0.75	0.56

1. *Management strategy – eradication*

- Methods and techniques: The current strategy to eradicate muskrat in Flanders is continued and the same approach is applied in Wallonia. The control programme is area-wide. To maximize coverage a similar formalized cooperation agreement on muskrat trapping in nature reserves is needed for the continental region. A coordinated control programme is implemented, thereby foreseeing the necessary human resources for trapping, coordination at catchment level and central coordination. Scientific follow-up is organized through regional research institutes. Clear targets are set for different catchments. The strategy is primarily active control which requires skilled trappers and knowledge of muskrat ecology. Trappers have to actively look for indications of muskrat presence in an area assigned to them which they check daily for signs of muskrat (e.g. faeces, traces, signs of herbivory, burrows, damage). This approach is more efficient and reduces non-target bycatch (Verbeylen & Stuyck, 2002). This active control is supplemented with passive control at the border areas with The Netherlands and France. Specific types of traps and devices are allowed and certified for muskrat control (conibear, ground traps, bait traps, fykes) in line with Regulation 3254/91 prohibiting the use of leghold traps in the Community or trapping methods which do not meet international humane trapping standards. The code of good practice for muskrat control (Stuyck, 2016) is implemented at all managerial levels specifying conditions for use of different traps types and baits in order to apply them ecologically (e.g. reduce bycatch or impact on fish migration) and with maximum respect to animal welfare. All captures are registered including bycatch to allow for scientific evaluation, e.g. by means of a dedicated smartphone application for management registration (cf. RattenApp). Additionally, the strategy requires increased coordination of the control programme, including the harmonization of control practice at the level of all actors involved in both bioregions as well as across all Belgian administrative regions.
  The use of rodenticides is not included in the eradication strategy as it generates considerable non-target effects on other biota, causes rats to become resistant (Baert et al. 2012) and because in general complete removal using chemical control is deemed not suitable (Bos 2017). Moreover, the labour required for baiting campaigns (e.g. using poisoned carrots) has shown to be substantially more than anticipated (Bos 2017).

- Post-intervention verification: Regular post-control monitoring using transect inventories for signs of muskrat presence is performed to verify rat-free status of a controlled area.

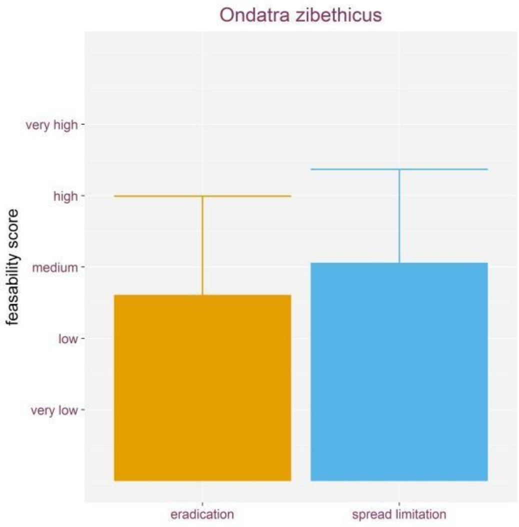
1. *Management strategy – spread limitation*

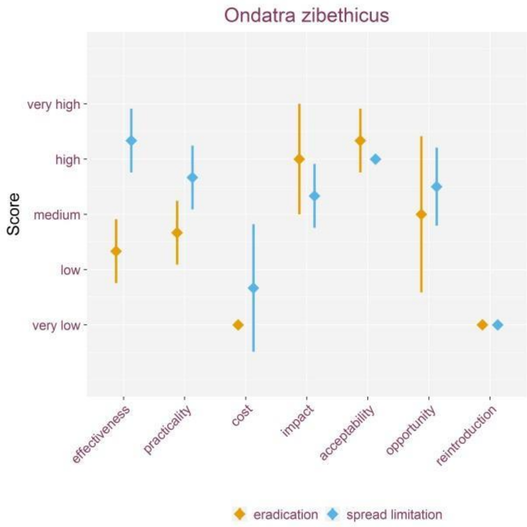
- Aim: *Option 4 - Maintenance of pest free area*

- Methods and techniques: Muskrat in Flanders is currently managed with the aim to maintain a pest free area. Therefore, the scenario is to maintain the Atlantic bioregion (as currently done in Flanders) as a pest free area. These areas are subjected to (i) dedicated surveillance by looking for muskrat traces (faeces, traces, burrows, traces of herbivory) and (ii) rapid eradication actions after detection. In invaded areas downstream passive control (as described in the eradication strategy, i.e. traps laid out at fixed distances) is maintained using the methods described in the eradication strategy. A low intensity trapping effort is implemented in the Continental bioregion to maintain low density muskrat populations and reduce the risk of species spreading towards the Atlantic bioregion.

- Post-intervention verification: Regular post-control monitoring, using transect inventories for signs of muskrat presence, is performed to verify rat-free status of the controlled area.

Assessment results





The experts assessed the eradication strategy between low and medium. Spread limitation was deemed more feasible with a medium score. This can be related to considerably higher scores for effectiveness (high to very high) and practicality (medium to high) for the spread limitation strategy. Experts also felt the cost for eradication would be higher but in both strategies cost scored very low to low. Clearly, assessors thought the species had a high probability to reinvade from neighbouring countries hence reintroduction was consistently scored very low.

Outcome from the workshop

1. General considerations

Muskrat is continuously invading Belgium from France around the river Sambre. Participants noted a serious lack of human resources for control in the continental region (15 full time equivalent are employed but the trappers do a lot of other work), with a low intensity trapping effort as a result. This is in clear contrast with the Atlantic region, which is managed as a pest free area and also has to deal with influx from the south.

2. Recommendations for management

The group agreed the recommendation should be to eradicate muskrat from the Atlantic bioregion (or rather removal with permanent effort along the border). Low intensity trapping should be continued in the continental bioregion with a focus to prevent influx to the north. More human resources are needed in Wallonia.

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3.2 Insects

3.2.1 Asian Hornet *Vespa velutina* (Aziatische hoornaar, frelon asiatique)

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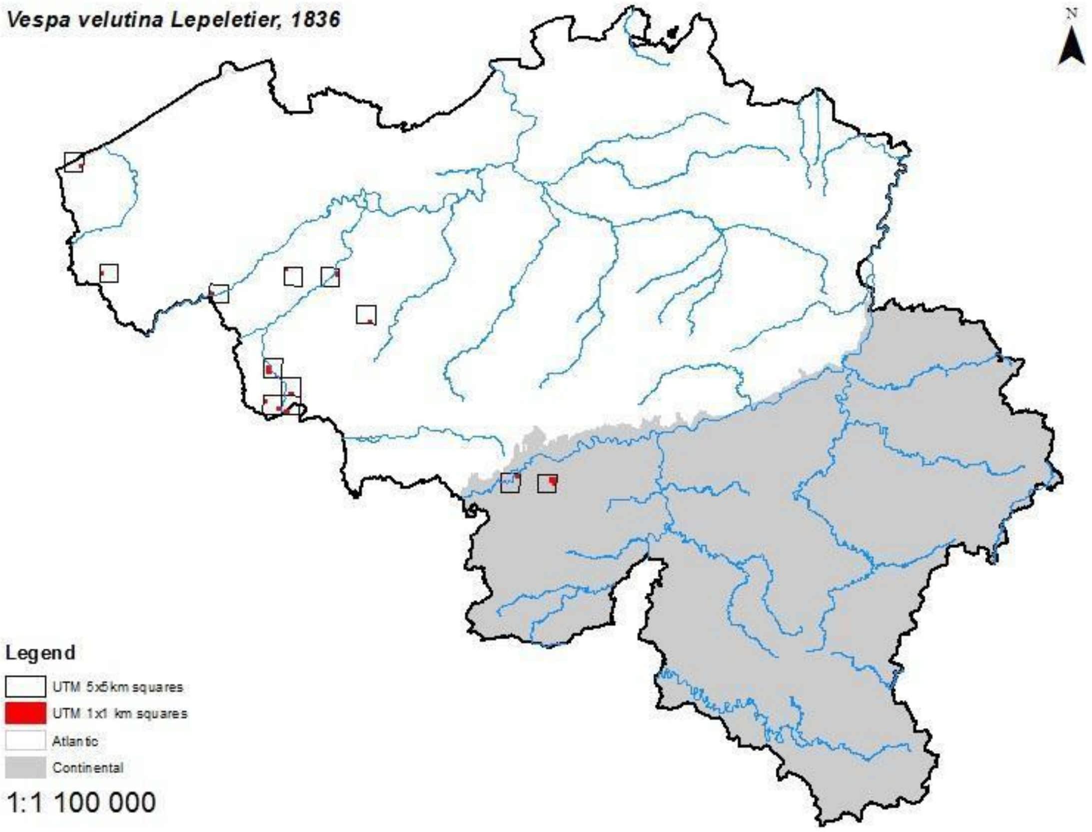
Invasion scenario

- Invasion situation and history in BE: In Belgium, a first report of an isolated male Asian hornet was performed in November 2011 in Flobecq. In november 2016 one nest was found in the crown of a birch tree in a garden, in the village of Guignies (rural environment near Tournai). This nest was removed. An empty nest was found in february 2017 in Poperinge suggesting the species was already present in the area since 2016. A few queens were observed flying during spring 2017 in the vicinity of the village of Guignies. Insects and several nests were detected (and destroyed) subsequently during summer and autumn 2017 at several localities near the French border, incl. Brunehaut, Ham-sur-Heure, Oudenaarde, Péronnes, Poperinge, Tournai, Waregem and Wevelgem; founder queens probably escaped from some of those nests due to late discovery. A rapid progression from France to Belgium is expected in the forthcoming years due to high dispersal capacities of the species (Keeling et al 2017b, Robinet et al 2017).

- Reliability of the BE distribution: Species is probably underdetected due to low insect densities, nests hidden high in tree canopies or nests that are not readily recognized as an asian hornet nest and the difficulty to involve beekeepers in active surveillance.

- Invasion situation in neighbouring countries: In France, the invasion front reached the Picardie and Nord-Pas-de-Calais in 2011. The first nests were found in this region by 2016 e.g. in Wattignies (Lille, nest eradicated) and Saint-Omer, both locations located more than 10 kilometers from the Belgian border. Probably about a dozen nests are currently present in the border region (e.g. Douai in the Avesnois, Boeschepe where a nest was removed in 2017) with France. In the Netherlands, in 2017, a first nest was destroyed 30km from the Belgian border in Dreischor (Zeeland).



	ATL	CONT
UTM 10km	10	2
UTM 5km	10	2
UTM 1km	13	4
% 1km SAC	0	-
Clustering index	-	-

Management strategy – eradication

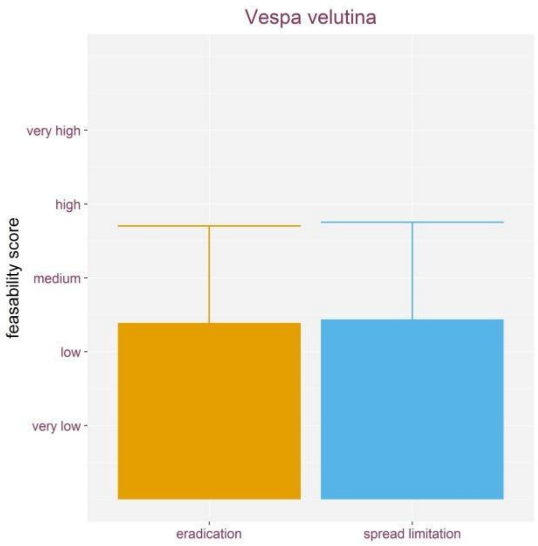
- Methods and techniques: As soon as hornets are reported around honeybee hives using a sentinel network of apiaries (Keeling et al 2017a), nests are actively searched for by trained people (these can be professionals or volunteers). Efforts are made to register the direction of flight (beelining) so as to delimit the nest searching perimeter (usually 2-3 km around the hive where the hornet was reported). Alternatively, nests can be tracked using harmonic radar (Milanesio et al. 2016) or visual inspections using thermal cameras but these techniques are imperfect, are largely under development and hardly more efficient than field observations. At least 95% of the reported nests are tackled and removed (Robinet et al 2017). Depending on the accessibility of the nest, this can be done manually (nest is put in a bag after sunset, which is then burnt or frozen) or by injection of insecticide (e.g. cypermethrin) by help of a telescopic tube or drone. The nest is maintained in the tree for a few days to allow every insect to come in contact with insecticide; it is subsequently removed from the environment and destroyed to reduce impact on non-target organisms. *In situ* burning or shooting at the nest are unsafe and ineffective (Turchi and Derijard 2018) and therefore not considered here. Methods that do not target nests e.g. capture of founder queens in spring using baited traps are not considered neither because they are largely ineffective and non selective (Rome et al 2011, Monceau & Thiéry 2017).

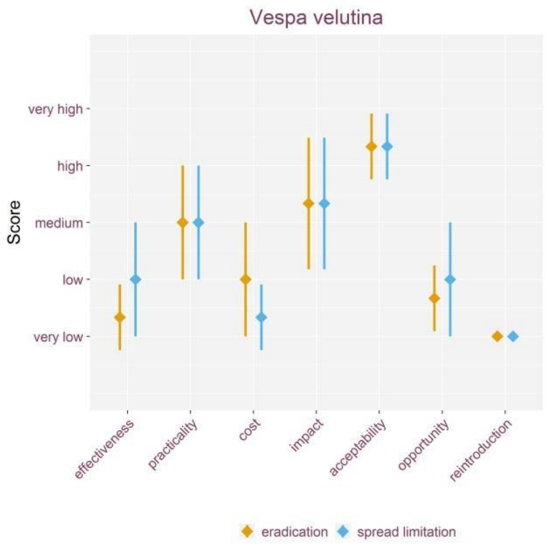
- Post intervention verification: To detect new nests that arise through escaped founder queens, after a nest is removed during summertime, a field survey is undertaken in fall through ivy flower inspection and the next year in a 5km buffer zone around the removed nest making use of spring traps and dedicated surveillance near apiaries.

Management strategy – spread limitation

- Aim: *Option 2 : Stand-still principle with core area along the French border.* Further colonization of the Belgian territory is avoided by reducing nest density within this core area and by establishing a buffer zone of 30 km wide around it where insect immigration is stopped through intensive nest destruction.
- Methods and techniques: techniques similar to those proposed for the eradication strategy are proposed with a target of 70% of nest destruction in the core area and at least 95% of nest destruction in the buffer zone.
- Post intervention verification: To detect new nests that arise through escaped founder queens, after a nest is removed during summertime, a field survey is undertaken in fall through ivy flower inspection and the next year in a 5km buffer zone around the removed nest making use of spring traps and dedicated surveillance near apiaries.

Assessment results





The eradication and spread limitation strategy were both scored low to medium by the experts. This is reflected in comparable scores across criteria. Although both management strategies were deemed very acceptable, experts assessed the effectiveness very low to low for eradication and spread limitation respectively. The cost for management would be high hence this criterium was scored low for eradication and very low to low for spread limitation. Experts clearly believed Asian hornet was likely to reinvade Belgium from neighbouring countries, hence a consistently very low score for reintroduction.

Outcome from the workshop

The species was not dealt with during the workshop.

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3.3 Aquatic plants

3.3.1 Carolina fanwort *Cabomba caroliniana* (waterwaaier, cabomba de Caroline)

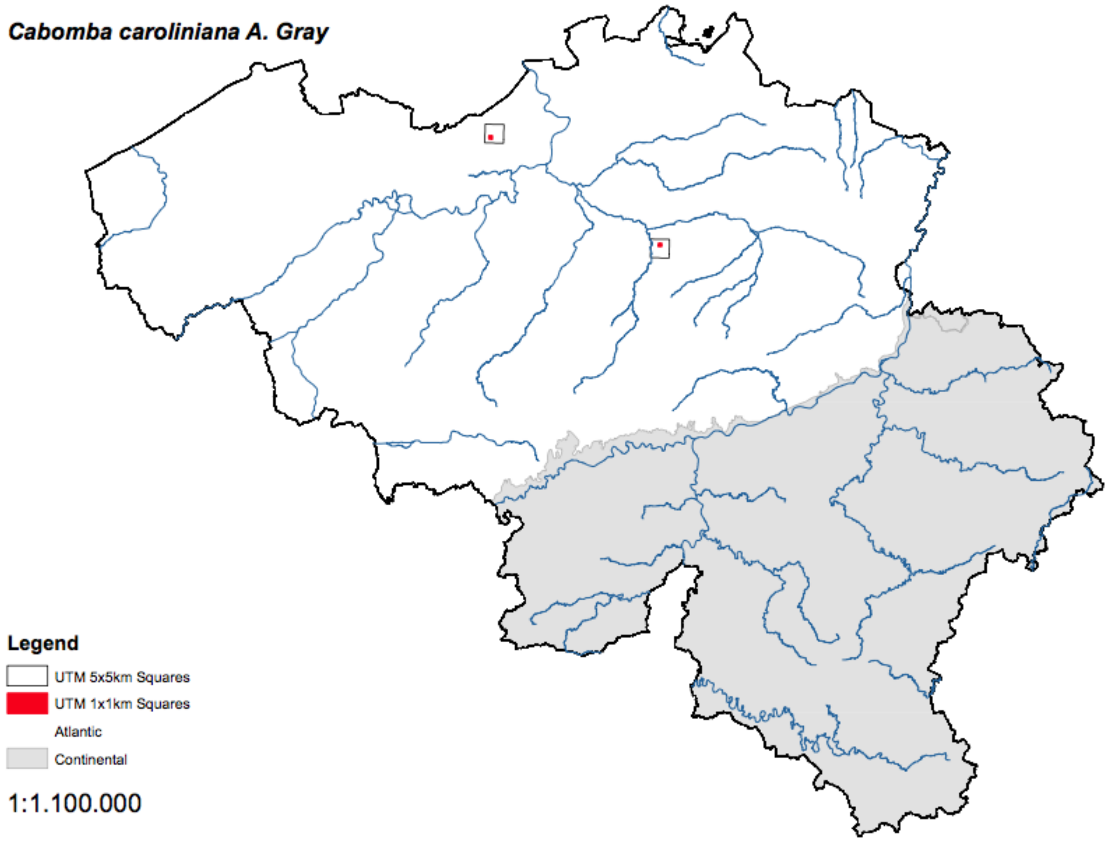
©Kevin Scheers

Invasion scenario

- Invasion situation and history in Belgium: A single population is known in the Atlantic bioregion: an isolated population was discovered in the village centre of Sint-Pauwels in May 2013 (Oost-Vlaanderen, Belgium) and most probably originated from an aquarium dump, hence the finding of goldfish in the ditch (Scheers et al., 2016). *Cabomba* is the only submerged macrophyte in an, L-shaped, four meter wide ditch (c. 1200 m2 , greatest depth 1.2 m) and reaches a vegetation cover of 65%. The ditch has a protected status for it has cultural and historical value as a remnant of an eighteenth century fortification. It is owned and managed by the municipality. The ditch is surrounded by villas, some of which have gardens that border it. The only other hydrophytes at the site are common native *Lemna minor* and the invasive *L. minuta*, covering most of the water surface. Riparian vegetation includes very common species like *Glyceria maxima* (locally abundant), *Typha latifolia* (frequent) and *Sparganium erectum* (occasional); some willows *Salix* sp. shade parts of the ditch but this does not hamper *Cabomba* growth. The substrate consists of c. 20 cm of organic mud on sand, the water is turbid and oxygen concentration is very low. *Cabomba caroliniana* was previously recorded in Belgium in an abandoned fishing pond at more than 50 km from the present location (Holsbeek, province Vlaams-Brabant) (Denys et al., 2003). Here, it disappeared along with all other aquatic vegetation after dredging and restocking with fish in 2006 to resume angling. In 2017 plant fragments were also found floating in the Campine canal (Dessel-Turnhout-Schoten).

- Reliability of the BE distribution: This submerged species can be rather inconspicuous and is not readily identified because of confusion with other plants species (e.g. *Ceratophyllum*, *Ranunculus*, *Myriophyllum*). It is therefore probably underdetected.

- Invasion situation in neighbouring countries: Several populations of Carolina fanwort are observed in Dutch water bodies near the Belgian border (e.g. near Breda) (Waarneming.nl database).



	ATL	CONT
Utm 10km	1	0
Utm 5km	1	0
Utm 1km	1	0
% 1km SAC	0 %	-
Clustering index	464.18	-

Management strategy – eradication

- Methods and techniques: This water weed may fragment into small shoot pieces that can easily regenerate new plants. The eradication strategy consists of (temporary) drawdown, followed by mechanical removal of the dried sediment layer that contains the plant material through dredging. The method is described in detail in Scheers et al. (2016). Drawdown requires active pumping, during which adequate precautions are taken not to spread plant fragments in the sewage system e.g. through the use of a biofilter or a sand filter. Plants are adequately disposed of as *Cabomba* is known to withstand desiccation and can remain viable even if dried. This action is followed by manual aftercare to remove any regrowth during at least two years. As a means of restoration, a tall helophyte belt (e.g. *Phragmites*, *Typha*) is planted and maintained along the shore after the *Cabomba* removal in order to reduce the open water area and the chances of reintroduction.

  Filling up the ditch is not an option as it lies in a protected village site and cannot be altered. The use of herbicide by public authorities is legally no longer possible. Also, biocontrol using grass carp *Ctynopharyngodon idella*, a non-native species, is regulated by fisheries legislation. It is not selective and high densities of grass carp can limit habitat quality for other organisms by complete loss of vegetation, changes in sediment composition and hydrochemistry (Pipalova, 2006). Biocontrol using weevils (Cabrera-Walsh et al., 2011) would not lead to permanent removal and non-target effects cannot be ruled out. Also, the use of non-native biocontrol agents is regulated and subject to preliminary risk assessment, which are not yet available. Light deprivation using matting (light-blocking synthetic foil or geo-textile such as jute) would provide an alternative on site, but would require additional removal of the surrounding fringe vegetation. Repeated clearing using an excavator with a mowing bucket, the removal of soft sediment or the use of pressurized air to uproot *Cabomba* (Hydro-venturi) lower biomass, but complete removal is unlikely (Van Valkenburg et al., 2011). Increased shading by trees or shrubs can also lead to reduced abundance of *C. caroliniana*, but the leaf litter could further impair the already problematic water quality. Therefore, these methods are not part of the strategy.

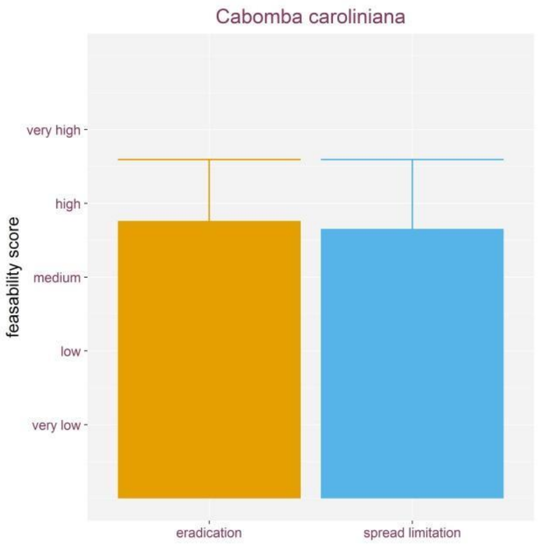
- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

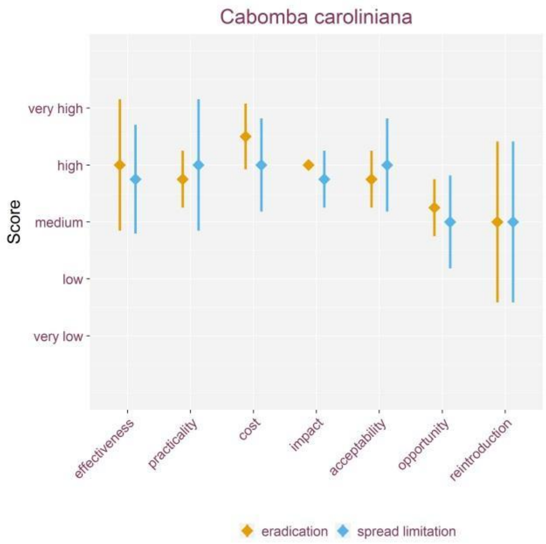
Management strategy – spread limitation

- Aim: *Option 1 - Stand-still principle into a single or a few patches*
  The spread limitation strategy aims at limiting the presence of *C. caroliniana* in Belgium to this single patch, avoid the production of any propagule that might result in further dispersion and rapidly eradicate any new patch discovered in the field.
- Methods and techniques: Newly discovered populations are eradicated using the techniques described in the eradication strategy (drawdown + dredging), with light deprivation using matting (light-blocking synthetic foil or geo-textile such as jute) as an alternative in smaller, less vegetated situations. Development of a tall helophyte belt (e.g. *Phragmites*, *Typha*) along the shore area limits the risk of translocation of plants by reducing human access to the plants. As the ditch is a protected village site, with every management action (eradication or spread limitation), public information is provided to villagers through targeted communication.

- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of the original population to be able to detect any further spread from it. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility of both eradication and spread limitation strategies was scored by experts between medium and high. In both strategies, the average scores were medium for opportunity and reintroduction and high for effectiveness, practicality, impact and acceptability. The average cost feasibility was scored as high for the spread limitation strategy and a little higher (between high and very high) for the eradication strategy.

Outcome of the workshop

1. General considerations

The spread limitation stragegy was adapted during the workshop in order to take into account plant records in Limburg from 2018, i.e. plant fragments found floating in several sites of the Campine canal (Dessel-Turnhout-Schoten) and the Albert canal (Lanaken-Hasselt-Herentals) (Scheers *et al.* 2019). There was a high uncertainty concerning the source population of these fragments and management was considered difficult because of fluvial navigation. Propagules may possibly originate from the Meuse/Maas river. As a consequence, option 1 was replaced by option 2 in spread limitation, wherein the Limburg canal system connected to the river Meuse was defined as a core area; the aim was therefore to reduce populations in this core area and to eradicate any population found outside it.

Workshop participants acknowledged that species is difficult to detect in the field, especially when no flower is produced and when it grows amongst *Myriophyllum* spp. and other aquatic plants (confusion with other hydrophytes is frequent). They suggested to increase field surveillance in order to improve knowledge on species distribution in Belgium and to identify the source of plant fragments observed in Limburg canals; molecular tools like e-DNA may potentially be used to reach that goal.

It was also mentioned that control tests conducted in the Netherlands demonstrate that small population as this found in the Sint-Pauwels ditch can be eradicated in closed water system through matting or extraction of the root system from sediments.

2. Recommendations for management

Having in mind the updated distribution of *Cabomba caroliniana* and the difficulty to conduct management in large canals with frequent fluvial navigation, all workshop participants recommended to implement the **spread limitation strategy** (option 2). The eradication strategy was considered as poorly feasible because of incomplete distribution data and difficulies linked to plant management in large canals with fluvial navigation.

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3.3.2 Nuttall's waterweed *Elodea nuttallii* (smalle waterpest, élodée de Nuttall)

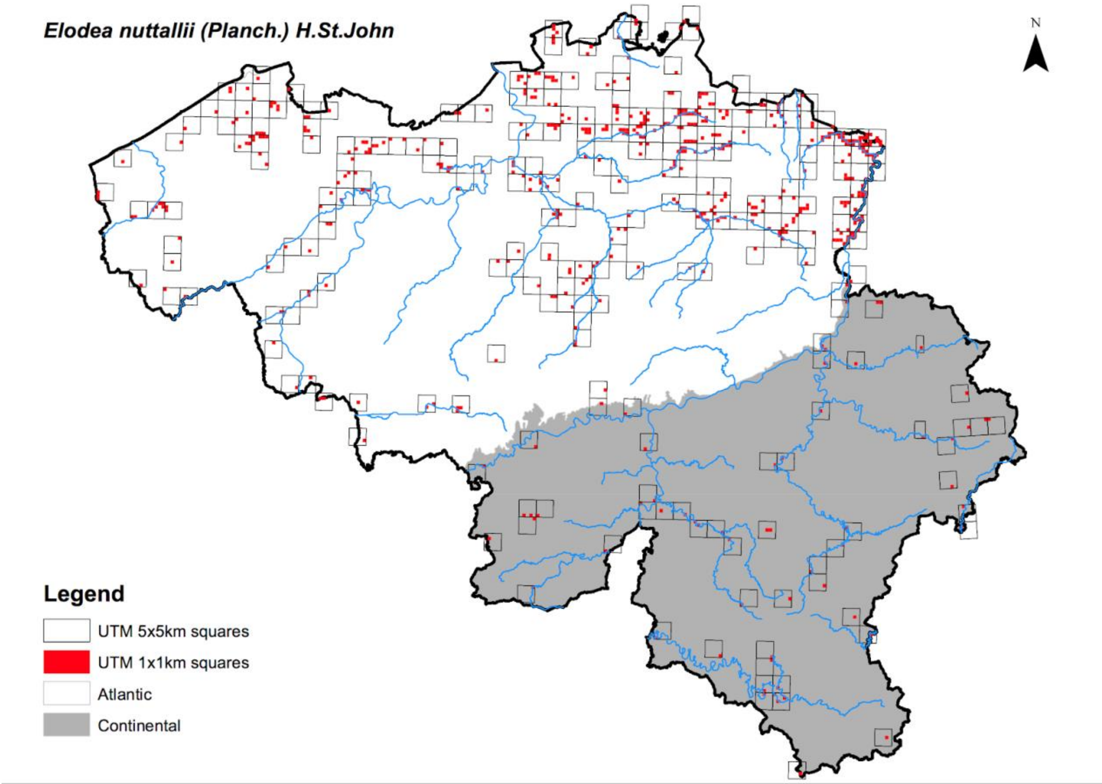
©Jo Packet

Invasion scenario

- Invasion situation and history in Belgium: *Elodea nuttallii*, with *E. canadensis*, is very widespread all over the country (Adriaens et al., 2009; Delbart, 2012). *E. nuttallii* is established in Belgium since the 1970s. It is found in ponds, canals, river branches and slow flowing stretches of rivers, including brackish waters. It is widespread both in the Atlantic and Continental bioregions, although populations are much more numerous in the Atlantic region. In the Atlantic bioregion, the species is common in all sorts of water types and strongly represented in the Campine, sandy and sandy-loam ecoregion (the river Scheldt and tributary river basins and the Grensmaas basin) (Van Landuyt et al., 2006). The species is less frequent in the western part of the Atlantic bioregion (e.g. the Polder region). In the continental bioregion, it is reported both in ponds and watercourses. It is widely spread in Lesse, Ourthe and Semois rivers.

- Reliability of the BE distribution: As a completely submerged macrophyte, this plant is not always easy to detect. It is probably underreported in both bioregions due to confusion with *E. canadensis* and absence of systematic survey.

- Invasion situation in neighbouring countries: Numerous dense populations of Nuttall's waterweed are known to occur in French and Dutch water bodies near the Belgian border (Siflore and Waarneming.nl databases, Levy et al 2015).



	ATL	CONT
Utm 10km	111	39
Utm 5km	209	45
Utm 1km	475	52
% 1km SAC	46 %	80 %
Clustering index	0.55	0.76

Management strategy – eradication

- Methods and techniques: This submerged rooted weed may easily fragment into small shoot pieces that can regenerate new plants. It is known to form non-anchored floating mats after root decay in autumn. In streams and canals, the eradication strategy is based on repeated manual or mechanical harvesting of biomass; mechanical harvesting is performed with weed-cutting boats, weed rakes usable from banks, or bucket-like shallow or deep dredges (Zehnsdorf et al 2015). In ponds and reservoirs, the methods are hand weeding (Hussner 2017; Hussner et al., 2017), drawdown and dredging or jute matting. Jute matting is applied to eradicate small populations with little vegetation in small by achieving light deprivation and facilitating the regrowth of native species (Caffrey et al. 2010; Hoffman et al. 2013; ; Zehnsdorf et al., 2015). On other sites drawdown is performed (in summer when water levels are already low or in winter allowing frostbite to reduce plant cover prior to removal) followed by mechanical removal using a mowing bucket on an excavator. On larger sites, this is performed off a barge. Care is taken not to spread any plant fragments during the drainage of the water and during the dredging using appropriate biofilters at in- and outlets of the water basins and cleaning the gear. Boats and dip nets are used to manually collect any floating fragments or hand pulled isolated plants that the excavator cannot get to. The removed plant and sediment material is allowed to leak out on geotextile tarps, reducing its weight and allowing invertebrates to escape back to the pond. It is

then incinerated. As *E. nuttallii* has a strong tolerance to mechanical cutting and a high capacity to recover from small plant fragments after management (Di Nino et al., 2005), aftercare is performed for five years on the sites, performing visual inspections of any remaining plants and the removal of any regrowth by hand pulling.
Biocontrol using herbivore fish like grass carp and chemical control using herbicides are not part of the strategy because of legal restrictions and drastic effects on non-target organisms and ecosystems (Pipalova 2006). Due to limited efficiency, mechanical control using a hydroventuri to uproot plant material from the substrate (Van Valkenburg et al., 2011) or underwater weed cutting are equally not a part of the strategy.

- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

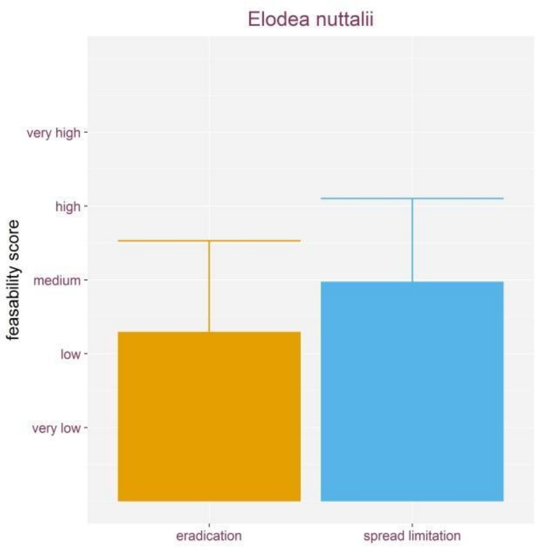
Management strategy – spread limitation

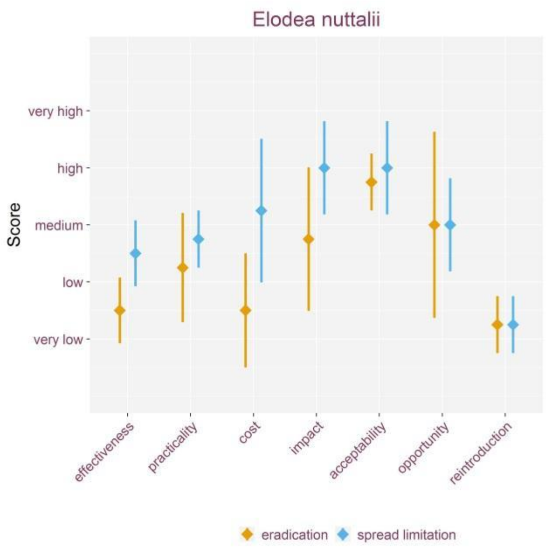
- Aim: *Option 4 - Maintenance of (small) pest free areas*
The spread limitation strategy aims at avoiding propagule propagation that would result in further dispersion of this widespread plant. Care is taken to avoid that it may reach uninvaded areas, especially upstream zones in river basins. Uninvaded areas are managed as pest free areas; they are subjected to (i) dedicated biosecurity measures, (ii) management actions aiming to increase habitat resistance to invasion, (iii) increased surveillance effort and (iv) rapid eradication actions after plant detection.

- Methods and techniques: Dedicated biosecurity measures are installed to prevent establishment of new populations following the human-mediated dispersal of plants to pest free areas : transport of plant fragments through the transfer of sediment material, human activity (incl. fishing clothing) and by boats and vehicles is avoided and physical barriers are installed where it may reduce introduction risks. Equipment and machinery are cleaned to remove plant fragments before moving to an uninfected area. Care is taken to reduce as much as possible nutrient input into freshwater ecosystems to reinforce their resistance to biological invasions and to promote competition by native aquatic vegetation (Zehnsdorf et al 2015). Increased surveillance effort is provided in pest free areas to allow a rapid eradication of new plant colonies, using similar techniques as those proposed in the eradication strategy.

- Post-intervention verification: An accurate surveillance is implemented within the pest free areas to be able to detect early establishment of the weed. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility was scored between low and medium for eradication and medium for the spread limitation strategy, with strong variations between the scores provided by the different assessors. The difference between both strategies was duet o higher scores for effectiveness, cost and impact in the spread limitation strategey compared tot he eradication strategy.

Outcome of the workshop

1. General considerations

Workshop participants proposed to slightly adapt the spread limitation strategy, focusing on nature reserves rather than on upstream zones as pest free areas.

Most participants considered that this species is so widespread and difficult to control that it could be a waste of money to invest to much in its detection and management. It is supposed to be everywhere in Flanders except maybe in some very polluted water bodies. The species looks less widespread in Wallonia but it is considered as strongly underdetected in this area as mentioned above. Participants also wondered if it make sense to take action against *E. nuttallii* without addressing *E. canadensis*, having in mind that they cause similar impacts and often behave as passenger of eutrophication and ecosystem change.

It was also suggested that measures to reduce transmission to non-infected water bodies (incl. communication to stakeholders) remain useful and that distribution mapping is necessary for both *Elodea* species, including possible molecular tools like e-DNA. Also improvement of water quality and ecosystem management should be considered to reduce plant abundance.

2. Recommendations for management

As no consensus was achieved amongst participants for common recommendations, a vote was held with the following results :

- Eradication : 0/11
- Spread limitation: 4/11
- Population control (impact mitigation) : 7/11
- Abstention : 0/11

The majority of participants recommended the **population control strategy** because of species widespread status, incomplete distribution data and low effectiveness of management practices. Spread limitation was seen as an alternative by others.

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3.3.3 Curly waterweed *Lagarosiphon major* (verspreidbladige waterpest, elodée à feuilles alternes)

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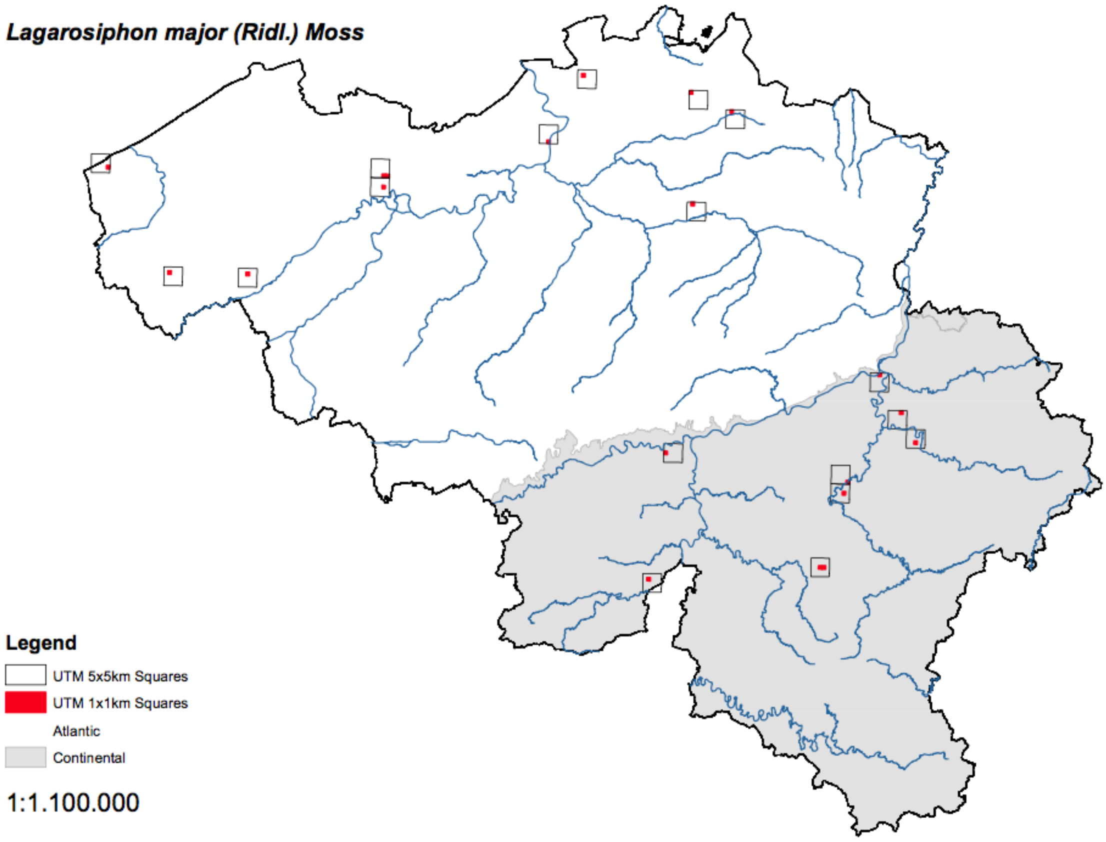
Invasion scenario

- Invasion situation and history in Belgium: First reported in Belgium in 1993, meanwhile established throughout the country and rapidly expanding through new aquarist introductions or attached to boats (e.g. in the Campine canals). Since 2004 there have been several observation in the Atlantic region, mostly the provinces of Western and Eastern Flanders and the province of Antwerp. In the Atlantic region, *L. major* is known from 12 locations. Populations range from smaller infestations in ponds (e.g. dunes in Koksijde, Kruibeke) to very large populations (>10 000m^2) such as the ones near Ghent (Lange Velden, Wondelgem) (Adriaens et al. 2016). *Lagarosiphon major* is mostly confined to standing or slow flowing water, but also occurs in canals (e.g. canal Dessel-Turnhout-Schoten) where it is spread from shallow winding holes and marinas by movement of boats and pleasure craft. Most populations in the Atlantic bioregion are either managed by public and semi-public authorities or by Natuurpunt. The Koksijde population (Fluithoek) was presumably eradicated manually by the Agency for Nature and forest. The population near the nature reserve Bourgoyen-Ossemeersen (Malpertuus site, Mariakerke) disappeared spontaneously. In the Continental region, the plant is known from 9 isolated populations. It is mostly confined to small ponds (invaded area < 1000 m2) but two larger populations occur, one in a deep lake found in an old excavation site near Floreffe and another one in a large leisure pond of the municipality of Doische (invaded area of 25000 m2). A few other populations were recently detected in small ponds, both in the Atlantic and the Continental regions (not shown on the map).

- Reliability of the BE distribution: *L. major* is probably underdetected because it can easily be confused with other macrophytes such as *E. nuttallii* and it has a submerged phenotype which is not readily detectable.

- Invasion situation in neighbouring countries: Several populations of curly waterweed are observed in French and Dutch water bodies near the Belgian border (Siflore and Waarneming.nl databases). It is reported from the Roubaix transboundary canal in Leers (Levy et al 2015).



	ATL	CONT
Utm 10km	10	8
Utm 5km	10	8
Utm 1km	11	9
% 1km SAC	45 %	63 %
Clustering index	1.28	1.20

Management strategy – eradication

- Methods and techniques: This submerged rooted weed may easily fragment into small shoot pieces that can regenerate new plants. The eradication strategy consists of drawdown and dredging or jute matting. Matting (light-blocking synthetic foil or geo-textile such as jute) is applied to eradicate small populations with little vegetation by achieving light deprivation and facilitating the regrowth of native species (Caffrey et al. 2010, 2011). This will often require additional removal of the surrounding fringe vegetation before matting can be applied. On other sites, temporary drawdown is followed by mechanical dredging removing the sediment layer that contains the plant material and removing any remaining plant fragments appearing during or after the procedure. Where site conditions do not allow this, hand pulling and/or mechanical removal of plants is applied. This is followed by five years of manual aftercare to check for regrowth in May-June and to remove any regrowth (Denys et al., 2014). Depending on the situation, drawdown may require active pumping (closed water bodies, ponds) or allowing water to pour out of water systems. During these procedures, adequate precautions are taken not to spread plant fragments in the sewage system or in other areas or water bodies e.g. through the use of biofilters and physical barriers. Also, machinery must be cleaned of any plant material. Plants are adequately disposed of as *Lagarosiphon* is known to withstand desiccation and can remain viable even if dried.

Biocontrol using herbivore fish like grass carp and chemical control using herbicides are <u>not</u> part of the strategy because of legal restrictions and drastic effects on non-target organisms and ecosystems (Pipalova 2006). Classical or inundative biocontrol using BCA's specific to *L. major* from its native range (e.g. the leaf-mining fly *Hydrellia lagarosiphon*, the chironomid *Polypedilum lagarosiphonia*), could in the long term reduce management costs but has to be integrated with other methods to really be effective (Baars et al., 2010). Due to limited efficiency, mechanical control using a hydroventuri to uproot plant material from the substrate or underwater weed cutting (Caffrey et al. 2011, Van Valkenburg et al. 2011) are equally <u>not</u> a part of the strategy.

- <u>Post-intervention verification</u>: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

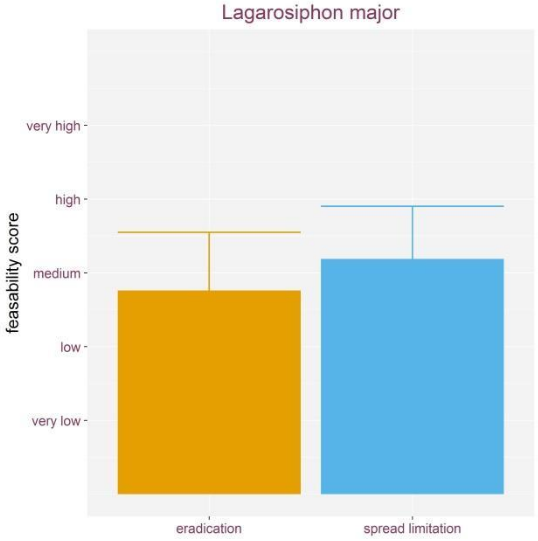
Management strategy – spread limitation

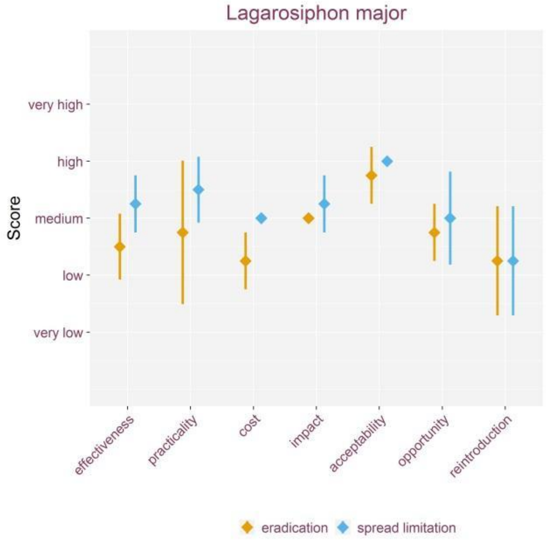
- <u>Aim</u>: *Option 1. Stand-still principle with a single or a few patches*
The spread limitation strategy aims at limiting the presence of *L. peploides* in Belgium to isolated baseline populations, avoid any further dispersal from them by limitation of shoot fragment production and rapidly eradicate any new patch discovered in the field.

- <u>Methods and techniques</u>: New populations are eradicated using similar techniques as those proposed in the former strategy: drawdown followed by mechanical dredging or jute matting. To limit the production of plant fragments, populations in standing waters are isolated by installing and maintaining physical barriers to plant dispersal and by preventing the fragmentation of stems. Patches may additionally be subjected to environmental management techniques like shading, reduction of the water nutrient status and enhanced competition with native vegetation (EPPO 2014). Habitat conversion is implemented by allowing natural succession from open water to closed vegetation e.g. through altered management practices and active planting planting (e.g. marsh species like *Phragmites*, *Typha*, then brook forest species like *Salix* and *Alnus*) towards a closed vegetation type. *Lagarosiphon* will then disappear or reduce substantially in cover through competition with taller helophytes and shading. Second, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- <u>Post-intervention verification</u>: An accurate surveillance is implemented in the immediate vicinity of existing populations to be able to detect any further spread from them. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility was scored between low and medium for eradication and between medium and high for the spread limitation strategy. The difference between both strategies was due to higher scores for effectiveness and practicality and a lower score for price in the spread limitation strategy compared to the eradication strategy. Similar scores were provided for other components of management feasibility.

Outcome of the workshop

1. General considerations

Workshop participants recommended to strongly enhance field surveillance for *L. major* because of the low detectability of its submerged phenotype and the confusion risks with other species, incl. *Elodea nuttalii*. Reliable distribution data are of utmost importance to reach management goals and communication and training are needed both to improve distribution data and reduce accidental introductions. They also considered that there is a large area for further spread of this species in Belgium's territory and that urgent action is needed to curb further plant expansion.

They acknowledged that this species has a strong environmental impact because it is an habitat transformer that may facilitate its own development and population increase. It is known to modify physico-chemical peculiarities of waterbodies it invades.

Experience gained from management actions already undertaken in Belgium showed that local eradication is usually costly and difficult to achieve.

2. Recommendations for management

All workshop participants recommended to implement the **spread limitation strategy** (option 1). The eradication strategy was considered as poorly feasible because of incomplete distribution data and low effectiveness of management techniques.

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3.3.4 Water pennywort *Hydrocotyle ranunculoides* (grote waternavel, Hydrocotyle fausse renoncule)

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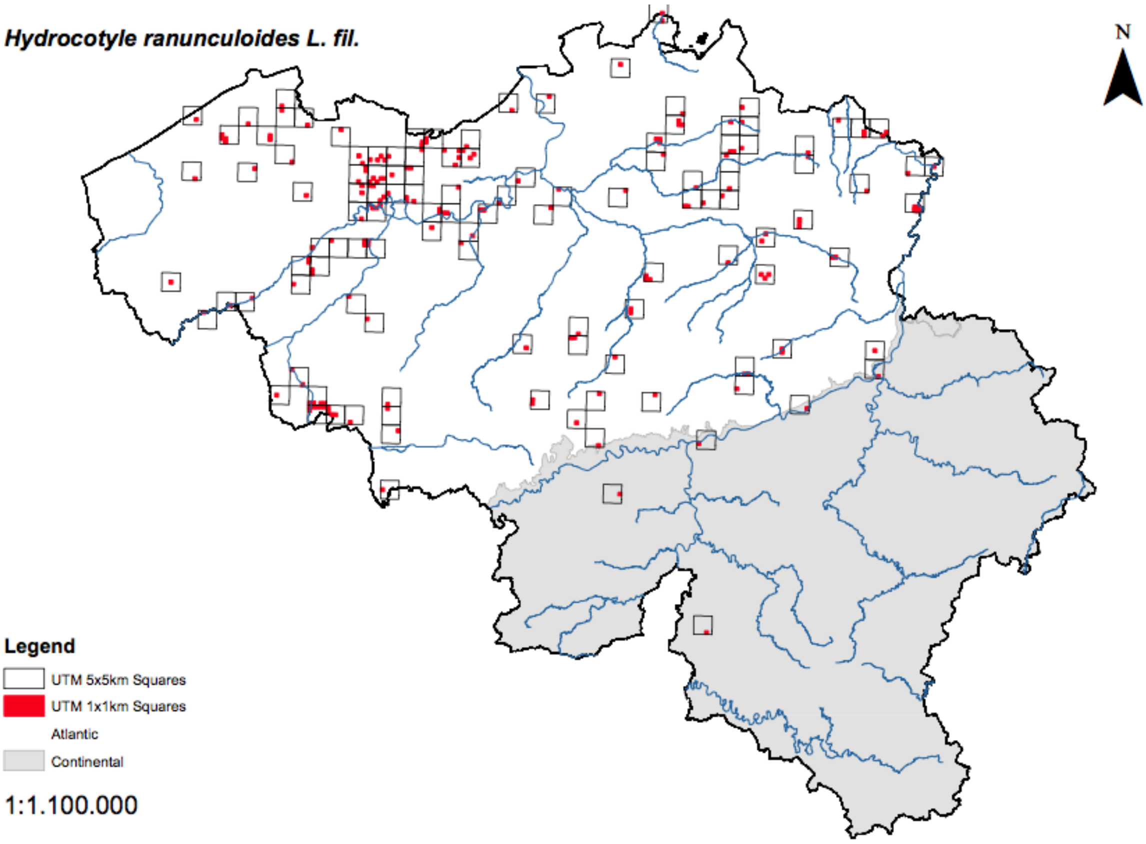
Invasion scenario

- Invasion situation and history in Belgium: First observed in Belgium in 1992, floating pennywort rapidly spreads within the country due to multiple introductions via the aquatic nursery trade and subsequent natural dispersal in the environment through water currents. During the reference period 2000-2015, it was observed in 190 1x1km squares in the Atlantic bioregion, but only 4 squares in the Continental bioregion. As observed in other countries for several aquatic weeds, floating pennywort is mainly observed in nutrient-rich water bodies and slow-flowing watercourses. At least 25% of the plant patches recorded in Flanders were found along watercourses (Adriaens et al 2016). A very high frequency is observed in some river systems like the Leie, the Nete and the Schelde. In the Continental region, only small populations are reported. Populations range from smaller infestations in ponds to very large populations observed along some canals and watercourses. Due to strong nuisances caused by the plant, it is actively tackled by water managers in Flanders since 2005 and has been one of the target species of the INVEXO INTERREG project (2009-2012).

- Reliability of the BE distribution: Species distribution is considered as rather exhaustive due to active monitoring and high detectability of the plant in the field. Young plants could however be confused with *Ranunculus* spp. and can be very difficult to find in between other more common water plants at early invasion stage. As a result of management actions undertaken in the last years, the percentage of infected water stretches has decreased significantly and the species is therefore overrepresented on the distribution map in particular in the provinces of Antwerp and East Flanders, (INVEXO 2012).

- Invasion situation in neighbouring countries: Invasion level in neighbouring countries is rather high and the plant is often found along transboundary watercourses and waterbodies in Netherlands and Northern France (Siflore and Waarneming.nl databases).



	ATL	CONT
UTM 10km	81	4
UTM 5km	115	4
UTM 1km	190	4
% 1km SAC	33%	50%
Clustering index	0.58	1.73

Management strategy – eradication

- Methods and techniques - The management of this water weed may induce fragmentation into small shoot pieces that can easily regenerate new plants. New and small infested patches (up to several hundreds of square meters) of floating pennywort are managed by manual removal (hand weeding) preferably in late spring, directly from banks or from small boats. A special care is taken to remove all the stems rooted at the lower parts of embankments in limiting shoot fragmentation. Where possible, water level reduction may be applied before management to facilitate the detection of plants rooted in banks. Subsequent hand picking of plant regrowth is performed every month during the vegetation period after the initial intervention, over 5 successive years (= follow-up management measures). Larger patches are managed either with excavators equipped with mowing baskets for cutting and collecting plant material (narrow waters) or with weed harvesting boats with a hydraulic controlled rack on the front for collecting plants floating and present on the banks (large water bodies), directly followed by a careful and intensive manual removal of viable plant fragments and manual post-harvest treatments during 5 successive years as described above (Plant Protection Service 2011, EPPO 2014, Sarat et al 2015, Hussner et al. 2017). The managed areas are fenced or netted off, to reduce plant spread downstream. Also, all cut plant material is removed and disposed off far away from freshwater to avoid new contaminations; harvested biomass is either dried, buried or composted. Biocontrol using grass carp or herbivorous insects and chemical treatments are not part of the strategy because of limited efficiency and/or legal limitations in the Belgian context (see e.g. Delbart et al 2013 and Aldridge et al 2015).

- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

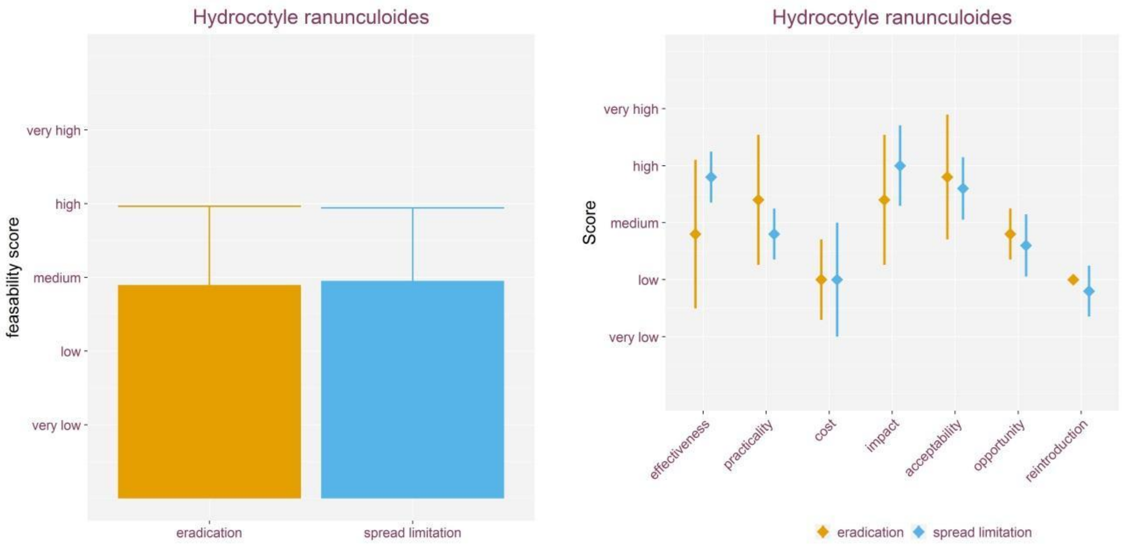
Management strategy – spread limitation

- Aim: *Option 3. Progressive elimination of the most dispersive populations*
  The spread limitation strategy aims at (i) eradicating populations growing along water courses that may easily expand towards remote areas and avoiding spread from ponds to the river systems in the Atlantic area and (ii) eradicating all isolated populations in the Continental area as they represent a potential source of invasion for the whole bioregion.

- Methods and techniques: Populations are eradicated using similar techniques as those proposed in the former strategy. Spread dispersion from ponds in the Atlantic bioregion is prevented by installing and maintaining physical barriers. Those ponds may additionally be subjected to environmental management techniques like shading, reduction of the water nutrient status and increased competition with native helophytes (EPPO 2014). At last, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of existing populations to be able to detect any further spread from them. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results



The average feasibility of both eradication and spread limitation strategies was scored around medium by experts. Similar scores were provided for the different management feasibility components in both strategies, except for increased effectiveness in the spread limitation strategy.

Outcome of the workshop

1. General considerations

Workshop participants considered that *H. ranunculoides* is the easiest invasive water plant to manage because of long experience gained in its management and high efficiency of actions undertaken so far in the field, providing that best management practices and aftercare are applied.

They however reported that investment in monitoring is needed to refine knowledge on current distribution (data on the maps are outdated) and better assess management efficiency.

They also stressed that good results may be achieved only when all populations are managed, including those established in private terrains. Access to these sites may be locally difficult as reported by experience in Flanders. Participants considered it is needed to secure money to control populations in private terrains, at least for the first operations., having in mind it could be rather expensive and potentially reduce the budget available to control other species.

2. Recommendations for management

As no consensus was achieved amongst participants for common recommendations, a vote was held with the following results :

- Eradication : 8/11
- Spread limitation: 1/11
- Population control (impact mitigation) : 0/11
- Abstention : 2/11

The majority of participants recommended the **eradication strategy**.

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3.3.5 Water primrose *Ludwigia grandiflora* (waterteunisbloem, Jussie à grandes fleurs)

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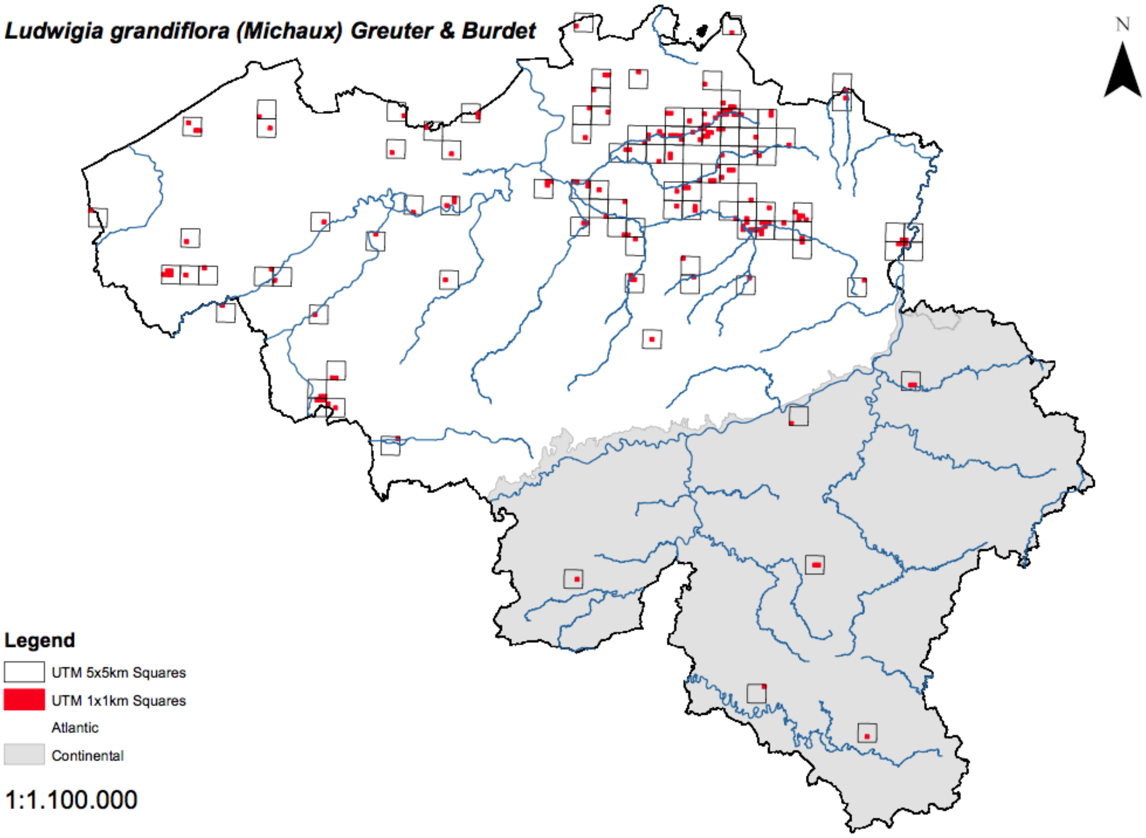
Invasion scenario

- Invasion situation and history in BE: Water primrose was first observed in Belgium in 1984, with a rapid increase of sightings during the 1990's. Most records are from nutrient-rich and artificial ponds, canals and other water bodies. However, since about 2001 it is also known from numerous localities alongside watercourses like the river Kleine Nete (Verloove 2017). At least 30% of the plant patches recorded in Flanders were found along watercourses (Adriaens et al 2016). Populations range from smaller infestations in ponds to very large populations (> 10.000 m^2) observed along some canals and watercourses. Plant spread within the country is due to multiple introductions via the aquatic nursery trade and subsequent natural dispersal in the environment through water currents. During the reference period 2000-2015, it was observed in 169 1x1km squares in the Atlantic bioregion, but only in 8 squares in the Continental bioregion. A very high frequency is observed in the Gete and the Nete river system (core area). Only small and isolated populations are reported so far from the Continental region.

- Reliability of the BE distribution: Species distribution is considered as rather exhaustive due to active monitoring and high detectability of the plant caused by massive flowering. The species is however difficult to distinguish from *L. peploides* and confusions between both species may occur. Also, young plants can be very difficult to find in between other more common water plants such as *Mentha aquatica*.

- Invasion situation in neighbouring countries: Invasion level in neighbouring countries is rather high and the plant is often found along transboundary watercourses and waterbodies in Netherlands and Northern France (Siflore and Waarneming.nl databases). It is well established in the Nord-Pas-de-Calais area. The species is e.g. present in the transboundary Haute-Colme canal (Levy et al 2015).



	ATL	CONT
UTM 10km	*61*	*6*
UTM 5km	*96*	*6*
UTM 1km	*169*	*8*
% 1km SAC	47%	71%
Clustering index	0.56	1.25

Management strategy – eradication

- Methods and techniques: *L. grandiflora* may fragment into small floating and rooted shoot pieces that can regenerate new plants. Populations may easily spread on long distances by seeds and establish from persistent seed bank after physical disturbance of sediments (Ruaux et al 2009, Thouvenot et al 2013).
  New and small infested patches (up to several hundreds of square meters) of water primrose are managed by manual removal (hand weeding) preferably in late spring, directly from banks or from small boats (Hussner et al. 2016). A special care is taken to remove all the stems rooted at the lower parts of embankments in limiting shoot fragmentation. Where possible, water level reduction may be applied before management to facilitate the management and reduce plant vigour due to water stress. Subsequent hand picking of plant regrowth is performed every month during the vegetation period after the initial intervention, over 5 successive years. Larger patches are managed either with excavators equipped with mowing baskets for cutting and collecting plant material (narrow

waters) or with weed harvesting boats with a hydraulic controlled rack on the front for collecting plants floating and present on the banks (large water bodies), directly followed by a careful and intensive manual removal of viable plant fragments and manual post-harvest treatments during 5 successive years as described above (Plant Protection Service 2011, EPPO 2014, Sarat et al 2015, Hussner et al. 2017). The managed areas are fenced with rubber flanges or netted off, to restrain the drift of free floating material and avoid plant spread downstream. Also, all cut plant material is removed and disposed off far away from freshwater to avoid new contaminations. Harvested biomass is either dried, buried or composted. Biocontrol using grass carp or herbivorous insects and chemical treatments are not part of the strategy because of limited efficiency and/or legal limitations in the Belgian context (see e.g. Aldridge et al 2015 and Delbart et al 2013).

- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

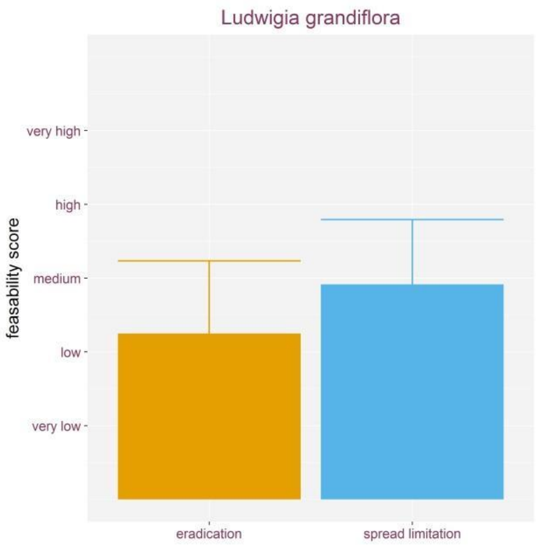
Management strategy – spread limitation

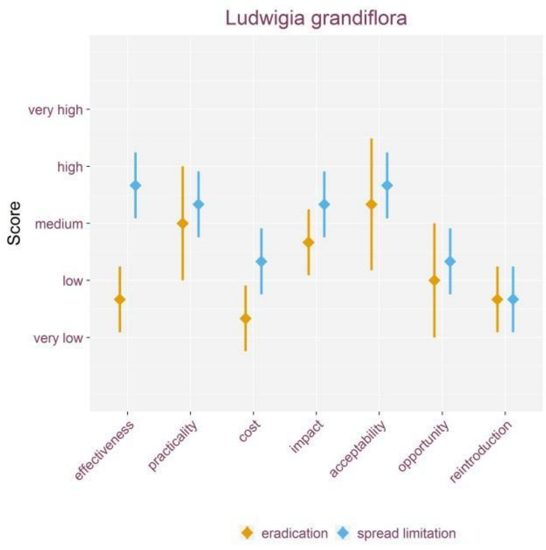
- Aim: *Option 2. Stand-still principle with core area(s)*
The spread limitation strategy aims limiting propagule production within its core area (the Gete and the Nete river system) and rapidly eliminating satellite and new populations discovered outside it. Seed production is reduced as much as possible both within the core area and outside the core area as seeds are more likely to participate in long-distance colonization (Thouvenot et al 2013).

- Management and techniques: Eradication of any population found outside the core area is applied using similar techniques as those proposed in the eradication strategy. In addition, *Ludwigia* populations of the core area are manually or mechanically harvested in July to reduce seed production. They may also be subjected to environmental management techniques like shading, reduction of the water nutrient status and increased competition with native helophytes (EPPO 2014). At last, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of the core area to be able to detect any further spread from it. A verification of the success of weed control is done in the same way as for the eradication strategy. .

Results





The average feasibility was scored between low and medium for both management strategies, with strong variations between the scores provided by the different assessors. Similar scores were reached for the different management feasibility components in both strategies, except for higher scores for effectiveness, cost and impact in the spread limitation strategy compared to the eradication strategy.

Outcome of the workshop

1. General considerations

Workshop participants proposed to slightly adapt the spread limitation strategy (option 2), considering that local eradication should be also performed where possible within the core area.

They considered that this species is much more difficult and costly to control than *Hydrocotyle*, e.g. because of more frequent fragmentation of stems during the management and difficulties to extract the root system from the substrate. Local peculiarities like bank shape or material, etc. can also make local eradication difficult to reach; this goal is easier to achieve in small water bodies that are easily accessible. Field practitioners feared that fertile seeds could be produced and regenerate new populations after management, to which scientists answered that this is highly incertain and that new plants can also come from fragments. In France, it was shown that vegetative reproduction is predominant.

Participants reminded that this species is known to cause a strong negative impact on biodiversity and ecosystem services, including fishing and navigation. Its management may also affect the ecosystem (e.g. impact on breeding birds).

Some participants suggested that biological control may be proposed as an option for risk mitigation in the future based on ongoing scientific research by CABI.

2. Recommendations for management

As no consensus was achieved amongst participants for common recommendations, a vote was held with the following results :

- Eradication : 2/11
- Spread limitation: 8/11
- Population control (impact mitigation) : 0/11
- Abstention : 1/11

The majority of participants recommended the **spread limitation strategy**. Eradication was seen as an alternative by others but considered as poorly feasible by the former group because of widespread status and low effectiveness of management techniques.

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http://www.q-bank.eu/Plants/Controlsheets/Ludwigia_State-of-the-Art.pdf

3.3.6 Floating primrose-willow *Ludwigia peploides* (postelein-waterlepeltje, kleine waterteunisbloem, Jussie rampante)

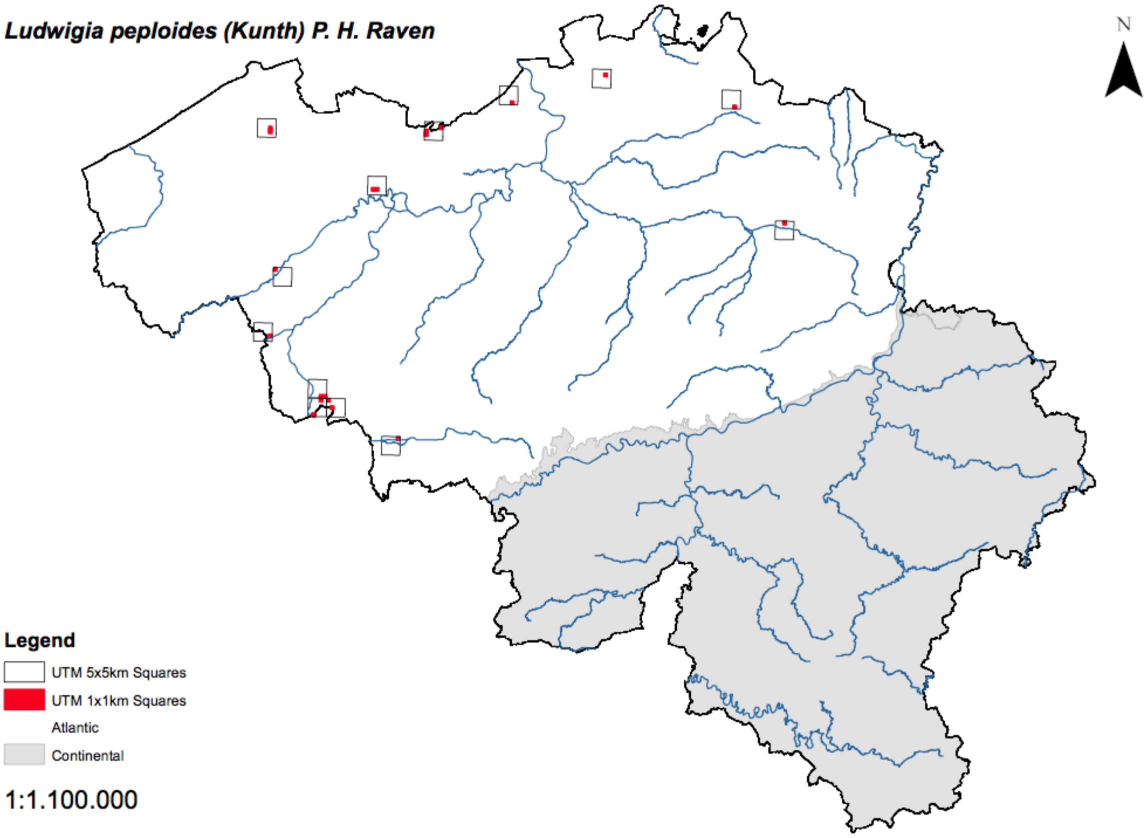
©Celine Prevot

Invasion scenario

- Invasion situation and history in Belgium: *Ludwigia peploides* was first observed in Belgium in 1995 and has been found in a few other localities ever since. It is a look-alike of *Ludwigia grandiflora* but is much less widespread than it and has a scattered distribution. During the reference period 2000-2015, it was found in 20 1x1km squares in the Atlantic bioregion but was not found in the Continental bioregion. Most Belgian records originate from nutrient-rich lakes, canals and slow flowing rivers with fluvial navigation. A large population is found along the Schelde river in direct connection with a French population. Several large populations are also present in lakes, e.g. at the ANB managed nature reserve Drijdijck in Antwerp harbour area (where it occurs as individual plants or patches of about 1m^2 in a *Crassula helmsii* dominated vegetation) and at the fish lake of Grand Rieu (Saint-Ghislain) in admixture with *L. grandiflora*. The population in Drijdijck is under management since 2016. Here, the water level was lowered after winter to expose plants to frost and to facilitate manual and mechanical removal. In august 2017 a few plants were still observed and manual aftercare was undertaken. In the nature reserve Bourgoyen-Ossemeersen (Ghent), a large population is present and is managed since 2015 by mechanical (sod cutting + burying on site) removal of a 3000 m^2 patch and 3 years of manual aftercare after lowering the water level.

- Reliability of the BE distribution: Species distribution is considered rather exhaustive due to active monitoring and high detectability of the plant caused by massive flowering. The species could however be under-detected due to confusions with *L. grandiflora.* Also, young plants can be very difficult to find in between other more common water plants such as *Mentha aquatica*.

- Invasion situation in neighbouring countries: The plant is abundant along several transboundary watercourses and waterbodies in Northern France (Siflore database). It is well established in the Nord-Pas-de-Calais area, the species is e.g. present in the transboundary Roubaix canal (Levy et al 2015). In the Netherlands, small infestations of the species have been successfully removed on several locations since 2002 (NVWA 2016), for example in the Biesbosch where it was eradicated by topsoil removal in 2007 (Van Valkenburg et al. 2013). However, a big populations is still present on the island of Tiengemeten (Haringvliet) which is under management by Natuurmonumenten with the help of volunteers since its discovery in 2012 by mechanical and manual removal (Withagen 2012) and in the city of Lelystad.



	ATL	CONT
UTM 10km	12	0
UTM 5km	13	0
UTM 1km	20	0
% 1km SAC	45 %	-
Clustering index	0.77	-

Management strategy – eradication

- <u>Methods and techniques</u>: *L. peploides* may fragment into small floating and rooted shoot pieces that can regenerate new plants. Populations may easily spread on long distances by seeds and establish from persistent seed bank after physical disturbance of sediments (Ruaux et al 2009, Thouvenot et al 2013). New and small infested patches (up to several hundreds of square meters) of floating primrose-willow are managed by manual removal (hand weeding) preferably in late spring, directly from banks, from small boats or from people wading through the water (Hussner et al. 2016). A special care is taken to remove all the stems rooted at the lower parts of embankments in limiting shoot fragmentation. Where possible, water level reduction may be applied before management to facilitate the management and reduce plant vigour due to water stress. Subsequent hand picking of plant regrowth is performed every month during the vegetation period after the initial intervention, over 5 successive years. Larger patches of stream populations are managed either with excavators equipped with mowing baskets for cutting and collecting plant material (narrow waters) or with weed harvesting boats with a hydraulic controlled rack on the front for collecting plants floating and present on the banks (large water bodies), directly followed by a careful and intensive manual removal of viable plant fragments and manual post-harvest treatments during 5 successive years as described above (Plant Protection Service 2011, EPPO 2014, Sarat et al 2015, Hussner et al. 2017). The managed areas are fenced with rubber flanges or netted off, to restrain the drift of free floating material and avoid plant spread downstream. Also, all cut plant material is removed and disposed off far away from freshwater to avoid new contaminations; harvested biomass is either dried, buried or composted.

Biocontrol using grass carp or herbivorous insects and chemical treatments are not part of the strategy because of limited efficiency and/or legal limitations in the Belgian context (see e.g. Aldridge et al 2015 and Delbart et al 2013).

- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

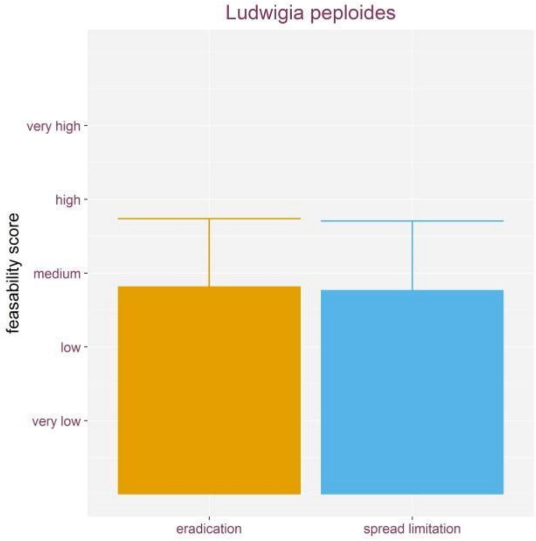
Management strategy – spread limitation

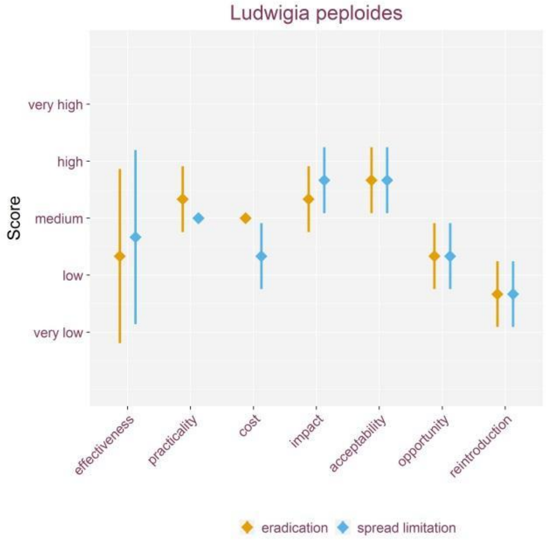
- Aim: *Stand-still principle with a single or a few patches*
  The spread limitation strategy aims at limiting the presence of *L. peploides* in Belgium to isolated baseline populations, avoid any further dispersal from them and rapidly eradicate any new patch discovered in the field. Seed production is reduced as much as possible as seeds are more likely to participate in long-distance colonization (Thouvenot et al 2013).

- Management and techniques: Eradication of any population found outside the existing sites is applied using similar techniques as those proposed in the eradication strategy. Within these sites, plants are manually or mechanically harvested in July to reduce seed production; populations are isolated as far as possible by installing and maintaining physical barriers to plant dispersal. They may also be subjected to environmental management techniques like shading, reduction of the water nutrient status and increased competition with native helophytes (EPPO 2014). Importantly, at sites which are grazed, exclosures should be installed around *L. peploides* populations to prevent spread of plant fragments (Withagen 2015). At last, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of existing populations to be able to detect any further spread from them. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility of both eradication and spread limitation strategies was scored by experts between low and medium. Similar scores were provided for the different management feasibity components in both strategies.

Outcome of the workshop

1. General considerations

Workshop participants recommended to enhance surveillance to have a better view of plant's distribution in Belgium and help defining realist management goals. Its includes awareness raising and training campaign to allow stakeholders to make the distinction between the 2 *Ludwidgia* species among which frequent confusions exists.

It was is also highlighted that action has to be taken in Northern France (e.g. canal de la Haute Colme) to reduce the risk of plant being reintroduced in Belgium from this territory.

2. Recommendations for management

All workshop participants recommended to implement the **eradication strategy**.

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3.3.7 Parrot's feather *Myriophyllum aquaticum* (parelvederkruid, myriophylle du Brésil)

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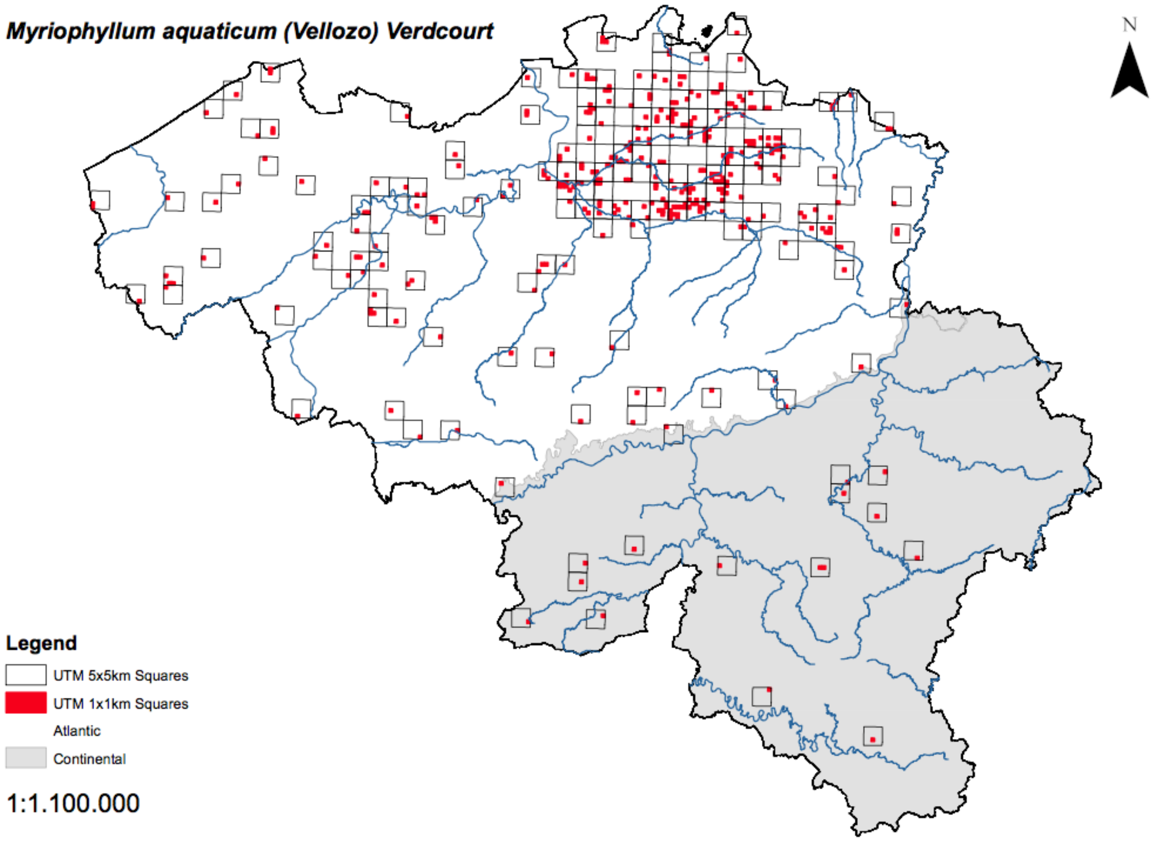
Invasion scenario

- Invasion situation and history in Belgium: Parrot's feather was first observed in Belgium in 1983. From 1995 onwards, it rapidly spreads within the country due to multiple introductions via the aquatic nursery trade (used as a very popular aquarium and garden pond plant) and subsequent natural dispersal in the environment through garden waste and water currents (Verloove 2017). During the reference period 2000-2015, it was observed in 338 1x1km squares in the Atlantic bioregion, but only 18 squares in the Continental bioregion. Parrot's feather is mainly observed in nutrient-rich shallow and muddy stagnant (ponds, ditches, marshes, etc.) from which the emergent shoots arise. It is also found in slow flowing water; at least 20% of the plant patches recorded in Flanders are found along watercourses (Adriaens et al 2016). A very high frequency is observed in some river systems like the Demer, the Dijle and the Nete. The situation seems quite different in the Continental region, wherein small and isolated populations are mostly reported.

- Reliability of the BE distribution: Species distribution is not considered as exhaustive due to the fact that it is often planted in private garden ponds where its presence is not reported. Available data may also be skewed because of confusion with a cultivar of *Myriophyllum* with red stems traded under the name of *Myriophyllum 'brasiliensis'* that has not proved to be very invasive so far (Clarke & Newman 2002, Ghahramanzadeh et al 2013, van Valkenburg pers. com.).

- Invasion situation in neighbouring countries: Infestation level in neighbouring countries is rather high and the plant is often found along transboundary watercourses and waterbodies in Netherlands and Northern France (Siflore and Waarneming.nl databases, Levy et al 2015).



	ATL	CONT
UTM 10km	93	16
UTM 5km	160	17
UTM 1km	338	18
% 1km SAC	37%	82%
Clustering index	0.62	1.12

Management strategy – eradication

- Methods and techniques: The management of this submerged evergreen water weed is a challenging task as (i) it may easily fragment into small shoot pieces that can regenerate new plants and (ii) it can take root in the sediment of water bodies up to several meters deep. For **new and small patches** (up to one hundred square meters) in shallow waters, the eradication strategy consists in hand-pulling, use of a tarpaulin, drawdown followed by sediment dredging or hand-pulling (Bailey & Calhoun 2008, Hussner et al 2017, Newman & Duenas 2017). Matting (light-blocking synthetic foil or geo-textile such as jute) is applied to eradicate small populations with little vegetation by achieving light deprivation and facilitating the regrowth of native species; this will often require additional removal of the surrounding fringe vegetation before matting can be applied. On other sites temporary drawdown is applied followed by mechanical dredging and removing the top sediment layer that contains the plant material. Where site conditions don't allow this, careful hand pulling is applied in minimizing plant fragmentation as much as possible. Dredging and hand weeding are followed by 5 years of manual aftercare to remove any regrowth. Depending on the situation, drawdown may require active pumping (closed water bodies, ponds) or allowing water to pour out of water systems. During these procedures, adequate precautions are taken not to spread plant fragments in the sewage system or in other areas or water bodies e.g. through the use of biofilters and physical barriers. For **larger infestations** in deep water systems, the eradication strategy consists in plant mechanical uprooting using either hydro-venturi or an excavator with a clawed bucket, directly followed by a careful and intensive manual removal of viable plant fragments and manual post-harvest treatments during 5 successive years (Sarat et al 2015, Hussner et al 2017). The hydro-venturi systems works by using a high pressure jet of water to uproot submerged aquatic plants and suck them to a collection point at the surface using a venture water entrainment device. Clawed buckets may also be used for uprooting and collecting plant material. Those mechanical control options may be better practised during the winter, when the plant is less active and regrowth is less likely, to reduce the effect on native vegetation and to reduce the competitive advantage of evergreen *Myriophyllum* in spring. The managed areas are fenced or netted off, to reduce plant spread downstream. Also, all cut plant material is removed and disposed off far away from freshwater to avoid new contaminations; harvested biomass is either dried, buried or composted. Biocontrol using grass carp or herbivorous insects and chemical treatments are <u>not</u> part of the strategy because of low palatability, limited efficiency and/or legal limitations in the Belgian context (see e.g. Delbart et al 2013, Newman & Duenas 2017).

- <u>Post-intervention verification</u>: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

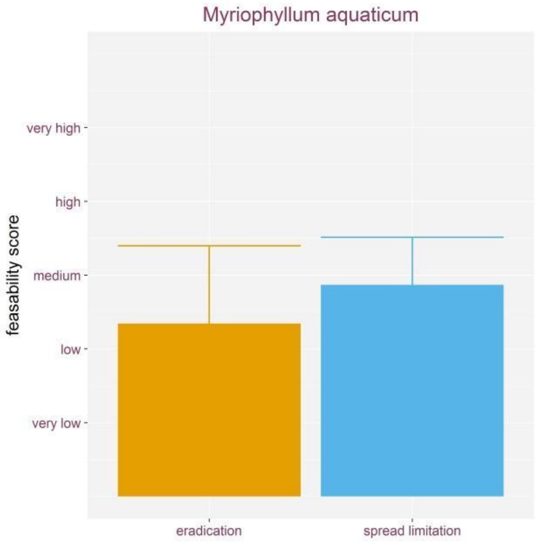
Management strategy – spread limitation

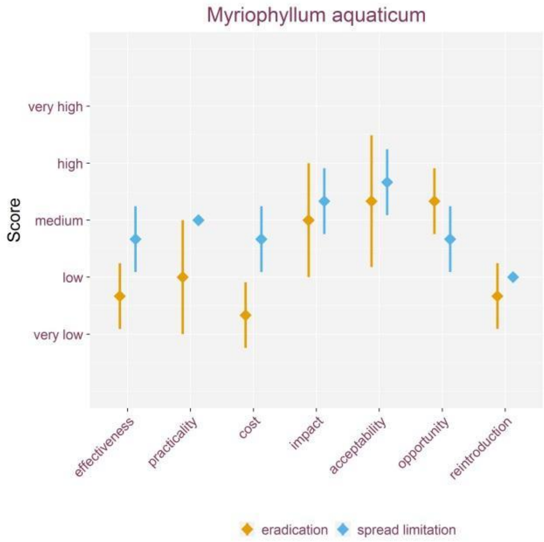
- <u>Aim</u>: Option 3 *Progressive elimination of the most dispersive populations*
  The spread limitation strategy aims at eradicating populations growing along water courses that may easily expand towards remote areas and avoiding spread from ponds to the river systems.

- <u>Methods and techniques</u>: Populations are eradicated using similar techniques as those proposed in the former strategy. Spread dispersion from ponds is prevented by installing and maintaining physical barriers. Those ponds may additionally be subjected to environmental management techniques like shading, reduction of the water nutrient status and increased competition with native helophytes (EPPO 2014). At last, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- <u>Post-intervention verification</u>: An accurate surveillance is implemented in the immediate vicinity of existing populations to be able to detect any further spread from them. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility of both eradication and spread limitation strategies was scored by experts between low and medium, with a strong variation between the scores provided by the different assessors regarding eradication. Similar scores were reached for the different management feasibility components in both strategies, except higher scores for effectiveness, practicality and cost in the spread limitation strategy compared to the eradication strategy.

Outcome of the workshop

1. General considerations

Workshop participants proposed to slightly adapt the spread limitation strategy (option 3), in order to add populations found in Natura 2000 sites and in public sites to those growing along water courses. Population control in Natura 2000 sites is especially important because the species may alter their conservation status.

Awareness rasing amongst home gardeners was considered as a priority action to launch because the species was often introduced in gardens ponds and should not be introduced on purpose or by accident (garden waste and sediments) in water courses and other water bodies. A better knowledge of plant distribution may be also reached in involving this target audience.

2. Recommendations for management

All workshop participants recommended to implement the **spread limitation strategy** (option 3). The eradication strategy was considered as poorly feasible because of widespread status, incomplete distribution data and low effectiveness of management techniques.

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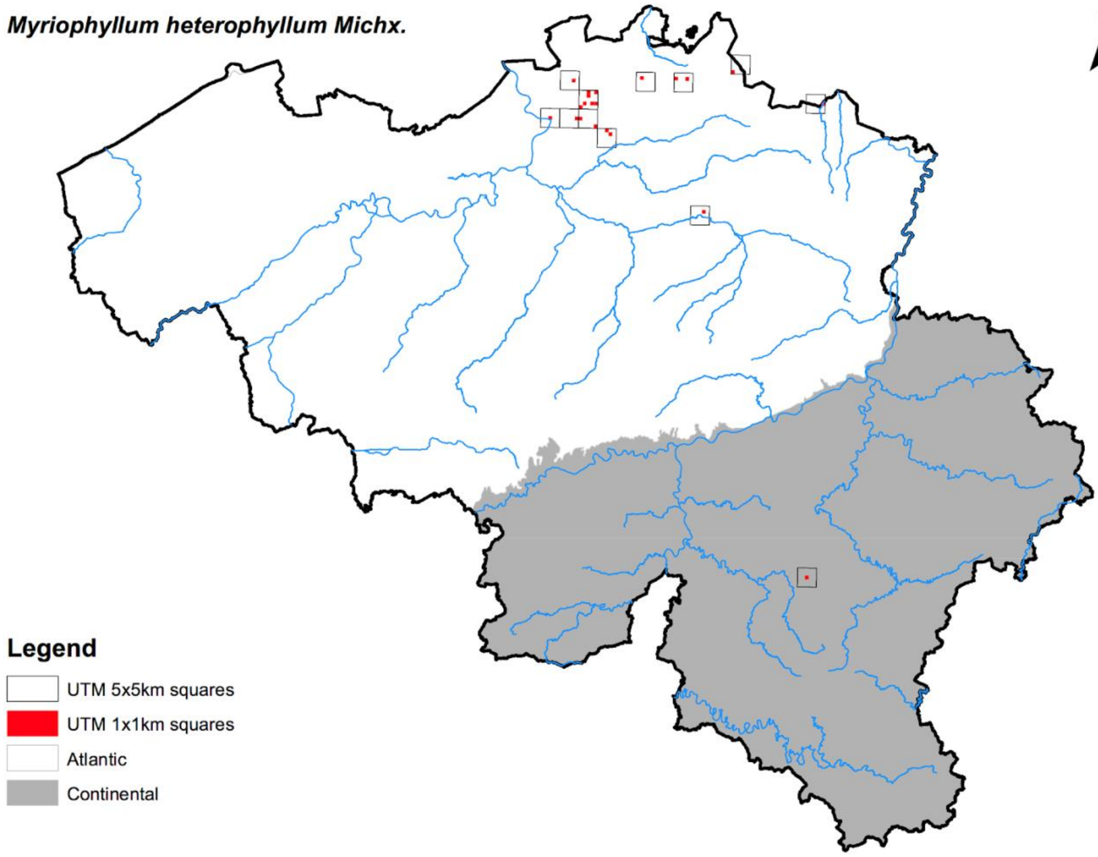
3.3.8 Broadleaf watermilfoil *Myriophyllum heterophyllum* (ongelijkbladig vederkruid, myriophylle hétérophylle)

©Leslie J. Mehrhoff (Wikimedia commons)

Invasion scenario

- Invasion situation and history in Belgium: Broadleaf watermilfoil is a rare, locally naturalised alien, probably overlooked, that has been observed in Belgium for the first time in 1993. It most likely was introduced as an aquarium plant and managed to escape from discarded aquarium contents. Meanwhile, it has been found in several canals and other artificial water courses in the northern parts of the province of Antwerp (core area) from 2007 onwards (De Beer & De Vlaeminck 2008). Here, populations are found along the shallow Dessel-Turnhout-Schoten canal (Turnhout) and the Antitankgracht (Sint-Job-in-'t Goor) where it is present since 1999 (Verloove 2017). Spread seems hitherto rather limited yet there are several other smaller populations in the area Schoten-Brecht-Beerse. Some populations, such as in Brecht (> 5000m^2) and Brasschaat have been managed by the Flemish Environment Agency, using dredging and manual aftercare (pers. Comm. L. Van Craen). More recently, it was found in small ponds near Nassogne where it has been introduced on purpose (Verloove 2017). During the reference period 2000-2015, it was observed in 20 1x1km squares in the Atlantic bioregion, but only one in the Continental bioregion. It grows in eutrophic freshwater ponds, lakes, ditches, standing and slow flowing waters.
- Reliability of the BE distribution: This *Myriophyllum* often spreads vegetatively and probably only rarely flowers under Belgian conditions; at vegetative stage, detection and identification are difficult and the plant may be easily confused with other native and non-native species of the same genus which may lead to species under-detection.
- Invasion situation in neighbouring countries: Several populations of broadleaf watermilfoil are observed in Dutch water bodies near the Belgian border (Waarneming.nl database). No observation is reported so far from Nord-Pas-de-Calais although the plant is known from the Somme Department (Levy et al 2015).



	ATL	CONT
UTM 10km	9	1
UTM 5km	11	1
UTM 1km	20	1
% 1km SAC	70%	-
Clustering index	1.03	1.03

Management strategy – eradication

- Methods and techniques: The management of this submerged evergreen water weed is a challenging task as (i) it may easily fragment into small shoot pieces that can regenerate new plants and (ii) it can take root in the sediment of water bodies more than 2-3 meters deep (Department of Conservation and Recreation Massachusetts 2005). This submerged evergreen water weed may easily fragment into small shoot pieces that can regenerate new plants. Fo**r new and small patches** (up to one hundred square meters) in shallow waters, the eradication strategy consists in hand-pulling, use of a tarpaulin, drawdown followed by sediment dredging or hand-pulling (Bailey & Calhoun 2008, Hussner et al 2017, Newman & Duenas 2017). Matting (light-blocking synthetic foil or geo-textile such as jute) is applied to eradicate small populations with little vegetation by achieving light deprivation and facilitating the regrowth of native species; this will often require additional removal of the surrounding fringe vegetation before matting can be applied. On other sites temporary drawdown is applied followed by mechanical dredging and removing the top sediment layer that contains the plant material. Where site conditions don't allow this, careful hand pulling is applied in minimizing plant fragmentation as much as possible. Dredging and hand weeding are followed by 5 years of manual aftercare to remove any regrowth. Depending on the situation, drawdown may require active pumping (closed water bodies, ponds) or allowing water to pour out of water systems. During these procedures, adequate precautions are taken not to spread plant fragments in the sewage system or in other areas or water bodies e.g. through the use of biofilters and physical barriers. For **larger infestations** in deep water systems, the eradication strategy consists in plant mechanical uprooting using either hydro-venturi or an excavator with a clawed bucket, directly followed by a careful and intensive manual removal of viable plant fragments and manual post-harvest treatments during 5 successive years (van Valkenburg 2011, Sarat et al 2015, Hussner et al 2017). The hydro-venturi systems works by using a high pressure jet of water to uproot submerged aquatic plants and suck them to a collection point at the surface using a venture water entrainment device. Clawed buckets may also be used for uprooting and collecting plant material. Those mechanical control options may be better practised during the winter, when the plant is less active and regrowth is less likely, to reduce the effect on native vegetation and to reduce the competitive advantage of evergreen *Myriophyllum* in spring. The managed areas are fenced or netted off, to reduce plant spread downstream. Also, all cut plant material is removed and disposed off far away from freshwater to avoid new contaminations; harvested biomass is either dried, buried or composted. Biocontrol using grass carp or herbivorous insects and chemical treatments are not part of the strategy because of low palatability, limited efficiency and/or legal limitations in the Belgian context (see e.g. Delbart et al 2013, Newman & Duenas 2017).

- Post-intervention verification: Managed sites and those downstream remain under close surveillance over a 5-year period after the post-harvest treatments in order to detect any resurgence of the weed.

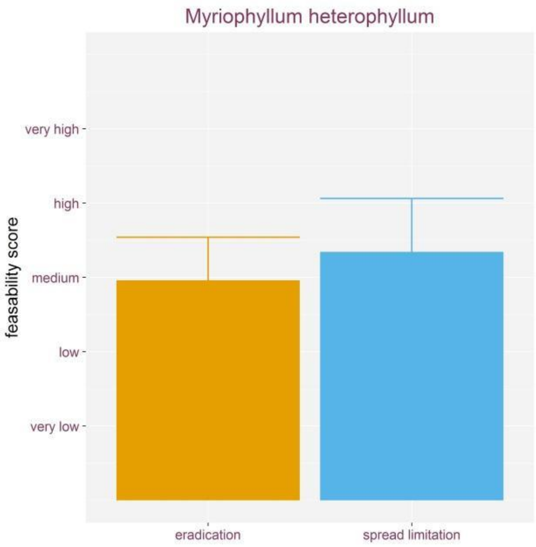
Management strategy – spread limitation

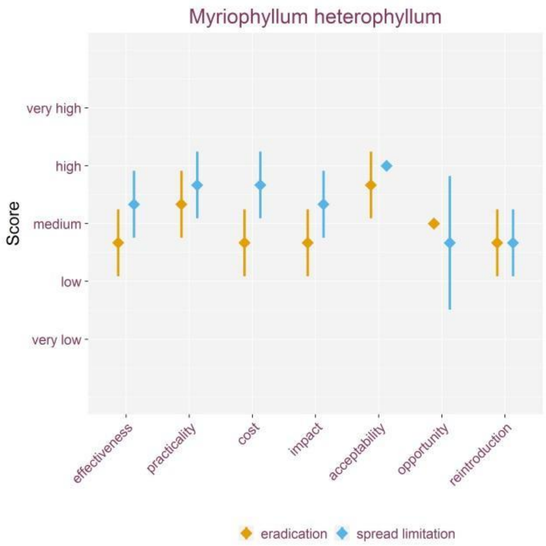
- Aim: Option 2 -*Stand-still principle Containment into core area(s)*
  The spread limitation strategy aims at containing *M. heterophyllum* within its core area in the Antwerp province and rapidly eliminating satellite and new populations discovered outside it.

- Methods and techniques: Populations outside the core area are eradicated using similar techniques as those proposed in the former strategy. Invaded ponds and waterways in the core area are subjected to environmental management techniques like shading, reduction of the water nutrient status and increased competition with native helophytes (EPPO 2014). At last, a biosecurity campaign is organised targeted at users and managers of harbours, rivers and water bodies in risk areas (i.e. checking boats and equipment and removing any plant material before use and moving from invaded to uninvaded areas).

- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of the core area to be able to detect any further spread from it. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility was scored between low and medium for the eradication strategy and between medium and high for the spread limitation strategy. The difference was due to higher scores for effectiveness, cost and impact in the spread limitation strategy compared to the eradication strategy.

Outcome of the workshop

1. General considerations

Workshop participants stressed that this species is very difficult to detect under its submerged vegetative form, which is mostly found in Belgium and can be easily confused with native *Myriophyllum* species. Enhanced training and surveillance is therefore needed to complete distribution data. Molecular techniques like e-DNA may potentially be used to reach that goal.

Additional information concerning plant distribution was provided by participants. The plant was recently found in Wallonia intermixed with *Lagarosiphon* in a deep flooded quarry near Floreffe. In Flanders, it was mostly found as extensive populations thriving in small canals with better water quality and vegetation than sites occupied by *Cabomba* in Limburg; it is present there since more than 10 years with no management undertaken so far.

Experience from the Netherlands shows that hydro-venturi (plant uprooting) is highly effective to control *M. heterophyllum* but . may adversely impact fish populations.

2. Recommendations for management

All workshop participants recommended to implement the **spread limitation strategy** (option 2). The eradication strategy was considered as poorly feasible because of incomplete distribution data and occurence of extensive populations difficult to control.

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3.4 Terrestrial plants

3.4.1 Himalayan balsam *Impatiens glandulifera* (reuzenbalsemien, Balsamine de L'Himalaya)

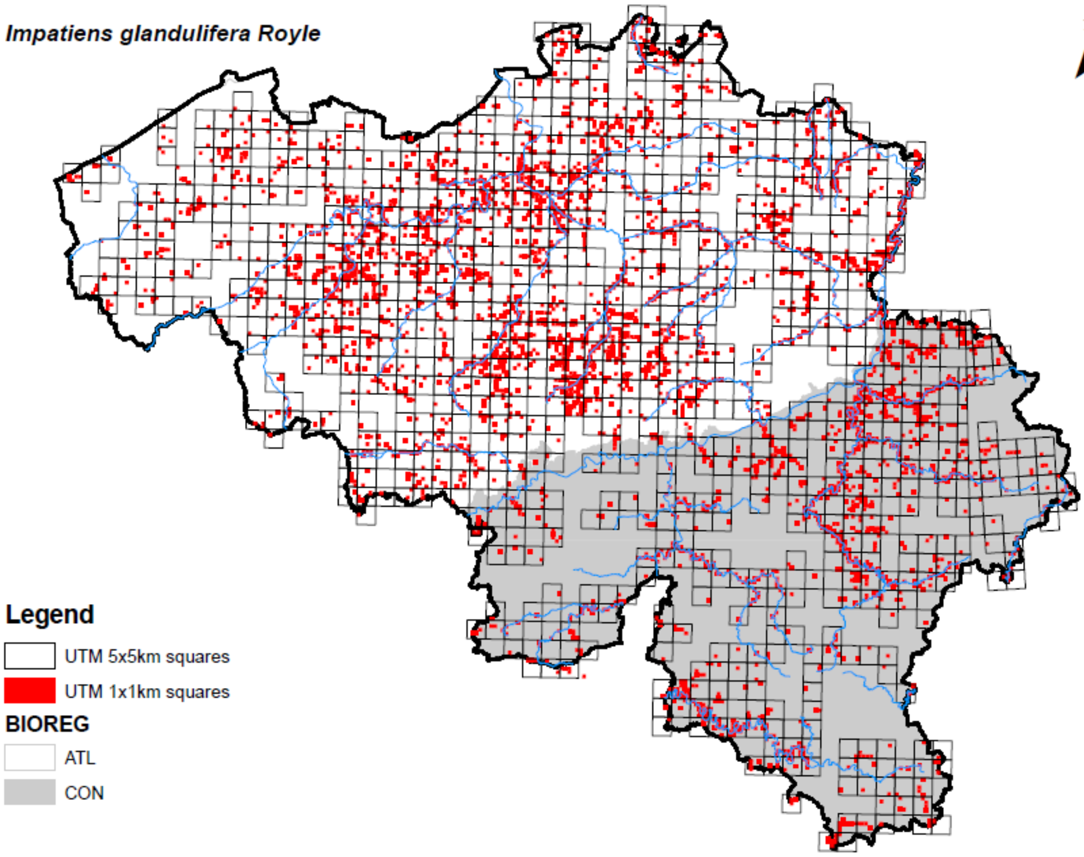
©Wouter Van Landuyt

Invasion scenario

- Invasion situation and history in Belgium: Himalayan balsam is very widespread all over the country and extremely common in riparian areas (Adriaens *et al* 2009, Vandevoorde et al. 2017, Aimont 2014). During the reference period 2000-2015, it was observed in 2488 1x1km squares in the Atlantic bioregion, and 903 squares in the Continental bioregion. Himalayan balsam populations are mostly found in riparian vegetation along rivers (see map). They are also found in wet disturbed sites, wet meadows and along forest edges. The size of *Impatiens glandulifera* colonies may be very impressive and often exceeds 1.000 individuals.

- Reliability of the BE distribution: Species distribution is considered as rather exhaustive due to active monitoring and large size and high detectability during flowering time in summer. However, the plant can be inconspicuous until it flowers late in the season (Tanner 2017).

- Invasion situation in neighbouring countries: Invasion level in all neighbouring countries (Netherlands, Germany, Luxembourg and France) is extremely high.



	ATL	CONT
UTM 10km	201	98
UTM 5km	620	247
UTM 1km	2488	903
% 1km SAC	39 %	91 %
Clustering index	0.79	0.64

1. *Management strategy – eradication*

- Methods and techniques: The Himalayan balsam is a tall annual herbaceous plant that is very prolific and exclusively propagated by seeds. Seeds are disseminated over long distance by water and with sediments. The plant has no persistent seed bank but there are indication that some seeds may persist for 18 months. It is able to rapidly form large populations from a few individuals, which implies that a high management efficiency (destruction > 99% of individuals on a yearly basis) is needed to reach eradication goals (Wadsworth et al 2000). Due to the downstream transportation of seeds, control measures start at the upper reaches of river catchment areas and move on downstream in the whole floodplain. Manual pulling (small colonies) and mechanical mowing (hand-held brush cutter or agricultural machinery for large colonies) are used as eradication techniques, applied locally at the beginning of the flowering and repeated 4 weeks and 8 weeks later in order to destroy as much specimen as possible and avoid seed setting. Shoot cutting is performed as close to the ground as possible to avoid plant regrowth (Delbart et al. 2010;

Tanner 2017). This technique is applied during at least 3 successive years. Where grasslands are invaded, intensive grazing by sheep or cattle is used as a complementary management technique. Due to the strong regeneration ability of the plant, all plant material is removed and stockpiled or composted away from the floodplain. Herbicide application is not part of the eradication strategy because of non-target effects and legal limitations in the Belgian context, especially along watercourses. Similarly, use of biocontrol agents (rust fungus *Puccinia komarovii*) is not part of the strategy because legal limitations and uncertain efficiency (Tanner 2017).

- Post-intervention verification: Regrowth of Himalayan balsam is monitored and controlled at the end of each growing season and during subsequent years by dedicated personnel. Eradication is considered to be achieved when no more growth occurs for at least 2 to 3 years.

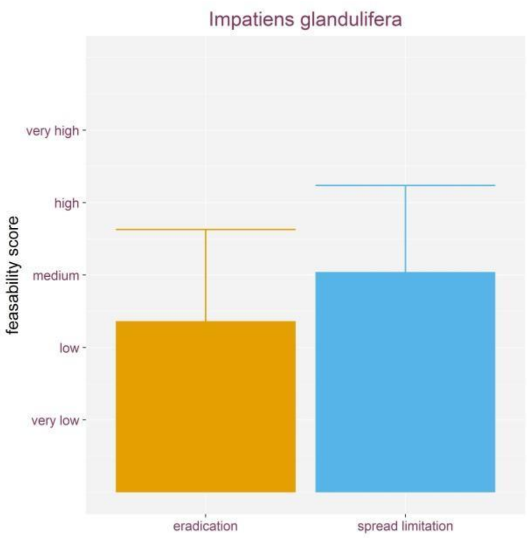
1. *Management strategy – spread limitation*

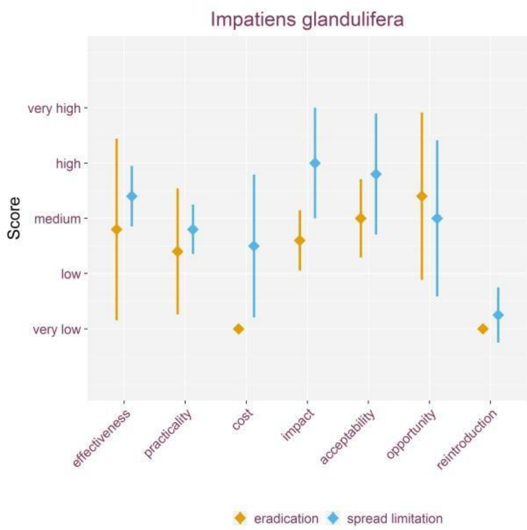
- Aim: Option 4 *Maintenance of pest free areas*
The spread limitation strategy aims at avoiding propagule propagation that would result in further dispersion of the species. Care is taken to avoid that it may reach uninvaded areas, especially upstream zones in river basins. Uninvaded areas are managed as pest free areas. They are subjected to (i) dedicated biosecurity measures, (ii) management actions aiming to increase habitat resistance to invasion, (iii) increased surveillance effort and (iv) rapid eradication actions after new plant detection. Invaded downstream zones nearby pest free areas are managed every two years to reduce seed contamination risk (buffer zones) .

- Methods and techniques: Dedicated biosecurity measures are installed to prevent establishment of new populations following the human-mediated dispersal of plants to pest free areas : transport of seeds through the transfer of sediment material, human activity (incl. fishing clothing) and by vehicles is avoided. Equipment and machinery are cleaned to remove plant fragments and sediments before moving to an uninfected area. Care is taken to reduce as much as possible soil compaction, clear cuttings and disturbance near the riverbanks to reinforce their resistance to invasive plants; grazing or mowing is performed/promoted in grasslands along uninvaded riverbeds to reduce the likelihood of plants moving in. Increased surveillance effort is provided in pest free areas to allow a rapid eradication of new plant colonies, using similar techniques as those proposed in the eradication strategy. Additionally, Himalayan balsam patches found in riparian habitats within a buffer zone of 3 kilometer long lower down the pest free areas are submitted to a dedicated management plan. It consists in destroying plants by manual pulling or mechanical mowing applied once during summer time every two years.

- Post-intervention verification: regrowth of the plant is carefully monitored and controlled after rapid eradication actions at the end of the growing seasons and during subsequent years within pest free areas.

Results





The average feasibility score of eradication is between low and medium; and medium for spread limitation. Strategies differed on average for scores given for cost, impact and acceptability.

Outcome of the workshop

1. General considerations

The group extensively discussed on the option to be proposed for spread limitation strategy. ‘Pest free area’ alone did not seem satisfactory when the species is fully absent from an area, as it likely corresponds to areas not suitable for the species. Participants rather suggested ‘pest free areas of high conservation value’, taking into account historical efforts. A coordination on which protected areas should be made free of *Impatiens* is necessary (which habitats should or should not be included). It is important to determine which upstream contaminated but not protected area should be treated in order to free the protected area downstream. A sustained and assured effort by all managers throughout the area is necessary.

There is a need to rely on expertise gained from years in managing this species locally.

2. Recommendations for management

<u>Spread limitation strategy</u> is consensual among participants. The option recommended is ‘<u>pest free areas of high conservation value’</u>

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3.4.2 Common milkweed *Asclepias syriaca* (zijdeplant, asclépiade de Syrie)

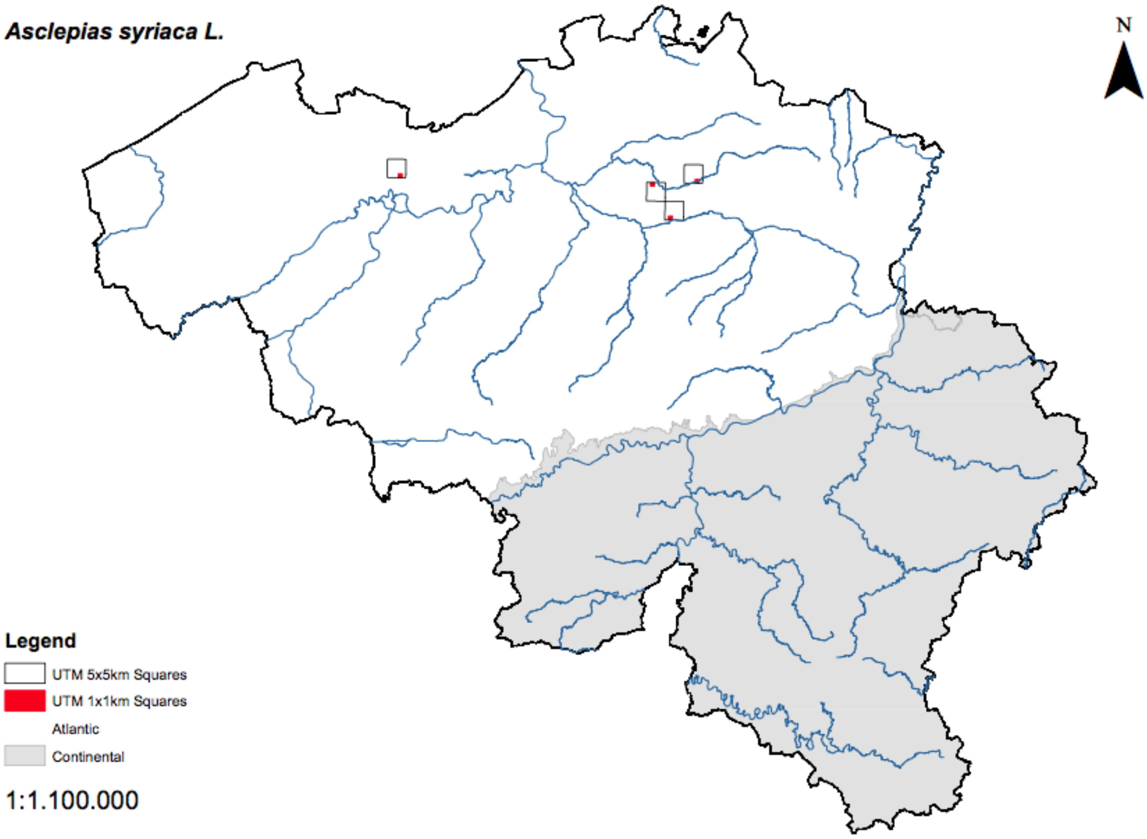
©Stefaan Reynaer (ecopedia)

Invasion scenario

- Invasion situation and history in BE: In Belgium, *Asclepias syriaca* is considered rare and usually ephemeral or temporarily persistent species, mostly an escape from cultivation in private gardens (Verloove, 2017). This species was first seen on a ground heap in Lichtaart in 1987 and could be slightly increasing recently (seen for instance in Begijnendijk, Dessel), possibly becoming naturalized locally (van der Meijden 2005, Verloove 2017). Furthermore recorded against a fence in the port of Antwerp in 1995. Observed several times as an escape on wasteland in Brussel in 2004 (not shown on the map). In the continental bioregion, a well-established population (several tens of plants) has been recorded in a road verge in Wandre (not shown on the map) since 2007, obviously as an escape or throw-out from a nearby garden. Furthermore, recently, a large patch was discovered ($10m^2$, > 100 flowering plants) in Etalle in the Gaume region (not shown on the map).

- Reliability of the BE distribution: Reliable. No confusion with other species in Belgium.

- Invasion situation in neighbouring countries: The species is recorded in Northern France from a few locations near Douais, Laon and Chauny. In Germany, the closest GBIF occurrence is in Aachen. In the Netherland, common milkweed is found in the dunes where it can form dense stands of vegetation. Elsewhere it also occurs on sandy soils, agricultural fields, open forests, along roads and on wasteland (QBank 2017) the closest GBIF occurrence is along the Belgian border at Grevenbicht. An additional observation is found in Maasgouw (waarnemingen.nl).



	ATL	CONT
Utm 10km	3	0
Utm 5km	4	0
Utm 1km	4	0
% 1km SAC	0 %	-
Clustering index	3.56	-

1. *Management strategy – eradication*

- Methods and techniques: *A. syriaca* is a perennial herb species showing long-spreading rhizomes (CABI 2010). Shoots are produced from adventitious root buds in April-May. Horizontal and vertical roots may reach 3,8 m. The species is wind pollinated and can produce large numbers of seeds which facilitates dispersal over a long distance (White, 1996). The eradication strategy for this species is glyphosate application to all plants recorded. Glyphosate is applied in June to act on early bud stage (Bhowmik PC, 1982). A derogation on the prohibition of use of herbicides in areas of public service or along watercourses is requested when necessary with competent authorities.

Other types of chemical methods are not part of the strategy as they have not proven to be effective on the root system of the plants (NAPPO, 2003). Removal of stalks by cutting is known to stimulates sprouting from adventitious underground buds from rootstock. Physical removal of specimen including their underground system is unlikely to provide good results because it is difficult to completely remove the rootstock (Lapin 2017). Roots fragments resulting from management actions generates new individuals (CABI 2010). As a result, these actions are not considered relevant here.

- Post-intervention verification: The patch area and its surroundings are monitored and any regrowth or seedlings are eradicated.
  As the species is cultivated in private gardens, dedicated communication actions are done close to the escape locations in order to convince private owners to eradicate the species in their garden.

1. *Management strategy – spread limitation*

- Aim: *Option 1 - Stand-still principle with a single or a few patches.*

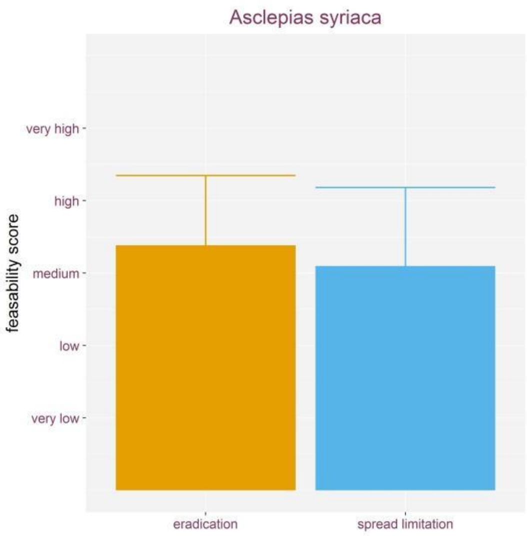
  The spread limitation strategy aims at limiting the presence of this species in Belgium to the few records already documented.

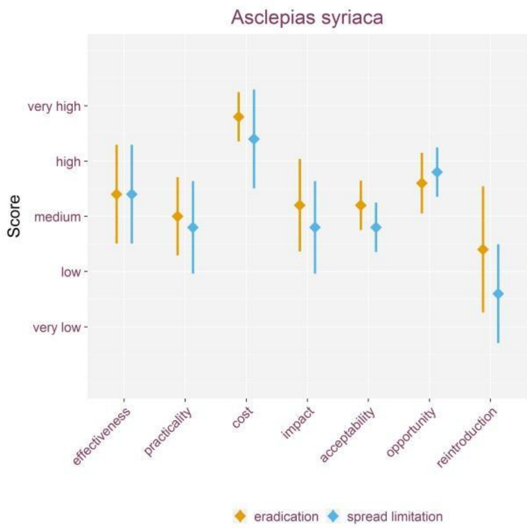
- Methods and techniques : The surroundings of the patches are regularly and continuously monitored in the long term in order to react as quickly as possible if the small populations start expanding. In case this happens, the strategy is to eradicate the new plants using glyphosate application.

  As the species is cultivated in private gardens, dedicated communication actions are done close to the escape locations in order to convince private owners to eradicate the species in their garden to avoid further spread of the species in the environment.

- Post-intervention verification: These newly eradicated individuals and their surroundings are monitored and any new seedlings are eradicated.

Results





The average feasibility score is between medium and high for eradication and medium for spread limitation. In both strategies, the average score for effectiveness was between medium and high. The cost was scored between high and very high on average. Reintroduction was scored between low and medium for the eradication strategy and between very low and low for the spread limitation strategy.

Outcome of the workshop

1. General considerations

The participants confirmed the existence of four populations in Flanders and one problematic population in Wallonia. Among those, the population currently present in Gent requires eradication. The risk associated with dispersal increase due to management is a concern for managers. Participants questioned the use of herbicides (glyphosate in particular) in urban environments and riparian habitats. In these habitats, mechanical treatments such as hoeing or hand-pulling can reduce the risk of further dispersal. Participants also questioned the reliability of distribution data and possible underestimation of current distribution considering the species is still poorly known and recognized.

2. Recommendations for management

A consensus was reached among workshop participants for the eradication strategy. Attention must be paid to use of herbicides in urban areas and riparian habitats. This species must be focussed by surveillance and efficient prevention.

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3.4.3 Eastern baccharis *Baccharis halimifolia* (struikaster, séneçon en arbre)

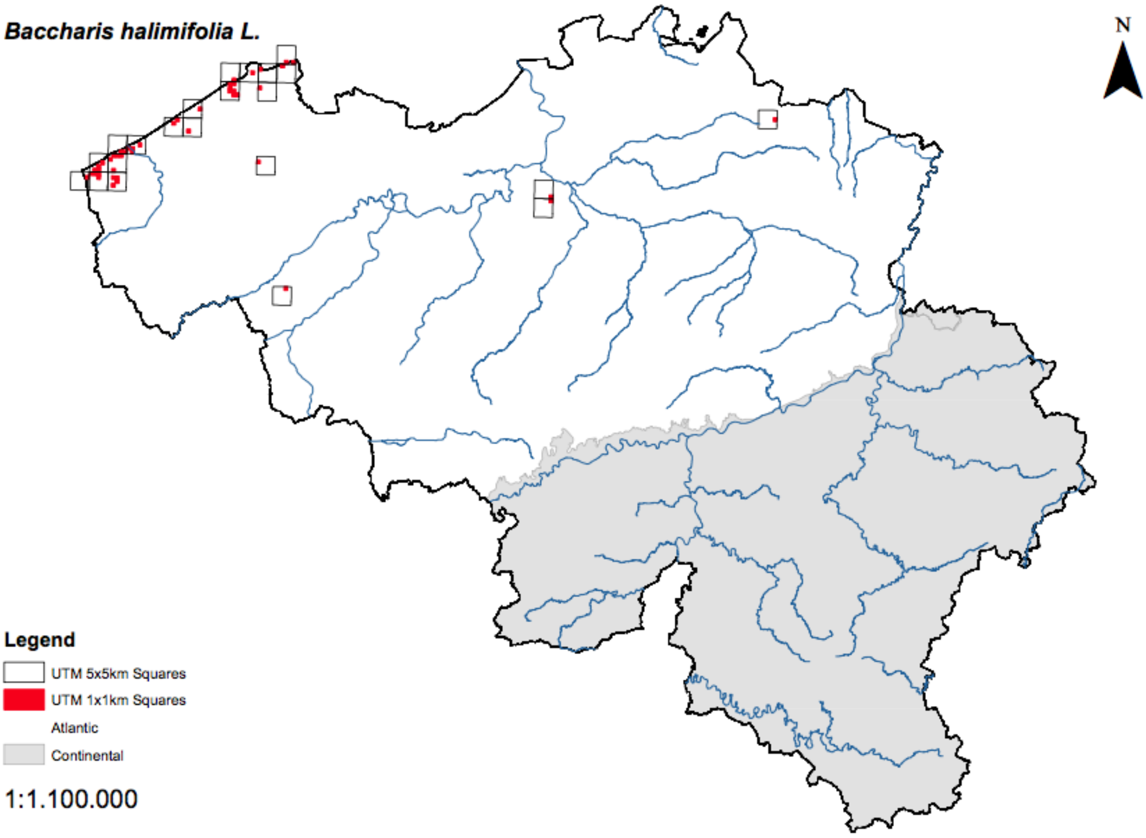
©Eric Wirtz

Invasion scenario

- Invasion situation and history in Belgium: The species benefited from urban sprawl along the Belgian coast and the demand for plants adapted to the coastal climate for plantations in public greenery, along roads and tramways (e.g. in De Panne), on roundabouts and in private gardens. Eastern baccharis has spread throughout the entire coastline since 1997 (Rappé, 2006; Rappé et al., 2004). Currently, based on field surveys in 46 nature reserves (Provoost et al. 2012, 2015), it occurs in 11 % of Belgian dune areas and the infected area in total is <100 m2 (unpublished data). It is mostly found in (sub)urban environments and fringes of nature areas, where it grows in grassland or open scrub. *Baccharis halimifolia* shows a particular preference for salty environments such as the banks and upper salt marsh of the Yzer estuary in Nieuwpoort or the green beach in the 'Bay of Heist' on the east coast (mostly publicly managed reserves but also many smaller stands on private property) (Provoost & Adriaens, 2011). Potential habitat is present as Atlantic salt meadows (Zwin, Uitkerkse polder, Scheldt estuary), an annex I habitat. The species starts growing as individual shrubs but can form an extended dense scrub. Outside coastal areas, there are some isolated *Baccharis* bushes that mostly represent planted shrubs, garden escapes and road planting (the plants withstand salt spray). It is only rarely found in agricultural areas. For some of those locations it is unclear whether the plants produce seedlings. The species is absent in the wild in the continental region, but planted *Baccharis* stands also exist in the continental region in parks and gardens. *Baccharis halimifolia* is currently already being managed in some nature reserves e.g. it is considered eradicated from the Bay of Heist and Uitkerke.

- Reliability of the BE distribution: The plant is unmistakable by the form of its leaves. Along the coast, the species is included in the floristic monitoring schemes, so the distribution is believed to be representative.

- Invasion situation in neighbouring countries: in the Netherlands individual plants are found only in a few locations (Zeeland province), but the species has no established populations. In the past it disappeared spontaneously in some places (van Valkenburg et al. 2014) and some plants have been actively removed by NVWA (NVWA 2016). In France, it is widely distributed along the entire Atlantic and Provence coast (Fried et al. 2016). Along the Atlantic coast, it reaches the Belgian border and occurs in nature reserves in Nord-Pas-De-Calais such as in Wimereux and Ambleteuse. Not in Luxemburg (neobiota.lu).



	ATL	CONT
Utm 10km	13	0
Utm 5km	22	0
Utm 1km	47	0
% 1km SAC	70 %	-
Clustering index	0.52	-

1. *Management strategy – eradication*

- Methods and techniques: The strategy is to remove all patches of *Baccharis* in the coastal zone and isolated patches in the Scheldt estuary, including the ones planted in cultivated areas such as along roadsides, in public greenery and in gardens etc. *Baccharis halimifolia* produces masses of small seeds which are easily dispersed by wind and water over long distances. It has a long lived seed bank expected to persist for a minimum of 2 years. Young plants are year-round manually removed by hand pulling of the entire plant including the roots. This is best done when the soil is moist, which facilitates total removal of the plant. Old shrubs (>1m) have to be removed before flowering to prevent the spread of pollen. Bigger shrubs, for which manual removal is impossible, can be removed mechanically using an excavator to pull out entire plants from the soil. They can also be cut with scissors after which glyphosate is applied on the stumps (glyphosate 36% diluted in oil in a proportion of 1:1) (Ihobe 2014). A derogation on the prohibition of use of herbicides in areas of public service or along watercourses is requested when necessary with competent authorities. All management interventions are performed before flowering to prevent the spread of pollen. As the species is still casual in the wild in the Netherlands eradication is preferably performed northeast to southwest along the Belgian coast. In combating this species, it is extremely important to control the contamination of adjacent areas given the simple distribution of the species via water and wind. In addition, it is crucial to thoroughly clean machines and materials to prevent further spread. If possible, the management waste is best treated by controlled burning to prevent regrowth. If this is not possible, dead plants can be stacked on a heap, taking into account that root material does not touch the bottom and inflorescences are placed at the bottom of the heap. Continued aftercare is necessary in light of the strong regrowth via root runners and seedlings (Miller & Skaradek, 2002).

Mowing or cutting *Baccharis* stands before bloom targets only aboveground plant material and does not ensure permanent removal. The same is true for management consisting of cutting inflorescences. These methods are therefore not part of the strategy.

- Post-intervention verification: Manual aftercare is needed on treated sites during at least 3 years to remove regrowth because eastern Baccharis has a high resprouting ability following mechanical damage (Fried et al., 2016; Weber, 2003) and the seed bank is expected to persist for a minimum of 2 years.

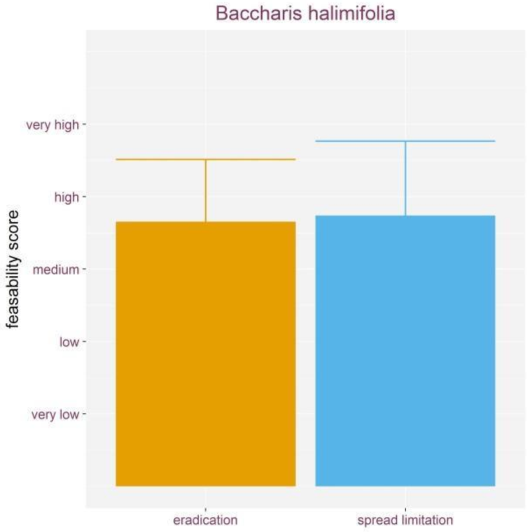
1. Management strategy – spread limitation

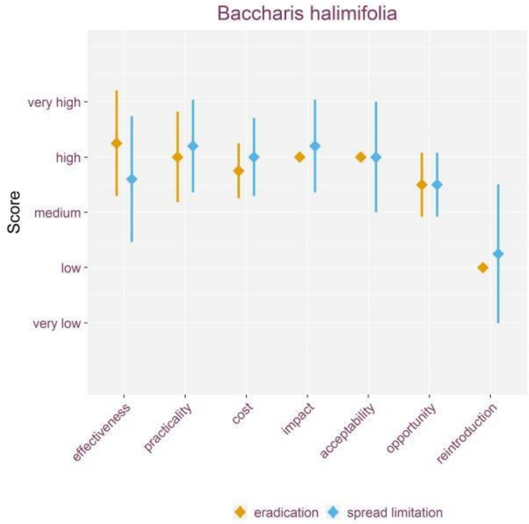
- Aim: *Option 2 Stand-still principle with core area(s)*
  The spread limitation strategy aims at containing *Baccharis* within its core area along the Belgian coast (dunes & polder area) and avoid any further spread elsewhere, through the limitation of propagule production and rapid eradication of any new patch discovered outside the core area. In case this proves feasible, the core area can be reduced by eradicating some satellite populations.

- Methods and techniques: Any new population that pops up outside the core area is destroyed using the techniques described in the eradication strategy (manual/mechanical removal with aftercare). Additionally, existing populations along the coast and in the polder area are managed to prevent flowering and seed production. Here, *Baccharis halimifolia* is subjected to repeated (2 times/year) mowing to prevent the species from setting seed and producing fruits (Fried et al. 2016). Patches of *Baccharis* planted along the coast along roadsides, in public greenery are equally managed. In private gardens, garden owners are stimulated to install mowing regime to prevent flowering or to remove their plants.

- Post-intervention verification: On treated sites outside the core area where eradication was applied, manual aftercare is needed during at least 3 years to remove regrowth because eastern Baccharis has a high resprouting ability following mechanical damage (Fried et al., 2016; Weber, 2003).

Results





The average feasibility score of eradication and spread limitation scenarios is between medium and high. Both strategies showed high scores for the different criteria, except for likelihood of reintroduction which scored low

Outcome of the workshop

1. General considerations

The species is mainly problematic in Flanders. The group raised the potential under detection of the species in Wallonia and in Flanders far from the seaside. The species may therefore require surveillance in sandy habitats.
Participants encourage actions in gardens to ensure low propagule pressure in nearby natural habitats, in particular flower cutting before seed production

2. Recommendations for management
A consensus was reached among workshop participants for the the eradication strategy. Legal basis for access to property is a requirement for ensuring eradication efficiency.

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3.4.4 Giant rhubarb *Gunnera tinctoria* (reuzenrabarber, rhubarbe géante du Chili)

©Stan Shebs (Wikimedia commons)

Invasion scenario

- Invasion situation and history in BE: Not currently established in the wild in Belgium.
  The invasion scenario is that at the point of detection there are three patches of plants reported in a wet meadow along the river Yser (Atlantic bioregion). The situation is the result of an escape from a nearby garden that dispersed downstream resulting in 3 patches of 5 to 10 square meters each. At the time of detection the plant patches were estimated to be 2-3 years old and started to form flower spikes.

- Reliability of the BE distribution : *Gunnera tinctoria* may easily be confused with *G. manicata* Linden ex André, a closely related species in the subgenus *Panke* from Brazil that is also widely cultivated. This is also a large leaved species (CABI, 2008). Overall, detectability of both species is good so established populations would probably not remain undetected for a long time except maybe on private property.

- Invasion situation in neighbouring countries : In France, the species is known from a few locations in Basse Normandie and Bretagne on coastal cliffs, waterways, roadsides, wet meadows.

1. Management strategy – eradication

- Methods and techniques :
  The eradication strategy of the three patches includes manual/mechanical methods (Williams, 2005; CABI, 2008). Removal and destruction of all flower heads is done as soon as possible before seed production. Then, plants and their rhizome system are removed using manual or mechanical cutting. Particular attention is paid to remove the entire rhizome because small pieces of live rhizome can re-sprout. As the species is cultivated in private gardens, dedicated communication actions are done close to the escape locations in order to convince private owners to eradicate the species in their garden.
  Herbicide (e.g. glyphosate) application is not part of the strategy because of legal restrictions on the use along watercourses.

- Post-intervention verification
  The patch and its surroundings are monitored and any regrowth or seedlings are eradicated. Follow-up monitoring of the eradication site and the surroundings is undertaken during the next 10 years after eradication as *G. tinctoria* forms a large and persistent seed bank (Gioria & Osborne's 2009).

1. Management strategy – spread limitation

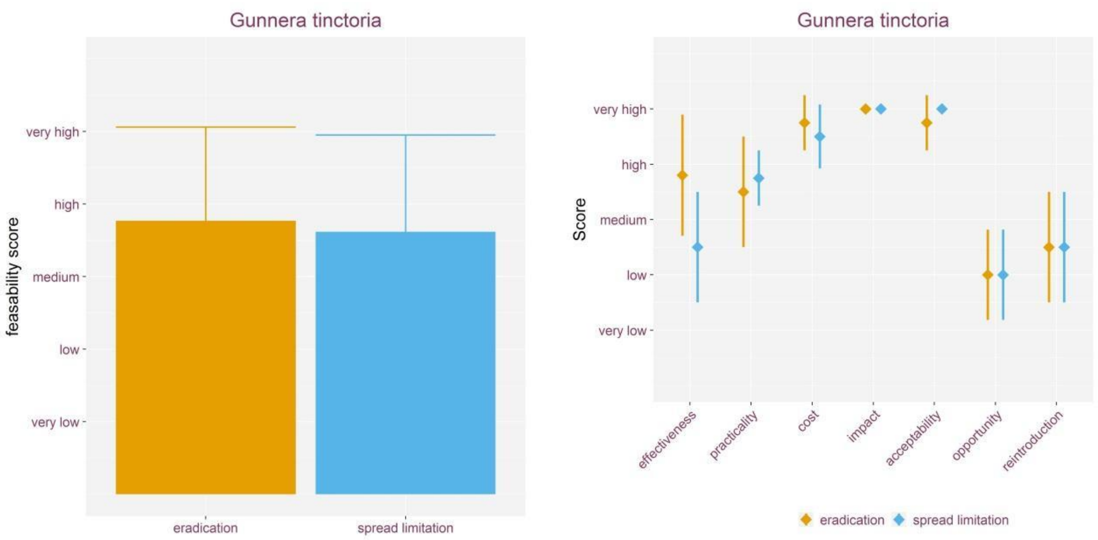
- Aim: *Option 1 - Stand-still principle with a few patches.*

  The spread limitation strategy aims at limiting the presence of *G. tinctoria* in Belgium to this few patches, avoiding the production of seeds that might result in further dispersion along the highway.

- Methods and techniques : Removal and destruction of all flower heads is done as soon as possible before seeds are produced. As the species is cultivated in private gardens, dedicated communication actions are done close to the escape locations in order to convince private owners to destroy flower heads or eradicate the species from their garden.

- Post-intervention verification: The surroundings are regularly monitored. In case new individuals are found, the methods used are the same as for the eradication strategy. Follow-up monitoring during at least ten years must be undertaken as *G. tinctoria* forms a large and persistent seed bank (Gioria & Osborne's 2009).

Results



The average feasibility score of eradication and spread limitation strategies is between medium and high. In both strategies, the average scores range from high to very high for cost, impact and acceptability; and between medium and high for practicality. Effectiveness scores between medium and high for the eradication strategy and between medium and low for the spread limitation strategy. For both strategies, opportunity scored low and likelihood of reintroduction scores between low and medium.

Outcome of the workshop

1. General considerations

This species is a good example of species for which the legal basis for management must probably be enlarged to ensure access to private property, including private gardens. Potentially support to eradication in gardens. Participants wondered what to do with species present in gardens but not yet in natural habitats ? No consensus was reached about the urgency to act in gardens. Participants questioned the possibility of anticipating budget required for management for species still absent from the territory and raised the importance of surveillance for species not yet present in Belgium and asked for increased recognition capacity of field workers.

2. Recommendations for management

A consensus was reached among workshop participants for the the eradication strategy as as a guiding principle of the EU reg for species not yet present in BE.

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3.4.5 Giant hogweed *Heracleum mantegazzianum* (reuzenberenklauw, berce du Caucase)

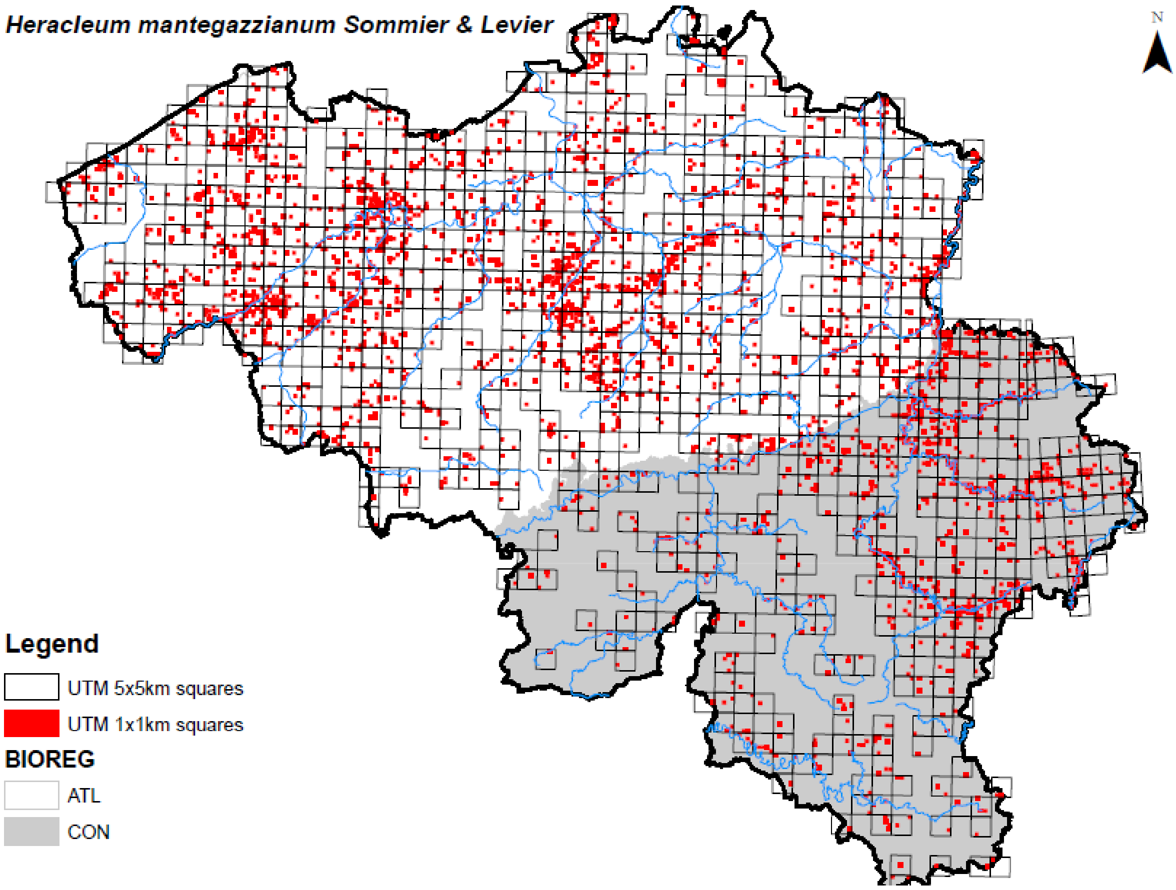
©Dave Vanhee

Invasion scenario

- Invasion situation and history in Belgium: Giant hogweed has been planted in Belgium for horticulture and apiculture since the end of WWII. Today, it is widely spread all over Belgium, both in Atlantic and Continental bioregions, with large number of patches found in some river basins such as the Leie, Brugse Polders, Boven-Schelde, Dijle, Meuse, Amblève, Leie, Ourthe, Vesdre and Zenne. During the reference period 2000-2015, it was observed in 1965 1km squares in the Atlantic bioregion, and 535 squares in the Continental bioregion. Giant hogweed populations are mostly found along rivers, roads and railways, where a clumped distribution is often observed. Frequent detection on earth embankments indicate that movements of soils contaminated with seeds are involved in plant spread. Most populations are small-sized and include less than 100 individuals. Due to plant control by land managers and landowners, population density/number is decreasing with time in some locations, e.g. in Wallonia (giant Hogweed regional action plan) (Branquart et al. 2011). In Flanders, there is no coordinated control at regional level, but systematic removal is applied by most public authorities (municipalities, cities, water managers). In West-Flanders, an eradication programme is coordinated at provincial level and involves the rat catchers for surveillance. Private owners can receive a letter from the governor with a request for cooperation

- Reliability of the BE distribution: Active monitoring and high plant detectability prior to reproduction (EPPO 2009b; Pergl 2017) result in good knowledge of the species distribution. However, the distribution map presented here and based on cumulative data is overestimated considering active management actions performed in the Belgian territory for the last few years

- Invasion situation in neighbouring countries: Invasion level in neighbouring countries is high, especially in Germany where the species is long established (Thiele & Otte 2008). Plant density is also high in Nord-Pas-de-Calais and in the south of the Netherlands (Siflore and Waarneming.nl databases). Frequency is however lower in Luxembourg, where giant hogweed is subjected to a management plan since 2009 (Krippel & Richarz 2013).



	ATL	CONT
UTM 10km	207	88
UTM 5km	597	190
UTM 1km	1965	535
% 1km SAC	26 %	76 %
Clustering index	0.77	0.68

1. *Management strategy – eradication*

- Methods and techniques: giant hogweed is a monocarpic plant species producing flowers and seeds only once at the end of its life cycle, i.e. in the third year of growth under favourable ecological conditions. A large seed bank can build up in the soil, remaining viable for at least five years (EPPO 2009a). Therefore, the eradication strategy consists in preventing the adult plants from flowering and to prevent seed setting for a period long enough (7 years) to be sure any remaining seeds are not viable. Root cutting of flowering plants and application of systemic herbicides in May-June (before seed production) are used as eradication techniques for giant hogweed, applied locally once or twice a year during at least 5-7 consecutive years in order to fully exhaust the soil seed bank. Root cutting of flowering plants at least 10 cm below the soil is favoured as much as possible except where its efficiency is reduced, e.g. on stony and shallow soils. Herbicide application early in the season (for which an exemption on the use of herbicides can be

acquired) or soil ploughing/milling is favoured to eradicate large populations (> 1,000 plants), for which root cutting is considered too labour-intensive (Nielsen et al 2005). Equipment and machinery are cleaned before moving to an uninfected area to prevent the movement of seed contaminated soil. Removed plants can be stockpiled directly on site after cutting the stems in 3-4 fragments and destroying or exporting inflorescences to avoid seed production.
A derogation on the prohibition of use of herbicides in areas of public service or along watercourses is requested when necessary with competent authorities.
Whole plants can be also exported towards industrial composting sites. Biocontrol, mowing, grazing and umbel removal are <u>not</u> part of the eradication strategy because those techniques are considered poorly effective to kill the plants and may lead to secondary growth and seed production (Pergl 2017).

- <u>Post-intervention verification</u>: Regrowth of hogweed is monitored and controlled at the end of each growing season and during subsequent years to avoid any new seed set. Eradication is considered to be achieved when there are no signs of plant growth. Since the seeds can survive for some years in the soil, follow-up monitoring is undertaken for at least 7 years, corresponding to field observations for not finding viable seeds in fields.

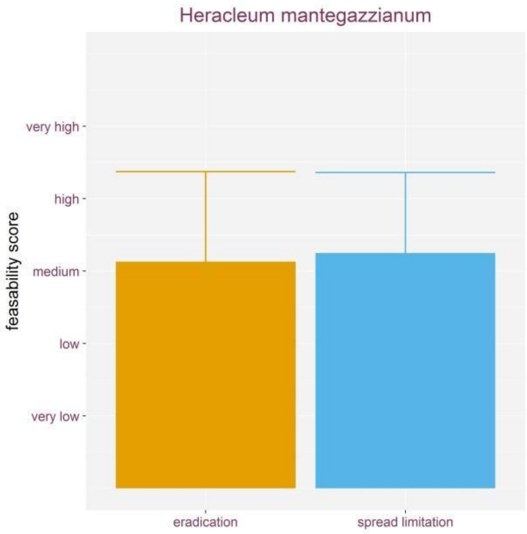
1. Management strategy – spread limitation

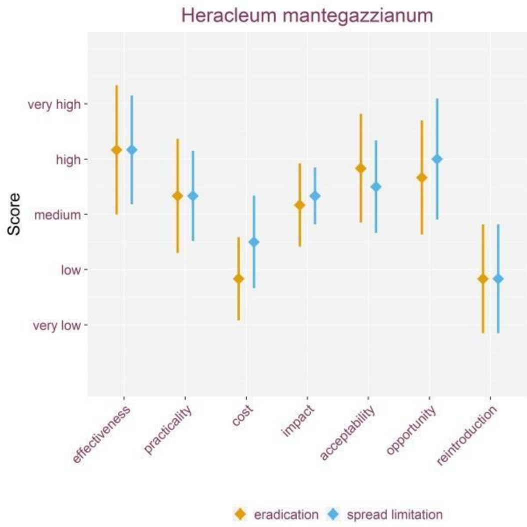
- <u>Aim</u>: *Option 3 - Progressive elimination of the most dispersive populations*
  The spread limitation strategy aims at eradicating dispersive populations growing along water courses, roads and railways that may easily expand towards remote areas and at limiting seed production by the plant elsewhere. When growing far from transport lines, dispersal is considered limited as 90% of fruits fall within a radius of a few meters from the mother plant (Nielsen et al 2005).

- <u>Methods and techniques</u>: Techniques similar to those used in the eradication strategy are applied to the most dispersive populations. Seed production by isolated and less dispersive colonies is reduced by cutting only flowering plants at mid-flowering stage (in this case, the production of new flowers will be reduced thanks to competition with remaining vegetative plants) (Nielsen et al. 2005).

- <u>Post-intervention verification</u>: Regrowth of hogweed along transport lines is monitored and controlled at the end of each growing season as described in the eradication strategy.

Results





The average feasibility score of eradication and spread limitation strategies is between medium and high. In both strategies, the average scores of effectiveness was high; between medium and high for practicality, impact, acceptability and opportunity. Cost was scores between low and medium and the likely of reintroduction was scores low as well.

Outcome of the workshop

1. General considerations

The Walloon 'Plan Berce' was described in details to group participants. Technically, 5 to 7 years of action as stated in the scenario appeared to be rather short based on participants experience: 7 years is rather a minimum as the number of plants is decreased but it does not allow for total population eradication. Root cutting of flowering plants 10 cm below the soil ('Coupe sous le collet') is not enough either. This should ideally be done around 15-20 cm. This technique is also applicable for large populations, no use of herbicides is necessary. Based on the experience from Wallonia, some participants feel eradication seems feasible at the Belgian scale. Other participants suggested 'Impact mitigation' rather than spread limitation should be considered as an alternative strategy.

As no consensus was achieved for common recommendations, a vote was held with the following results :

- Eradication : 8/14
- Impact mitigation : 2/14
- Abstention : 4/14

2. Recommendations for management

The majority of participants recommended the eradication strategy. Impact mitigation was seen as an alternative strategy tob e considered by some other participants.

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3.4.6 Persian hogweed *Heracleum persicum* (Perzische berenklauw, Berce de Perse)

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Invasion scenario

- Invasion situation and history in Belgium: Not currently established in the wild in Belgium. The invasion scenario is that at the point of detection one patch of plants (about 30 square meters) is reported on the roadside of a highway under renovation near Liège. This unintentional introduction is the result of seeds being transported in soil imported for road works.
- Reliability of the BE distribution : *Heracleum mantegazzianum* and *H. sosnowskyi,* are morphologically (Nielsen et al., 2005; EPPO, 2009; Fröberg, 2010) and genetically (Jahodová et al., 2007; Maras, 2008) close to *H. persicum*. As a result there is a risk of misidentification and underestimation in BE.
- Invasion situation in neighbouring countries : The species seems absent from neighbouring countries

1. *Management strategy – eradication*

- Methods and techniques: Unlike other giant hogweeds, *H. persicum* is polycarpic perennial and can reproduce vegetatively when sexual reproduction fails. Thus, *H. persicum* may demand a longer period for eradication as the plant lives longer than other invasive Heracleum and may be more resistant as it is able to store more nutrient reserves in the root system (Fremstad & Elven, 2006). However, mechanical or physical methods that efficiently uproot the plant should help control species. The eradication strategy of this patch therefore includes manual and mechanical methods, as suggested by Nielsen et al. (2005). Root cutting of flowering plants in early spring before seed production are used as eradication techniques, applied locally twice a year during at least 10 consecutive years in order to fully exhaust the soil seed bank. Root cutting of at least 10 cm below the soil layer is favoured as much as possible except where its efficiency is reduced, e.g. on stony and shallow soils. Equipment and machinery are cleaned to remove soil before moving to uninfected area. Plants are adequately disposed of to avoid seed production and burns to managers and the general public. They can be stockpiled directly on site after cutting the stems in 3-4 fragments and destroying or exporting inflorescences to avoid seed production. Whole plants can be also exported towards industrial composting sites.

  Biocontrol, mowing, grazing and umbel removal are not part of the eradication strategy because those techniques leave the root system intact and are therefore considered poorly effective to kill the plants. Also, they may lead to secondary growth and seed production (CABI, 2015). Herbicides) are not part of the strategy since the patch is relatively small.

- Post-intervention verification: The patch area and its surroundings are being monitored and any regrowth or seedlings are eradicated. Follow-up monitoring of the eradication site for at least five years is undertaken (Nielsen et al., 2005).

Regrowth of *H. persicum* is monitored and controlled at the end of each growing season and during subsequent years to avoid any new seed set. Since the seeds can survive for some years in the soil, follow-up monitoring is undertaken for at least 7 years, corresponding to field observations for not finding viable seeds in fields.

1. *Management strategy – spread limitation*

- Aim: *Option 1 - Stand-still principle with a single or a few patches.*

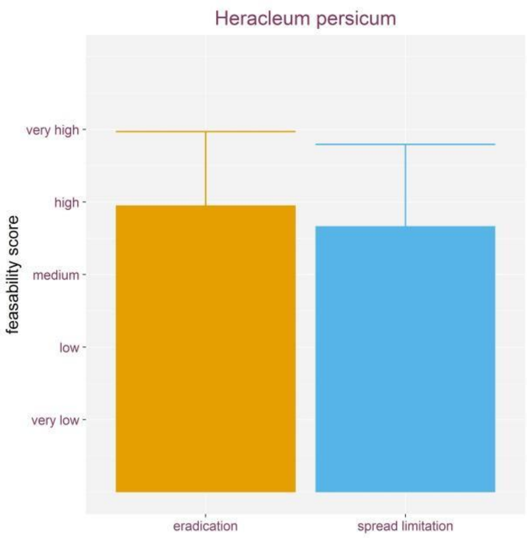
  The spread limitation strategy aims at limiting the presence of *H. persicum* in Belgium to this single patch, avoid the production of seeds that might result in further dispersion along the highway.

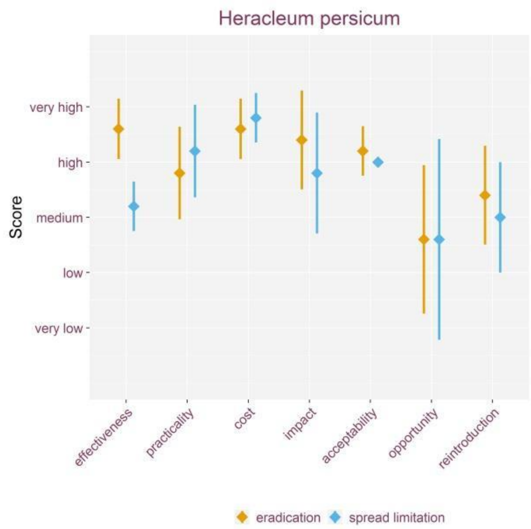
- Methods and techniques :

  As *H. persicum* is known for primary, secondary and tertiary umbels, inflorescence removal before seeds are produced is required several times during the growing season. Management waste are exported and destroyed or burnt on site.

- Post-intervention verification: The surroundings are regularly monitored. In case new individuals are found, the methods used are the same as for the eradication strategy : mechanical removal and uprooting of the entire plants and root system (Nielsen et al. 2005). Follow-up monitoring during at least five years must be undertaken (Nielsen et al., 2005).

Results





The average feasibility score of spread limitation strategies is between medium and high, and high for eradication. Effectiveness was scored between high and very high for the eradication strategy and between medium and high for spread limitation. In both strategies, the average scores for opportunity was between low and medium and between medium and high for the likelihood of reintroduction. Practicality, cost, impact and acceptability were scored between high and very high. Effectiveness scored between hihg and very high for eradication, but between medium and high for spread limitation.

Outcome of the workshop

1. General considerations
   No general consideration was made during the workshop

2. Recommendations for management
   A consensus was reached among workshop participants for the the eradication strategy as as a guiding principle of the EU reg for species not yet present in BE.

References

CABI - Invasive Species Compendium (2015) Datasheet : *Heracleum persicum*. Downloaded from http://www.cabi.org/isc/datasheet/120209 on 27-07-2017.

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3.4.7 Sosnowsky's hogweed *Heracleum sosnowskyi* (Sosnowsky's berenklauw ; Berce de Sosnowski)

©Аимаина хикари (Wikimedia commons)

Invasion scenario

- Invasion situation and history in BE: Not currently established in the wild in Belgium. Therefore, the invasion scenario is that at the point of detection one patch of plants about 30 square meters is reported on the roadside of an agriculture field around Turnout. This introductions is thought to be the result of seeds being accidentally transported by trucks coming from Poland.

- Reliability of the BE distribution : *Heracleum mantegazzianum* and *H. persicum* are morphologically (Nielsen et al., 2005; EPPO, 2009; Fröberg, 2010) and genetically (Jahodová et al., 2007; Maras, 2008) close to *H. sosnowskyi*. As a result there is a risk of misidentification and consequent underestimation in BE.

- Invasion situation in neighbouring countries : The species seems absent from neighbouring countries

1. Management strategy – eradication

- Methods and techniques: The eradication strategy of this patch therefore includes manual and mechanical methods, as suggested by Nielsen et al. (2005). Root cutting of flowering plants in early spring before seed production are used as eradication techniques, applied locally once or twice a year during at least 5-7 consecutive years in order to fully exhaust the soil seed bank. Root cutting of at least 10 cm below the soil layer is favoured as much as possible except where its efficiency is reduced, e.g. on stony and shallow soils. Equipment and machinery are cleaned to remove soil before moving to uninfected area. Plants are adequately disposed of to avoid seed production and burns to managers and the general public. They can be stockpiled directly on site after cutting the stems in 3-4 fragments and destroying or exporting inflorescences to avoid seed production. Whole plants can be also exported towards industrial composting sites.
  Biocontrol, mowing, grazing and umbel removal are not part of the eradication strategy because those techniques leave the root system intact and are therefore considered poorly effective to kill the plants. Also, they may lead to secondary growth and seed production (CABI, 2017). Herbicides) are not part of the strategy since the patch is relatively small.

- Post-intervention verification: The patch area and its surroundings areis being monitored and any regrowth or seedlings are eradicated. Follow-up monitoring of the eradication site for at least five years is undertaken (Nielsen et al., 2005). Regrowth of *H. sosnowskyi* is monitored and controlled at the end of each growing season and during subsequent years to avoid any new seed set. Since the seeds can survive for some years in the soil, follow-up monitoring is undertaken for at least 7 years, corresponding to field observations for not finding viable seeds in fields.

1. *Management strategy – spread limitation*

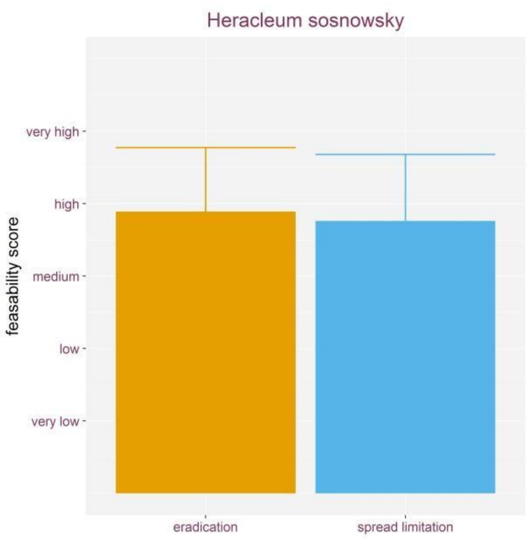
- Aim: *Option 1 - Stand-still principle with a single or a few patches.*

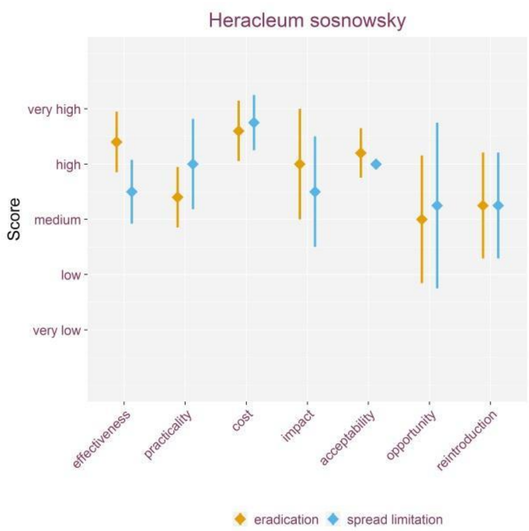
  The spread limitation strategy aims at limiting the presence of *H. sosnowskyi* in Belgium to this single patch, avoid the production of seeds that might result in further dispersion.

- Methods and techniques : Inflorescence removal in early June before seeds are produced is required. This is done a second time later during the growing season in case secondary umbels are produced. Management waste are exported and destroyed or burnt on site.

- Post-intervention verification: The surroundings are regularly monitored. In case new individuals are found, the methods used are the same as for the eradication strategy : mechanical removal and uprooting of the entire plants and root system (Nielsen et al. 2005). Follow-up monitoring during at least five years must be undertaken (Nielsen et al., 2005).

Results





The average feasibility score of eradication and spread limitation strategies is between medium and high. Effectiveness was scored between high and very high for the eradication strategy and between medium and high for the spread limitation strategy. In both strategies, the average scores for practicality, impact and opportunity was between medium and high; and between high and very high for cost. Opportunity and likelihood of introduction were scored between medium and high for both strategies.

Outcome of the workshop

1. General considerations

No general consideration was made during the workshop

2. Recommendations for management

A consensus was reached among workshop participants for the the eradication strategy as as a guiding principle of the EU reg for species not yet present in BE.

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3.4.8 American skunk cabbage *Lysichiton americanus* (moerasaronskelk, Faux arum)

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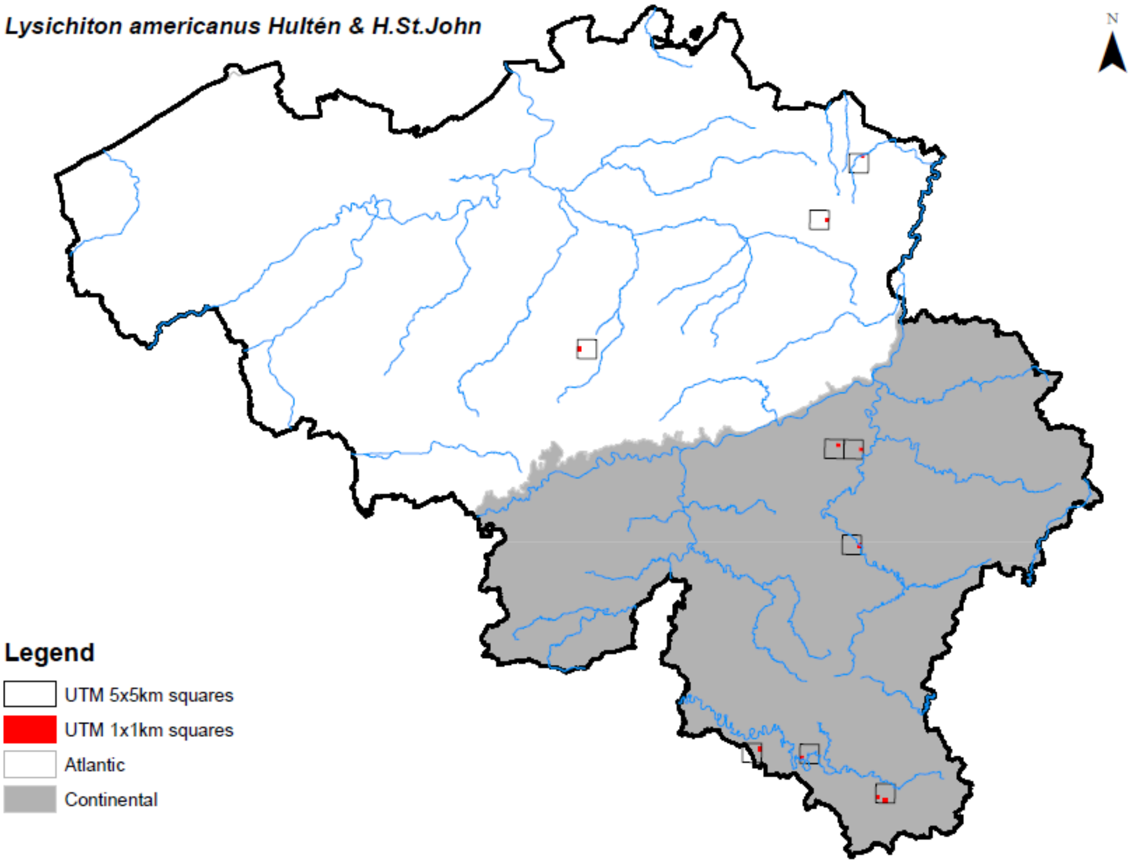
Invasion scenario

- Invasion situation and history in Belgium: *Lysichiton americanus* is an ornamental plant that has been introduced in a few localities near garden ponds, from which population establishment and spread may occur. It can live up to 75 years and reproduces almost exclusively by seeds from 3 years old onwards; a large seed bank can build up in the soil, remaining viable for at least eight years (EPPO 2009). American skunk cabbage grows in the transition zone between terrestrial and aquatic habitats like wellspring areas, swamps, fens, wet meadows and alluvial woodlands along riverbanks and ponds. During the reference period 2000-2015, it was observed in 3 1x1km squares in the Atlantic bioregion and 7 squares in the Continental bioregion (see map). A small population was removed in Essen in 2016 (not shown on map). A bigger population is present in Bokrijk (Limburg). A few additional localities were found ever since, e.g. in the Brabant district. The largest population (about 250 specimens) is located in the Arboretum Robert Lenoir in Rendeux where it was introduced in the early 1950's, along with *L. camtschatcensis*, and now spreads along a small tributary of the Ourthe river, close to confluence; this population is extremely polymorphic and includes few specimens of pure *L. americanus* and many hybrids. Most of other Belgian populations were only detected during the 2010's and are small-sized (1-50 specimens). Many of them are located in private gardens. A few isolated plants have also been observed along rivers, which suggest that downstream dispersal by water started from several localities.
- Reliability of the Belgian distribution: Large size and plant persistence make it easy to detect in the field. At young stages, it may be confused with related taxa like the eastern skunk cabbage (*Symplocarpus foetidus*), another Araceae native to North America. We assume that distribution data are reliable but that a few populations may remain undetected in private terrains.
- Invasion situation in neighbouring countries: A few populations of *L. americanus* are established in Germany and Netherlands at several kilometers from the Belgian border.



	ATL	CONT
UTM 10km	3	5
UTM 5km	3	6
UTM 1km	3	7
% 1km SAC	100 %	57%
Clustering index	4.63	0.89

Management strategy – eradication

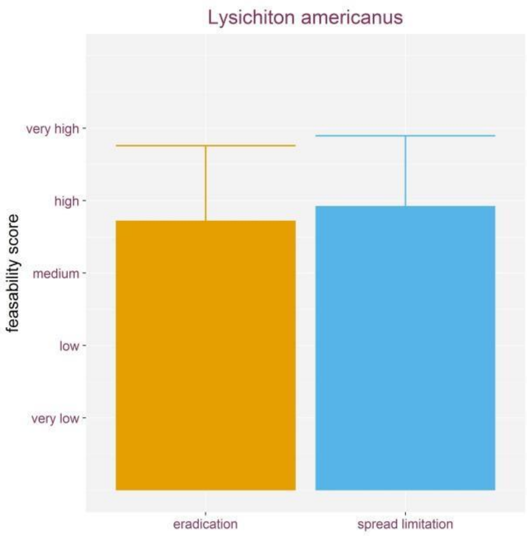
- Methods and techniques: Mechanical removal (Jörg 2007, Rotteveel 2007, EPPO 2009, Klingenstein & Alberternst 2010, Alberternst & Nawrath 2013, Aldridge et al 2015) is favoured over other techniques because of early invasion stages of most *Lysichiton* populations and high sensitivity of ecosystems where it occurs. Hand pulling of any mature and immature plant combined with manual rhizome excavation is performed in early summer, up to a depth of 50 cm (but without removing deep small vertical growing contractile roots). The treatment is repeated during successive years to gradually exhaust the seed bank. Care is taken when handling plants to avoid skin contacts with the sap that contains calcium oxalate crystals (Matthews and Berardi 2015). For large populations with numerous seedlings, plant destruction focuses each year on mature plants only; deep mechanical soil excavation is also conducted if an access is available for machinery. Plant waste is exported and eliminated by incineration or composting. Root and seed contaminated soils are disposed of through burrowing in landfill sites. Chemical treatments are not part of the strategy because of non-target effects and legal limitations in the Belgian context.

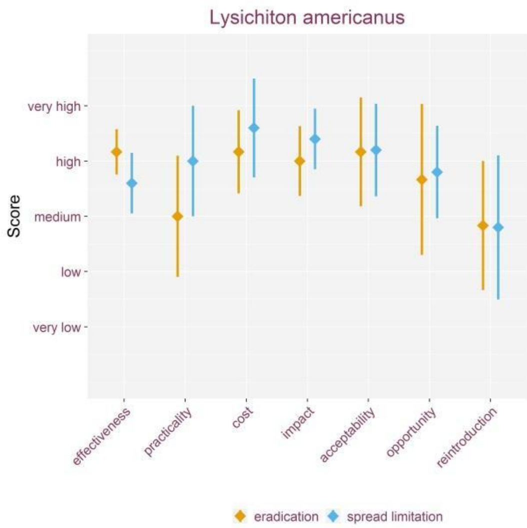
- Post-intervention verification: Regrowth of *L. americanus* is monitored and controlled every 2 years (only plants older than 2 years produce seeds) for at least 10 years due to the presence of a long-lived seed bank in the soil.

Management strategy – spread limitation

- Aim: *Option 1 - Containment into a single or a few patches.* The spread limitation strategy aims at limiting the presence of *L. americanus* in Belgium to the existing large patches (difficult to eradicate), avoid the production of any propagule that might result in further dispersion from them and eradicate existing small patches and any new patch discovered in the field.
- Methods and techniques: Small and newly discovered populations are eradicated using the techniques described in the eradication strategy. Spring mowing is performed twice a year in large populations with a special care taken to destroy inflorescences before seed production
- Post-intervention verification: An accurate surveillance is implemented in the immediate vicinity of the residual populations to be able to detect any further spread from it. A verification of the success of weed control is done in the same way as for the eradication strategy.

Results





The average feasibility score of eradication and spread limitation strategies was between medium and high. On average, effectiveness was scored high for eradication and between medium and high for spread limitation. Practicality was scored medium for eradication and high for spread limitation. Cost, impact and acceptability were scored between high and very high for both strategies. Opportunity was scored between medium and high for both strategies.

Outcome of the workshop

1. General considerations

This species is a good example of species for which the legal basis for management must probably be enlarged to ensure access to private property, including private gardens. Potentially support to eradication in gardens is needed. Control must be performed in shops, garden centers etc. to ensure proper implementation of the EU regulation (in particular ban on trade). There is a need for coercitive measures. Alternative species should be identified.
Management methods must be applied properly. Monitoring and aftercare were deemed very important by the group.

2. Recommendations for management

A consensus was reached among workshop participants for the the eradication strategy. Legal basis for access to property is a requirement for ensuring eradication efficiency.

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3.4.9 Nepalese browntop *Microstegium vimineum* (Japans steltgras, herbe à échasses japonaise)

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Invasion scenario

- Invasion situation and history in BE: The species is not established in the wild in Europe. The invasion scenario is that at the point of detection the species is present as a single population less than 20 square meters at the edge of warehouses on an industrial estate near Liège. The population is known by local naturalists for several years, expanding at that site but only recently identified. It produces fertile seeds and stolons. The species was probably introduced through spill-over from imported bird seed mixtures.

- Invasion situation in neighbouring countries : The species is not known from any other country in Western Europe.

- Reliability of the BE distribution : *Microstegium vimineum* can be distinguished by the hairy axis of the inflorescence and the presence of awns. In Belgium, confusion with similar native species is unlikely yet the species is inconspicuous and can be hard to detect.

1. Management strategy – eradication

- Methods and techniques: *Microstegium vimineum* is an annual therophyte species producing abundant seeds that remain viable in the soil for up to five years. The eradication strategy is hand pulling the entire patch. This involves pulling seedlings from the ground when plants are 5-20 cm tall and easily distinguished from native species. Plants do not need to be bagged or removed. This is operated at the end of the summer, before the seed release and when new seedlings have germinated (EPPO, 2016). Attention is paid to avoid seed dispersal during management actions (machinery, foot traffic, …). Because of the seed bank present in the soil, the management action is repeated every year during at least five years (Barden, 1991).
  Herbicide application is not part of the strategy because of potential non-target effects.
  Grazing is not part of the strategy since cattle, deer and goat do not feed on the plant (EPPO, 2016).

- Post-intervention verification: The patch area and its surroundings are being monitored and any regrowth or seedlings are eradicated during a minimum of 5 years (Barden, 1991). Attention is paid to avoid any soil movement that might facilitate seed transport from the invaded areas to uninvaded areas. Similarly, attention is paid to avoid seed dispersal during management actions (cleaning up of the machinery, limited foot traffic, …).

1. *Management strategy – spread limitation*

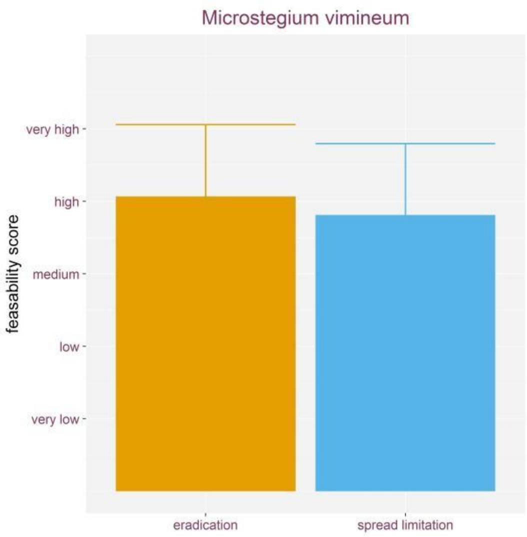
- Aim: *Option 1 - Stand-still principle with the single patch.*

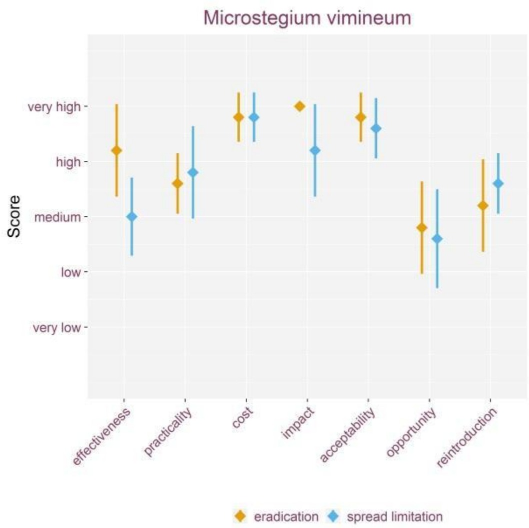
  The spread limitation strategy aims at limiting the presence of this species in Belgium to the single record already documented. As the species dispersal mainly relies on seeds, spread limitation strategy focuses on limiting seed production .

- Methods and techniques : The plants are mowed up to ground level (< 5cm) so no seeds are produced in late summer. This is done with brushcutters as heavy duty mowers risk spreading soil with grains. Care is taken not to miss any plants. The surroundings of the patch are regularly monitored in order to react as quickly as possible if the small populations start expanding. In case this happens, the strategy is to eradicate the new plants using methods suggested in the eradication strategy. Attention is paid to avoid any soil movement that might facilitate seed transport from the invaded areas to uninvaded areas. Similarly, attention is paid to avoid seed dispersal as a result of management actions (cleaning up of the machinery, limited foot traffic, …). No grazing regimes are allowed in the surrounding area so as not to promote its spread by reduced competition with native species (Knight et al. 2009).

- Post-intervention verification: The surroundings are regularly monitored. In case new patches were eradicated, here, follow-up monitoring must be undertaken for a period of at least five years (Barden, 1991).

Results





The average feasibility score of eradication was high, and between medium and high for spread limitation. On average, effectiveness was scored between high and very high for eradication and medium for spread limitation. Cost, impact and acceptability were scored between high and very high for both strategies. Practicality and likelihood of introduction were scored between medium and high; and opportunity was scored between low and medium.

Outcome of the workshop

1. General considerations
The group recognized the importance of surveillance for species not yet present in Belgium. There is a need for increasing identification capacity of field workers.

2. Recommendations for management
A consensus was reached among workshop participants for the the eradication strategy as a guiding principle of the EU reg for species not yet present in BE.

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3.4.10 Mile-a-minute weed *Persicaria perfoliata* (gestekelde duizendknoop, renouée perfoliée)

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Invasion scenario

- Invasion situation in BE: Not currently established in the wild in Europe. Therefore, the invasion scenario is that at the point of detection a single large patch of plants is reported covering a 30m hedge between a private garden and an agricultural field in the North of Brussels. The introduction is associated with a big heap of garden waste nearby so probably originated from a contaminated lot of ornamental plants from Asia.

1. *Management strategy – eradication*

- *Methods and techniques*: The eradication strategy of this patch is a combination of manual and mechanical removal methods dedicated to plant and seed bank removal (Mountain, 1989; EPPO 2008; Kumer & DiTomaso 2005; CABI, 2017). Hand pulling is applied to remove large plants and decaying plant material before removing and composting the heap of garden waste (wearing thick gloves, long trousers and a long-sleeved shirt to prevent skin abrasion caused by the spines). Repeated mowing of regrowth and new seedlings is applied once a month afterwards during 2-3 years in order to exhaust the seed bank and favour competition by native grasses. Attention is paid to avoid any soil movement that might contain seeds.

- Post-intervention verification: The patch area and its surroundings are being monitored and any regrowth or seedlings are eradicated. Follow-up monitoring of the eradication site is done for at least two years to be sure that the seed bank is fully exhausted .

1. *Management strategy – spread limitation*

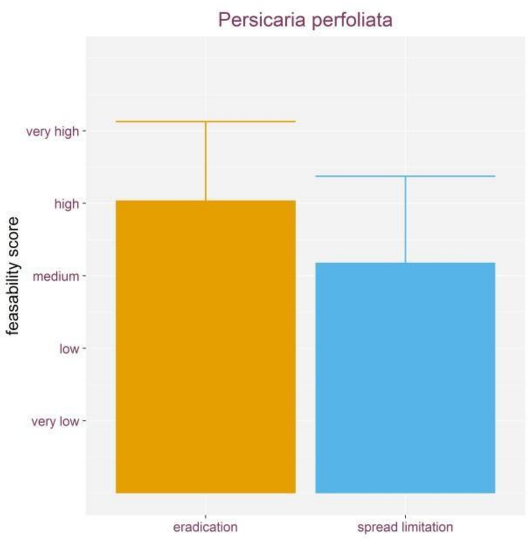
- Aim: *Option 1 - Stand-still principle with a single or a few patches.*

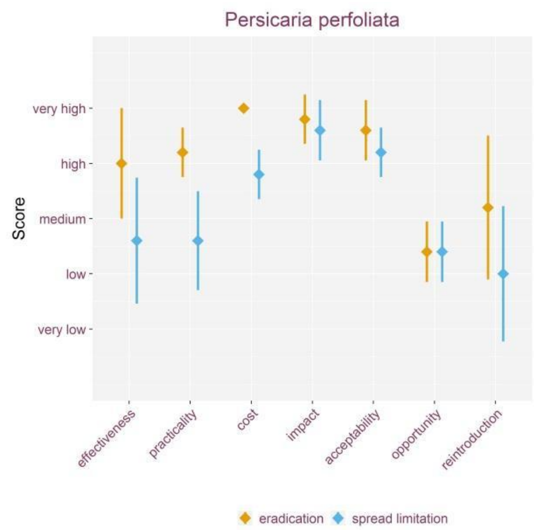
The spread limitation strategy aims at limiting the presence of *P. perfoliata* in Belgium to this single patch, avoid the dispersal of seeds that might result in further expansion. As the species is a vine and its dispersal mainly relies on seeds, the spread limitation strategy focuses on limiting seed dispersal.

- Methods and techniques : The patch is subjected to a repeated mowing regime to prevent flowering and fruit production. As long distance dispersal occurs with birds (Verwaijen 2017), the patch is checked in the flowering season and any flowers/berries are manually removed. The surroundings of the patch is regularly monitored in order to react as quickly as possible if the small population starts expanding. In case new seedlings are reported outside the patch they are quickly pulled out before summer (see eradication strategy).

- Post-intervention verification: The surroundings are regularly monitored. In case new individuals are found, the methods used are the same as for the eradication strategy. Follow-up monitoring during at least 3-4 years must be undertaken (Van Clef and Stiles, 2001).

Results





The average feasibility score of eradication was high, and between medium and high for spread limitation. On average, effectiveness and practicality were scored high for eradication and between low and medium for spread limitation. Cost was scored very high for eradication and between medium and high spread limitation. Impact and acceptability were both scored between high and very high; opportunity was scored between low and medium. Likelihood of reintroduction was scored medium for eradication and low for spread limitation.

Outcome of the workshop

1. General considerations

No general recommendations were made during the workshop

2. Recommendations for management

A consensus was reached among workshop participants for the the eradication strategy as a guiding principle of the EU reg for species not yet present in BE.

References

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3.5 Aquatic animals

3.5.1 Amur sleeper *Perccottus glenii* (amoergrondel, Goujon de l'Amour)

©Petrtyl

Invasion scenario

- Invasion situation and history in Belgium: The Amur sleeper is currently not established in the wild in Belgium. Therefore, the invasion scenario is that at the point of detection about 50 individuals are reported by local fishermen in two small isolated natural ponds in Zonhoven (Limburg, Atlantic bioregion) just outside a contaminated aquaculture facility. It originated from a stowaway introduction of common carp from Estonia.

- Reliability of the BE distribution: Other established populations may be underdetected in standing waters since dedicated fish monitoring is mostly confined to rivers and streams in Belgium.

- Invasion situation in neighbouring countries: The species is not known to be established in neighbouring areas (Retshenikov, 2013; Verreycken, 2015).

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy is a to drain the two infected ponds at the point of detection. Lime chloride (0.3 g/l water at a minimal exposure of 6 hours) is applied to the ponds on the aquaculture facility as it is routinely performed to kill remaining life (Bogutskaya & Naseka, 2002; Verreycken, 2015; CABI, 2017). The aquaculture facility is also isolated by installing fine mesh screens on all outlets to minimize escapees contaminating connected water bodies.
  Active capture (angling, fykes, traps), biological control are not part of the strategy since these methods can hardly eradicate Amur sleeper populations (Verwaijen, 2016). Sterile Male Release is still largely under development so is not applied either. Landing nets, fish (funnel net) traps, electrofishing, and fishing with rod and line are used to confirm presence of the species rather than as a control method (e.g. Nehrig & Steinhof, 2015; Pupina et al. 2015). In general, intensive trapping is not seen as an option to control or eradicate the species (De Vries et al. 2012).

- Post-intervention verification: Post eradication verification includes implementation of stringent biosecurity measures at the aquaculture facility by monitoring for species presence (e.g. eDNA, captures).

1. *Management strategy – spread limitation*

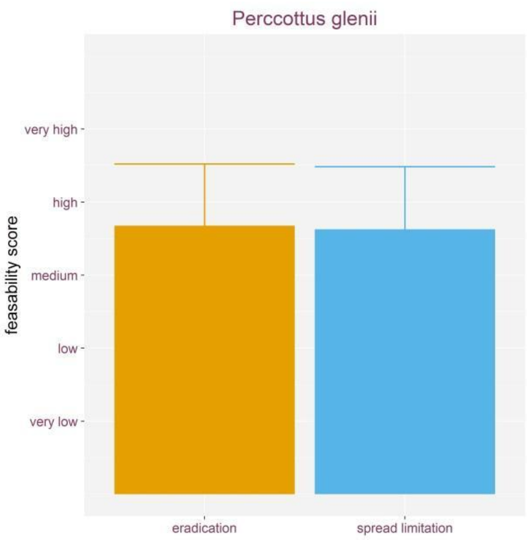
- Aim: *Option 1 - Stand-still principle with a single or a few patches.*

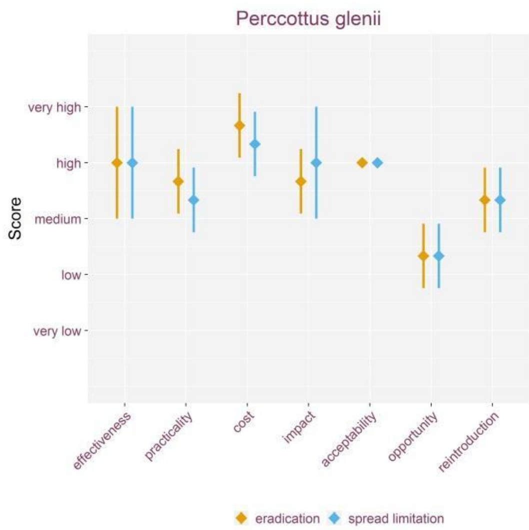
The spread limitation strategy aims at limiting the presence of *P. glenii* in Belgium to the two natural ponds and to destroy its source population.

- Methods and techniques : The two infected ponds are made inaccessible to the public so they can no longer be used for angling. They are also isolated from the water system by installing fine mesh screens on all outlets to minimize escapees. The source population is destroyed by applying lime chloride (0.3 g/l water at a minimal exposure of 6 hours) to the ponds on the aquaculture facility.

- Post-intervention verification : Inaccessibility of the location for the general public and the hydrological isolation of the ponds in question are monitored regularly. Subsequently, these waterbodies are monitored and this action repeated in case some individuals are still present.

Results





The average feasibility of both scenarios is scored medium to high by experts. Average feasibility scores of the criteria are also relatively similar for both scenarios: cost is scored high to very high in both scenarios, effectiveness and acceptability are scored high, practicality and reintroduction are scored between medium and high and impact is scored between medium and high for the eradication scenario but high for the spread limitation scenario (with more variation around the mean in the latter). Only window of opportunity is scored below medium (between low and medium) for both scenarios.

Outcome of the workshop

1. General considerations
Workshop participants acknowledge that aquatic animals are usually difficult to contain in a closed environment. The chances of successfully containing or eradicating an aquatic animal are not high but this does not mean that it should not be the management goal. A remark was made on the strategy itself by the workshop participants who insisted on the fact that the two ponds should be first isolated in order to limit the spread of the species. Also, an analysis of the impacts of the management measures should be conducted before proceeding with the practical implementation of the strategy.

2. Recommendations for management
The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.5.2 Topmouth gudgeon, stone morocco *Pseudorasbora parva* (blauwbandgrondel, goujon de Chine)

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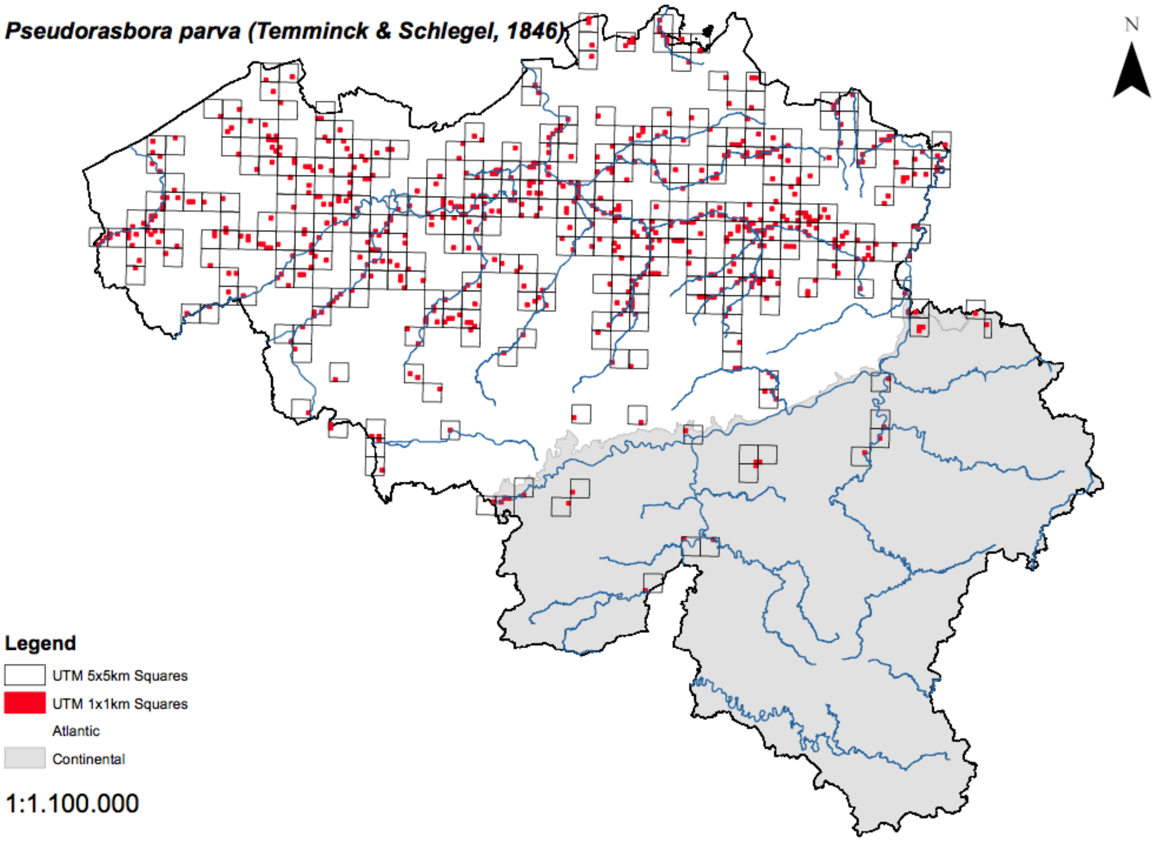
Invasion scenario

- Invasion situation and history in Belgium: Topmouth gudgeon is, with gibel carp *Carassius gibelio*, the most widespread non-indigenous fish species in the Atlantic bioregion, occurring in all river basins (Verreycken et al., 2007). It was unintentionally introduced in Atlantic bioregion the early nineties via 'contaminated' fish transports and stocking activities. The use as live bait for angling also contributed to introduction and spread. The species is common, tolerant to a wide range of environmental conditions and occurs frequently in both streams and standing waters, but with the highest densities in shallow ponds (Verhelst et al., 2016). In the continental bioregion *P. parva* is less widespread. The species is however established in the Meuse, the Ourthe basin and has been reported in several smaller streams and rivers.

- Reliability of the BE distribution:The known current distribution is probably underestimated in standing waters since dedicated fish monitoring is mostly confined to rivers and streams in Belgium. Probably also underdetected in Walloon region because of lower intensity of fish monitoring here.

- Invasion situation in neighbouring countries: First detected in Luxembourg in 2005, when it was found in the upstream dam of the Upper Sauer Lake in Bavigne (neobiota.lu). First observed in The Netherlands in 1992, core populations are present in the south-eastern part of the country in the tributaries of Rhine and Meuse along the Belgian border. Established and widespread in western Germany from which the species invaded the low countries via the Rhine drainage (Gozlan et al. 2010).



	ATL	CONT
Utm 10km	143	14
Utm 5km	317	19
Utm 1km	622	23
% 1km SAC	42%	83%
Clustering index	0.66	0.62

1. *Management strategy – eradication*

- Methods and techniques: Management methods are only known for standing waters: no non-chemical methods are known to effectively eradicate the species in rivers. The present strategy therefore only applies to standing waters occurrences. River occurrences are left unmanaged. The eradication strategy consists of a combination of the drainage of ponds with *P. parva* presence and biomanipulation. Both actions are best combined but in some cases can be applied solely. Draining requires complete control over drainage and refill of the water body. To reduce the impact on other native fish, the native species are caught and kept in quarantine after draining to be restocked on site after refill (Britton et al., 2010). Care is taken to check these lots of fish before restocking to prevent reintroduction of any remaining topmouth gudgeon. As small topmouth gudgeon easily get stuck in nets, biosecurity measures are applied to clean this gear before moving to another location. In ponds with native amphibians present, drainage is performed between September and January, after metamorphosis and before the start of the new breeding season. Biomanipulation involves stocking water bodies with native predatory fish, notably juvenile pike. This technique appears to be effective with in some cases complete eradication of topmouth gudgeon and almost no reduction in

native species (Lemmens et al., 2015). Ideally, depending on the local situation, this is a combination of pelagic predators such as perch *Perca fluviatilis* and littoral predators such as pike *Esox lucius* because juvenile pike tend to reside in the littoral zone forcing prey fish into the pelagic. To increase the resilience to new invasions, water bodies where topmouth gudgeon was removed, are stocked with predatory fish as aftercare (Lemmens et al., 2015). Chemical methods, such as using rotenone (Britton & Brazier, 2006) which would potentially be an eradication method in large, interconnected rivers and streams, or calcium oxide (quicklime) are difficult to apply in Belgium because of regulations regarding the use of biocides in aquatic environments, even if waters can be hydrologically isolated from the environment for the duration of the treatment. Davison et al. (2017) report on an unsuccessful eradication attempt using trapping with crayfish traps (5mm mesh netting) combined with biomanipulation. Therefore, these methods are not part of the eradication strategy.
Post-intervention verification: Sites where *P. parva* was eradicated should be monitored using e-DNA methodology (Davison et al. 2017) and trapping operations.

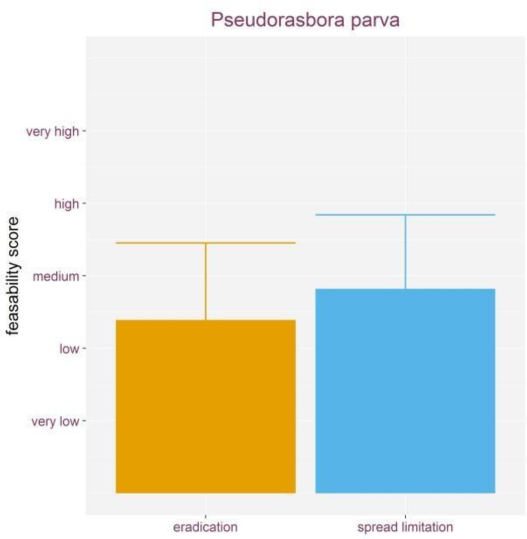
1. *Management strategy – spread limitation*

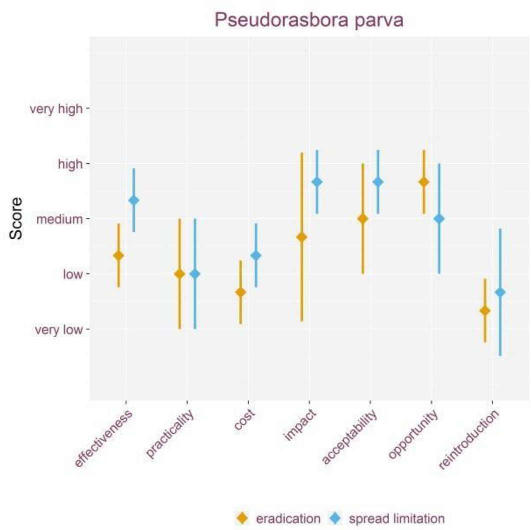
- Aim: *Option 4 : maintenance of pest free areas in Southern Belgium*
  The spread limitation strategy aims at avoiding propagule propagation that would result in further dispersion. Care is taken to avoid that the species may reach uninvaded areas south of the Meuse and Ourthe.

- Methods and techniques: Uninvaded areas are managed as pest free zones; they are subjected to (i) dedicated biosecurity measures related to fish stocking, (ii) management actions aiming to increase habitat resistance to invasion, (iii) increased surveillance effort using generic fish monitoring methods (electrofishing, fyke netting) and e-DNA (iv) rapid eradication actions for any newly detected populations in the pest free area using the methods described in the eradication strategy. Additionally, in a 50 km buffer zone around the pest free area, to increase the resilience to new topmouth gudgeon invasion, owners of suitable water bodies are stimulated to stock with predatory fish (Lemmens et al., 2015). As dispersal from (former) aquaculture facilities represents a key factor in the spread of *P. parva* (and other small bodied non-native fish) (Davies & Britton, 2016), additional biosecurity measures are applied at infected sites, for example, fine mesh screens on all outlets to minimize escapees contaminating connected water bodies and, where feasible, eradication, using appropriate methods.

- Post-intervention verification: Sites where *P. parva* was eradicated should be monitored using e-DNA methodology (Davison et al. 2017) and trapping operations.

Results





The average feasibility score of the eradication and spread limitation scenarios is between low and medium. The average appreciation of the effectiveness and impact was the most divergent score between the both scenarios (both criteria score between low and medium and for the eradication strategy and between medium and high for the spread limitation strategy). Reintroduction had the lowest average score in both scenarios (between very low and low). The average practicality of both scenarios is scored as low and the cost of both scenarios is judged as very low to medium (although the average is higher in the spread limitation scenario). The average score of acceptability is medium in eradication scenario and between medium and high in the the spread limitation scenario. The average score of window of opportunity shows the opposite image.

Output of the workshop

1. General considerations
No general consideration were formulated for this species.

2. Recommendations for management
Workshop participants reached consensus about the fact that eradicating the species is not feasible in Belgium. The spread limitation strategy was not deemed feasible either. The general impression is that the species should not be a priority for management in Belgium (too costly, not effective and lack of practical methods). Other measures such as regular control of fish breeding facilities (maybe through e-dna) are relevant for this species. According to participants, biological control (for example having predator fish such as pike in the system) and providing a rich biodiversity is the best option to manage the species. Some eradication measures at local level could be implemented on a case by case basis where relevant.

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3.5.3 American bullfrog *Lithobates catebeianus* (stierkikker, grenouille taureau)

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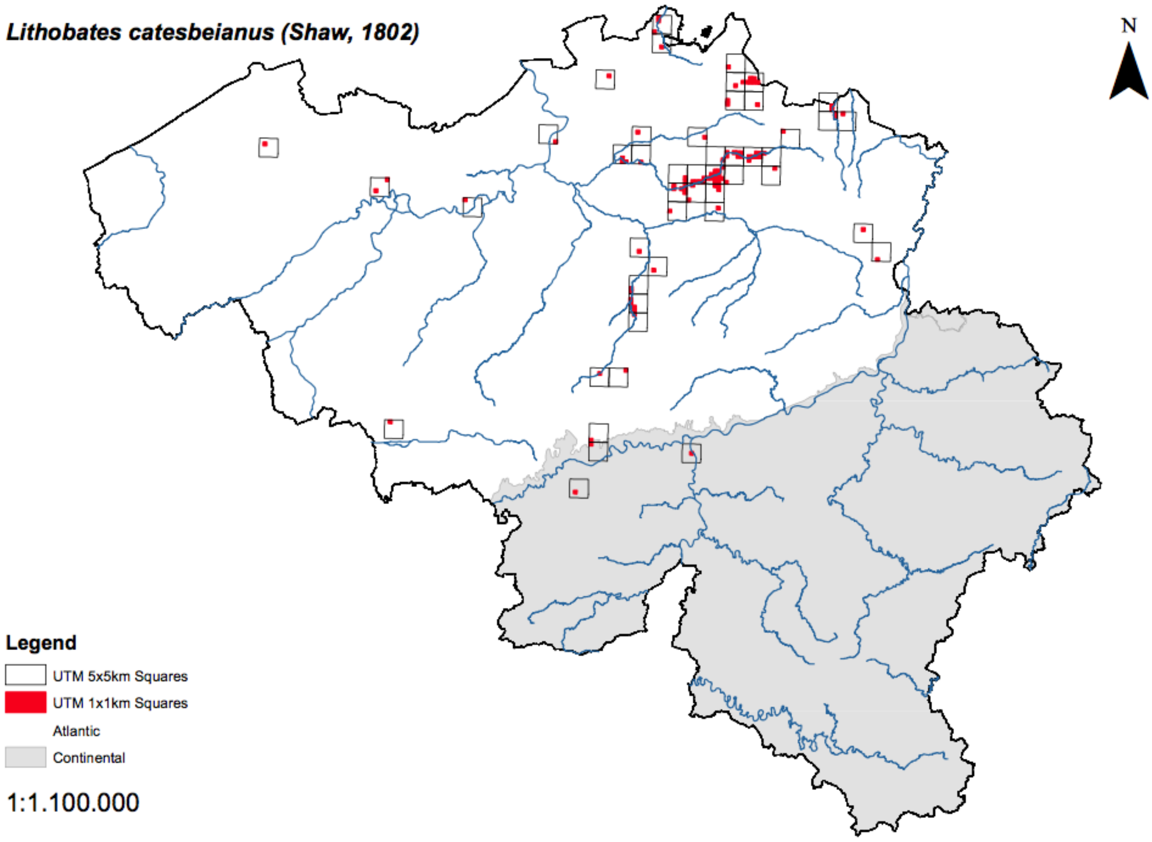
Invasion scenario

- Invasion situation and history in Belgium: The scenario is a single population in the Continental bioregion and several populations, including one large metapopulation in the valley of the Grote Nete (Westerlo-Balen), in the Atlantic bioregion (Jooris, 2005). Here, bullfrogs thrive in a complex of several hundreds of - largely private - ponds used for recreational fishing and gardening (Adriaens et al., 2013). Bullfrogs are in a big metapopulation here and disperse through the river. A life+ project is currently ongoing which will favour the species by restoring and creating brook forests. Also, the management plan of the SAC Grote Nete is expected to increase the dispersion of bullfrog and create more suitable habitats (Descamps & De Vocht 2016). These ponds are mostly nutrient rich, with low vegetation structure and high abundance of non-native fish species such as topmouth gudgeon (*Pseudorasbora parva*), another Union list species. Furthermore, isolated populations with a few contaminated ponds exist in the Mark valley (Hoogstraten, northern Antwerp), the Wamp valley (Arendonk, Antwerp), the Dommel (Lommel, Limburg) (Devisscher et al., 2013) and the valley of the Dyle in Sint-Agatha-Rode in the ANB managed nature reserve Grootbroek. The Dyle valley population seemed to formerly extend along a stretch of four kilometres between Sint-Agatha-Rhode, Ottenbourg and Florival. A 2008 inventory, however, did not yield additional sightings in the valley besides the known population in Grootbroek (about 10 calling males and tapoles) and one calling male at Etang du Grand Pré (Pécrot) at about 1 km from Grootbroek (Martin, 2009). The status and size of the Dyle valley population is unclear and the same is true for the Dommel population. In the Continental bioregion, at current, the only known population occurs at Ransart (Charleroi) on a private property in a suburban context. According to the site owner, bullfrog have been present here for more than 15 years. The surroundings of this site were also checked in 2008 and yielded one adult at a site nearby (< 500m), indicating the population in this urban context remains localised and is currently not spreading. It probably does not contain more than 20 calling males.

- Reliability of the BE distribution: considered representative, although numerous records of bullfrog actually concern marsh frog *Pelophylax ridibundus*.

- Invasion situation in neighbouring countries: In the Netherlands no longer established after two breeding ponds in the border region with Belgium in Baarlo (Limburg), were removed in 2011-2012 through a combination of fencing, seine netting, fyke netting, electrofishing and drainage (Crombaghs, 2012; Goverse et al., 2012). In France, reproducing populations are present over a very large area (> 2000 km2) in the southwest (Gironde and Dordogne) and in central France (Sologne) (Berroneau et al., 2008; Detaint & Coïc, 2006). In France, the species is managed using a combination of methods. Luxemburg: no occurrences reported.



	ATL	CONT
Utm 10km	31	4
Utm 5km	44	4
Utm 1km	99	4
% 1km SAC	61 %	25 %
Clustering index	0.60	2.16

1. *Management strategy – eradication*

- Methods and techniques: The eradication scenario consists of applying a combination of eradication methods depending on location and habitat (Devisscher et al., 2012; Louette et al., 2012a; Louette et al., 2012b): (1) drainage of breeding ponds (which should also sometimes be repeated several times); (2) active trapping using double fyke nets for several consecutive years; (3) frogging (using rifles, nightlighting, electrofishing, multicapture traps) in case areas are not suited for fyke netting (Devisscher et al., 2017; Snow & Witmer, 2011) (a decision support scheme is available at www.ecopedia.be) ; (4) repeated pike introduction with 5-10 cm fingerlings (6 weeks old) at a density of 500/ha as biomanipulation aftercare between consecutive capture campaigns (Louette, 2012). When fyke netting, bycatch (excluding topmouth gudgeon, turtles and crayfish) is released in good condition, but invasive fish species have to be simultaneously removed. Importantly, to be effective, methods have to be combined (Doubledee et al. 2003) e.g. drainage of ponds followed by seine netting to capture remaining larvae in the mud or in case the pond cannot be drained completely due to upwelling groundwater; drainage combined with the shooting of adults. These actions have

to be contained/repeated for several years. Active trapping has to target both larvae, metamorphs ánd adults in order to be effective e.g. fyke netting and frogging. The partial removal of tadpoles may lead to higher tadpole survival and development rates and higher post-metamorphic survival due to decreased density-dependent competition. Removal of adults leads to higher survival of early metamorphic stages through reduced cannibalism (Govindarajulu et al. 2005). Bullfrog are overdosed in a benzocaine (ethyl aminobenzoate) solution and humane killing is performed in a closed container to avoid any chemical release into the environment. When drainage is performed, the ponds are fenced in order to intercept dispersing individuals. Hydroperiod adjustments are performed between September and January, after metamorphosis and before the start of the new breeding season of native amphibians. During the actions, biosecurity measures are applied to disinfect clothing, vehicles and capture gear (with VirkonS or by extended periods of drying the gear) before moving to another location in order not to spread amphibian disease such as chytrid fungus or ranavirus. The strategy includes the drafting of a detailed management plan for all populations, considering key breeding sites, population density (determined by one catch per unit effort), potential dispersal routes, priority sites for conservation, ownership of ponds and local site conditions that determine the choice of methods.
Chemical methods, such as spraying caffeine on bullfrogs, the use of chloroxylenol, rotenone or calcium hydroxide (Witmer et al., 2015) and the destruction of egg masses using chemicals are difficult to apply in Belgium because of regulations regarding the use of biocides in aquatic environments. Sterile male release using triploid bullfrogs (Descamps & De Vocht, 2017) is still under development. Hence, these methods are <u>not</u> part of the strategy.

- <u>Post-intervention verification</u>: after eradication, follow-up is needed to assess whether bullfrog have effectively been removed. In case of drainage, the ponds should be monitored for at least two breeding seasons after control. This can be done by performing captures using fykes or by using eDNA from water samples.

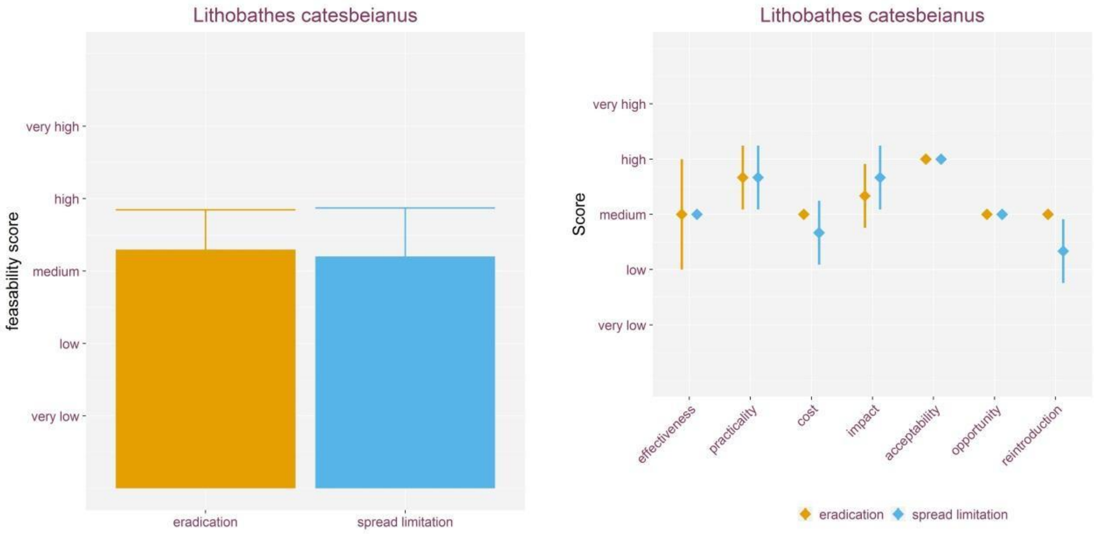
1. *Management strategy – spread limitation*

- <u>Aim</u>: *Option 2 Stand-still of populations in core area(s)*
  The spread limitation strategy aims at containing bullfrog within its core area in the Netevallei and at avoiding any further spread within or outside this area. The current populations outside this core area (Arendonk, Dommel, Hoogstraten, Ransart) are eradicated as well as any new populations popping up outside the boundary around this area.

- <u>Methods and techniques</u>: Eradication of new populations is performed using the methods described in the eradication strategy (drainage, capture). The creation of new ponds or wetlands within dispersal distance (3km) (Descamps & De Vocht 2016) of existing populations is to be avoided to not favour further spread. Additionally, awareness raising is performed with fishermen and garden pond owners about the risk of accidentally transposing larvae when moving fish.
  Fencing is considered unrealistic as a method for preventing dispersal at the scale of a large interconnected river valley. Installing barriers on rivers and streams is equally considered unrealistic because it counteracts measures for fish migration.

- <u>Post-intervention verification</u>: after eradication of new populations, follow-up is needed to assess whether bullfrog have effectively been removed. In case of drainage, the ponds should be monitored for at least two breeding seasons after control. This can be done by performing captures using fykes or by using eDNA from water samples. The volunteer surveillance is supplemented with regular repeated sampling of suitable habitat in priority zones for population expansion using e-DNA.

Results



The average feasibility score appointed by experts is medium for both the eradication and spread limitation scenario. The average scoring of component criteria is also comparable between the two scenarios, with all criteria scored from medium to high - though with lower averages for the cost and reintroduction criteria (between low and medium) for the spread limitation scenario.

Output of the workshop

1. General considerations

In general, methods need more research, and some methods are being questioned during the workshop (especially release of predators). Also, it is pointed by workshop participants that an analysis of the impacts of the management measures should be conducted before proceeding with the practical implementation of the strategy.

For the Nete Valley, knowledge gaps in current distribution need to be closed through increased surveillance effort e.g. using e-DNA.

2. Recommendations for management

A consensus was reached for the the spread limitation strategy Option 2: Stand-still of populations in core area(s) as the most feasible strategy, the core area being the Nete valley. For isolated populations outside the Nete valley, the goal should be eradication. Ponds should be isolated in order to limit the spread.

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3.5.4 Red-eared slider *Trachemys scripta* (lettersierschildpad, tortue de Floride)

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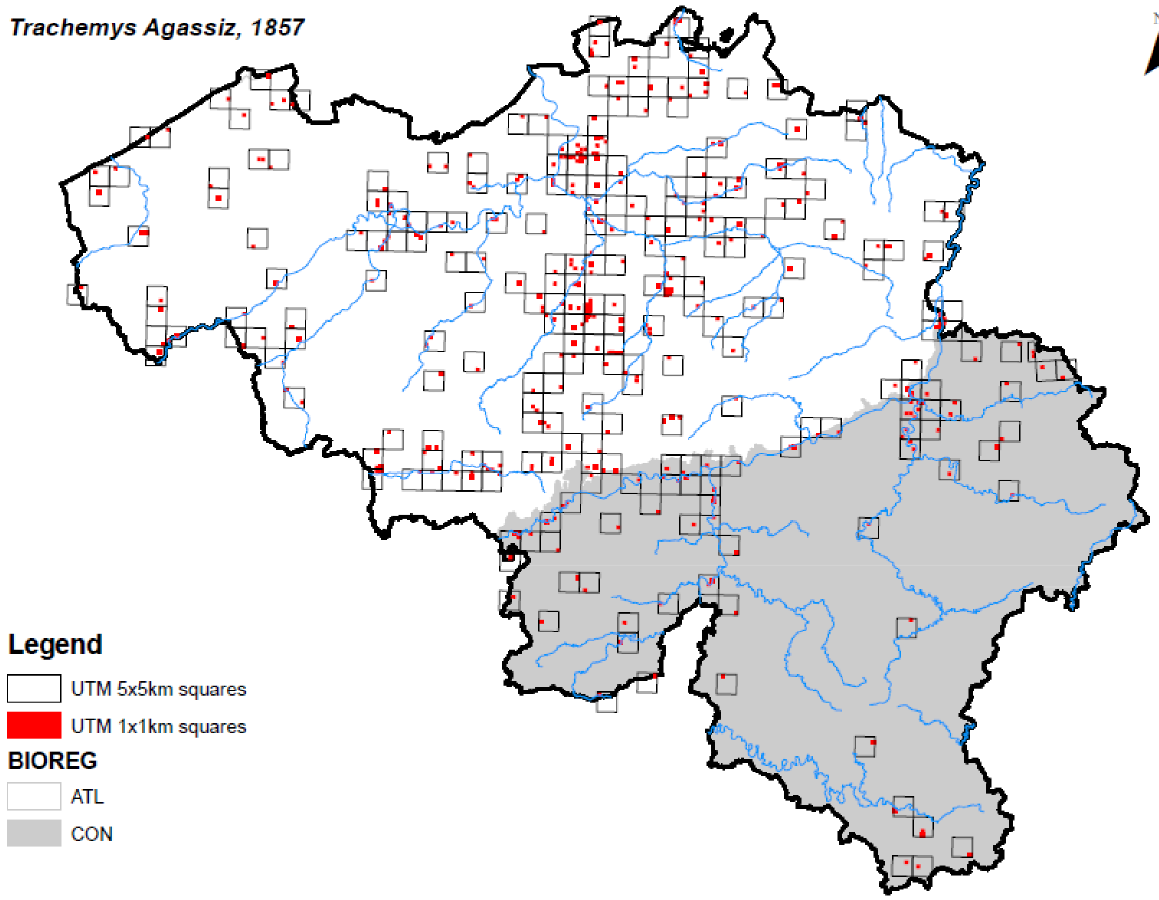
Invasion scenario

- Invasion situation and history in Belgium: Currently not established in Belgium. Red-eared sliders easily survive but are unable to reproduce under the Belgian climate (Jooris 2012). The animals can survive severe winters by hibernating at the bottom of shallow water bodies. Sliders live up to 20-30 years in the wild but shorter lifetimes are observed in urban habitats due to higher mortality as a result of shortage of terrestrial basking spots and unfavourable feeding opportunities (Bringsoe 2006). Sliders observed in the wild in Belgium originate from multiple intentional releases by pet owners since the end of the 1970's. About 300,000 were imported yearly in Belgium during the 1990's with a maximum of 360,000 specimens in 1997 just before the importation ban within the European Union (Jacob & Kinet 2007). In its native range, *T. scripta* is known to disperse over large distances (up to several kilometers) during the reproductive period (Bodie & Semlitsch 2000, Jaeger & Cobb 2012). In Northern Europe, it rarely disperses away from the water where it was introduced, despite some spread via waterways (Bringsoe 2006). Red-eared sliders (including the subspecies *T. scripta elegans*, *T. s. scripta* and *T. s. troostii*) are widespread within the Atlantic and the Continental bioregion. During the reference period 2000-2015, they were found in 293 1km squares in the Atlantic bioregion and in 82 squares in the Continental bioregion, with a stronghold in urban areas. It is mostly found in vegetation-rich eutrophic ponds, meanders and canals in peri-urban environments, where several tens of individuals may sometimes occur. It is especially abundant in the vicinity of Antwerp, Brussels, Ghent, Mons, Ottignies and Liège. It is however also observed in more natural environments like the wetlands of the river Haine valley.

- Reliability of the BE distribution: Due to the absence of a systematic survey of red-eared sliders in Belgium (but see Adriaens *et al* 2016 for Flanders) and the fact that it is rather secretive (it can remain submerged for a considerable time), its presence is probably under-recorded in some sectors.

- Invasion situation in neighbouring countries: High *T. scripta* densities are also reported from neighbouring countries, especially in Northern France and in the border area between Belgium, Germany and the Netherlands.



	ATL	CONT
UTM 10km	117	47
UTM 5km	190	62
UTM 1km	293	82
% 1km SAC	46%	75%
Clustering index	0.65	0.68

Management strategy – eradication

- Methods and techniques: The red-eared slider's eradication programme is based on live trapping using a range of turtle traps adapted to local site condition such as basking turtle traps, Aranzadi turtle traps (Valdeón et al. 2010), cathedral traps or Fesquet cage trap (see figure) in all the sites where the species is detected, including peri-urban areas (Gamble 2006, O'Keefe 2009, Sarat et al 2015).

The use of seine net to catch the turtles is poorly efficient because they tend to drop to the bottom of the water body and burrow into the mud for several hours when disturbed; this is therefore <u>not</u> part of the strategy (O'Keefe 2009). As many turtles are living in peri-urban zones, shooting is <u>not</u> part of the strategy for safety reasons.

- <u>Post-intervention verification</u>: turtle monitoring is maintained during at least one year after trap removal using basking platforms to confirm local eradication.

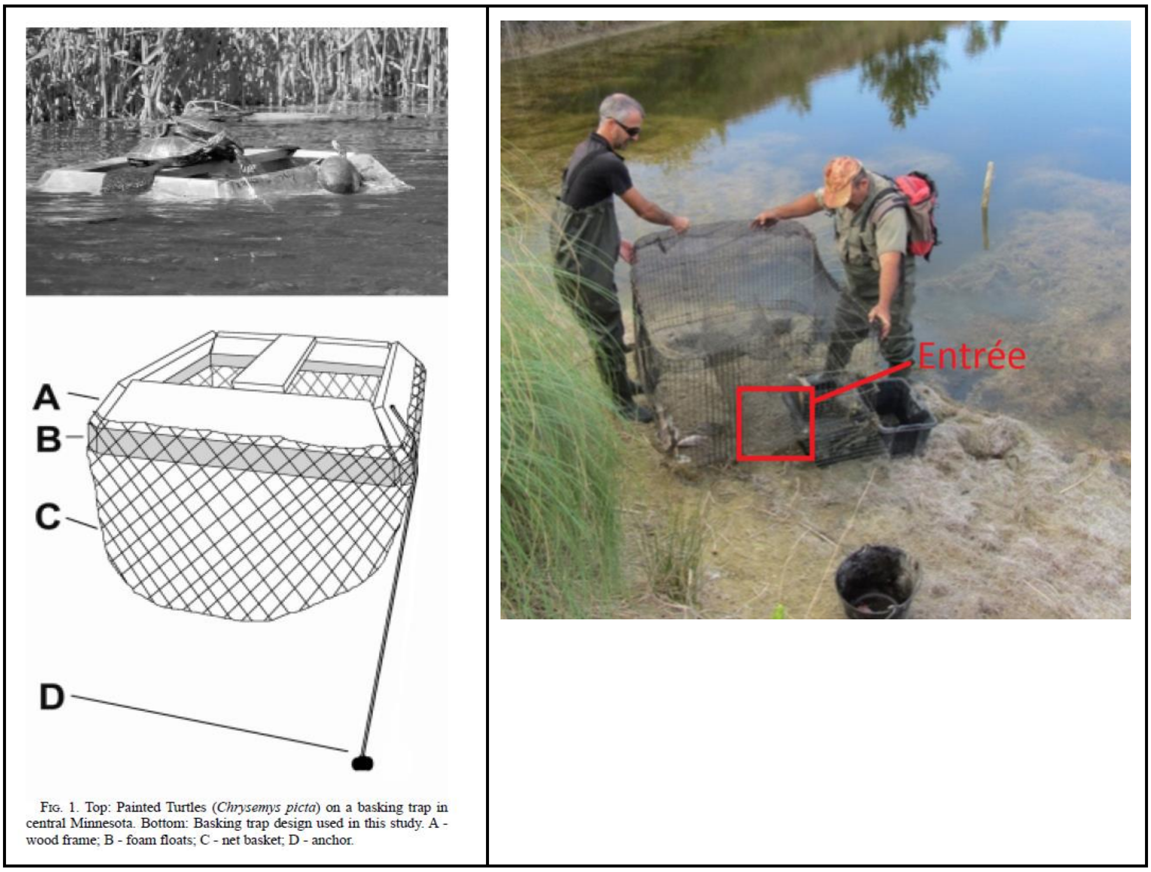


Figure 4: Two types of traps used to catch red-eared sliders. Left: turtle basking trap (A - wood frame, B - foam floats, C - net basket, D- anchor) (Gamble 2006). Right: Fesquet cage trap (Sarat et al 2015).

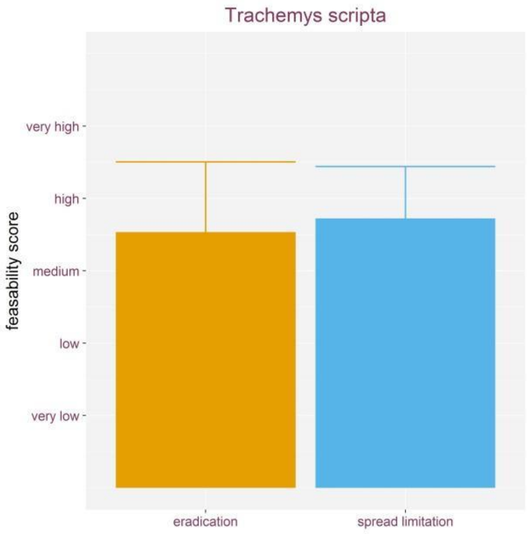
Management strategy – spread limitation

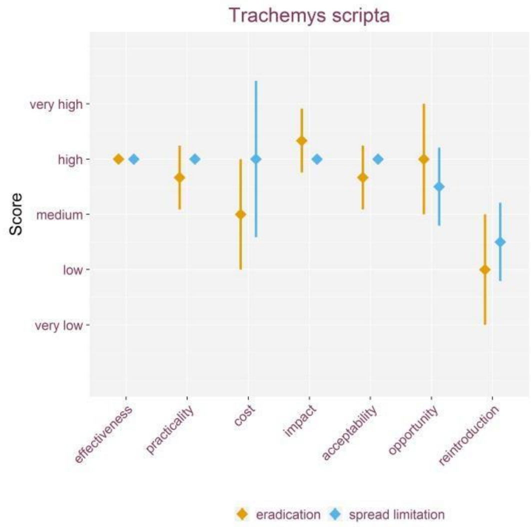
- <u>Aim</u>: Option 4 - *Maintain (semi-)natural wetlands as pest free areas*. In the spread limitation strategy, *T. scripta* are only removed from protected wetlands where an adverse impact on native biodiversity might occur. No management is performed in ponds, lakes and canals in suburban environments.

- <u>Methods and techniques</u>: use of similar techniques as described for the eradication strategy.

- <u>Post-intervention verification</u>: see the eradication strategy.

Results





The experts scored the average feasibility of both the eradication and spread limitation scenarios medium to high. 6 out of 7 component criteria are scored as medium or higher in both management scenarios. For both scenarios, the possibility of reintroduction is the lowest scoring criterium (low in the eradication scenario and between low and medium in the spread limitation scenario).

Outcome of the workshop

1. General considerations

Divergent opinions were shared on the future reproductive capacity under climate change and also on the impact of the species on native biodiversity (current and future). A remark was made that managing pathway of introduction (dumping) is an important measure: public authorities could lead the way by managing the turtle populations in their ponds in order to limit people being tempted to releasing their turtles in those ponds or in the wild in general. Additionally, a positive list for reptiles is perceived as a great prevention tool for limiting the introductions of sliders and reptiles in the wild.

Concerning management method, some participants noted that the trapping method needs to be fine-tuned.

2. Recommendations for management

Neither eradication nor limiting spread strategy seemed feasible to the workshop participants. Management where it is easy/possible/not too costly to capture, could be performed (Control).

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3.5.5 Chinese mitten crab *Eriocheir sinensis* (Chinese wolhandkrab, crabe chinois)

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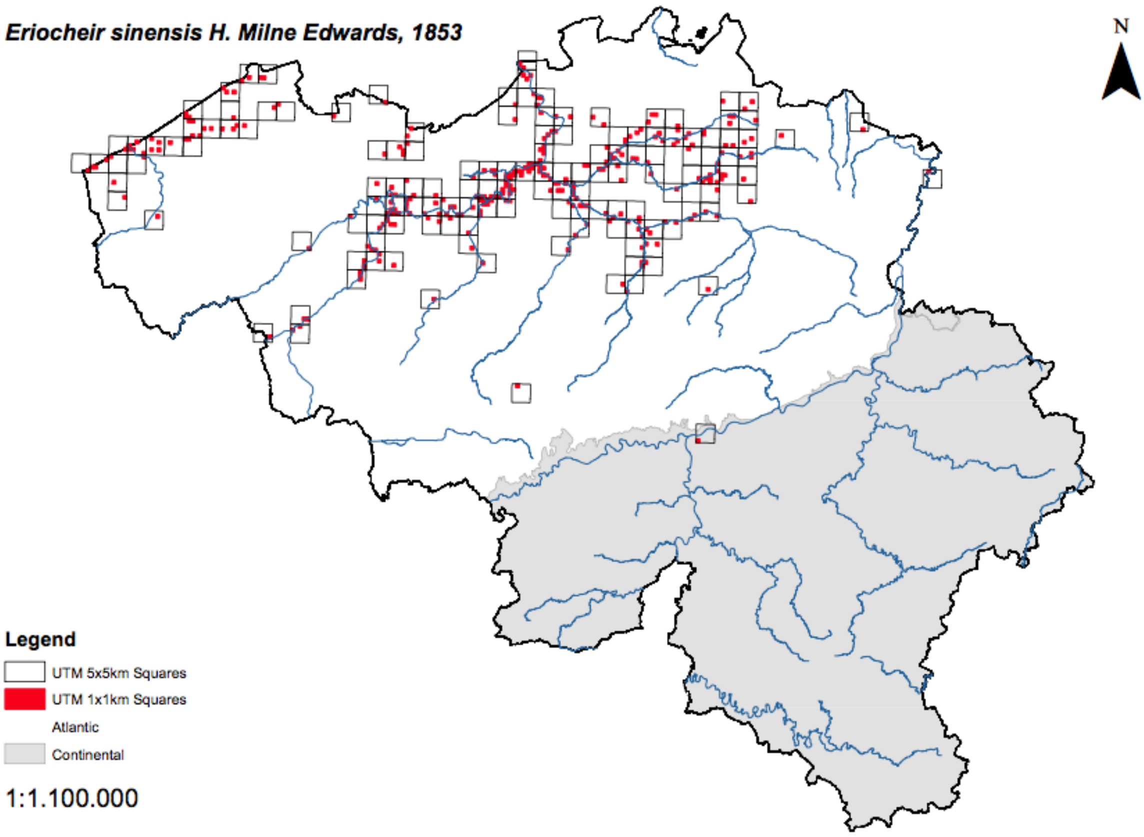
Invasion scenario

- Invasion situation and history in Belgium: The first Chinese mitten crab in Belgium was found in 1933 (Lestage, 1935; Wouters, 2002) and the species rapidly expanded its range in the Atlantic bioregion in the period 1933-1956 (Kerckhof et al., 2007). It decreased significantly during the fifties due to severe water pollution and after that expanded again in the period 1970-2001 (Boets et al., 2016; Messiaen et al., 2010). The exact migration routes of *E. sinensis* are unclear but from the North Sea and the river Scheldt the species uses rivers, canals and smaller watercourses as migration routes and all kinds of freshwater bodies for growth. Spawning and larval growth are performed in brackish or saline waters as the optimum salinity to pass through all larval stages is between 20-25 ‰ (Hanson and Sytsma, 2005; Bentley, 2012; Dittel and Epifanio 2009). Consequently, crabs have been reported along all water courses with direct connection to the North Sea: Yser; Canal Gent-Brugge-Oostende; Boudewijn canal, Leopold canal and Schipdonk canal; canal Gent-Terneuzen. The river Scheldt and its tributaries are at the heart of the current range of the species (Stevens, 2010). Mitten crabs are mostly recorded when they leave the water especially during spring migration when they are confronted with barriers (sluices, mills, other obstacles) that prevent further upstream migration. The number of crabs varies strongly from year to year and water flow rate probably determines intensity of the migration to an extent. Migration distances are known to go up to several hundred kilometers so the species can be expected to occur virtually everywhere in the Atlantic bioregion (ANB & INBO, 2016). Flanders has adopted an action plan to reduce local nuisance by mitten crabs during migration with trapping efforts, using fixed fyke constructions, focused on the Demer basin (ANB & INBO 2016). In the continental bioregion, there is currently only one observation in a small brook in the Meuse Basin in the vicinity of Namur.

- Reliability of the BE distribution: The distribution of mitten crabs in the Atlantic bioregion is considered representative. Probably, invasion is still limited in the continental bioregion but possibly Chinese mitten crabs are in fact more widespread here but have not been observed/reported.

- Invasion situation in neighbouring countries: Widespread in the Netherlands in all coastal provinces and outside coastal areas most abundant in the larger river systems (Rivierengebied). The highest numbers of Chinese mitten crabs are recorded in downstream areas of the River Rhine system (Bouma and Soes 2010).



	ATL	CONT
Utm 10km	70	1
Utm 5km	140	1
Utm 1km	314	1
% 1km SAC	45 %	100 %
Clustering index	0.55	0.55

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy consists of mass trapping of mitten crabs using adapted fykes in order to reduce fish bycatch (e.g. lobster fykes or modified rat fykes with bait). These passive trapping devices can be applied year round, although the trapping effort will increase during spring and autumn migration and varies with the specific locations of the traps (Garcia-de-Lomas et al., 2010). Typically, trapping success is highest in the vicinity of migration barriers where the animals amass during upstream migration in spring and downstream migration in autumn. At specific locations along the migration route, fixed trapping constructions with a specific conduction system are installed. These infrastructures require high investment but are more sustainable than mobile traps. To increase their efficiency, such constructions are combined with fencing (i.e. smooth metal or PVC plates of about 50 cm height placed on the shore or dyke) the area over a distance downstream the migration barrier. Alongside the fence, plastic containers with steep, slippery walls (up to 80 cm deep) are dug into the soil so the crabs are contained and can easily be disposed of. Fykes and containers must be emptied regularly to remove crabs and release bycatch. Crabs caught are macerated on site using an industrial blender installed on a truck. The resulting bio-waste is properly treated and disposed of by a professional waste treatment company. In terms of implementing the eradication programme, commercial harvesting is considered on top of the use of dedicated professionals.

- Post-intervention verification: fyke constructions remain in place at strategic migration barriers outside the Scheldt basin and alongside the edge of the core area where mitten crabs are known to aggregate during, and are used as a monitoring tool to check for remaining mitten crabs.

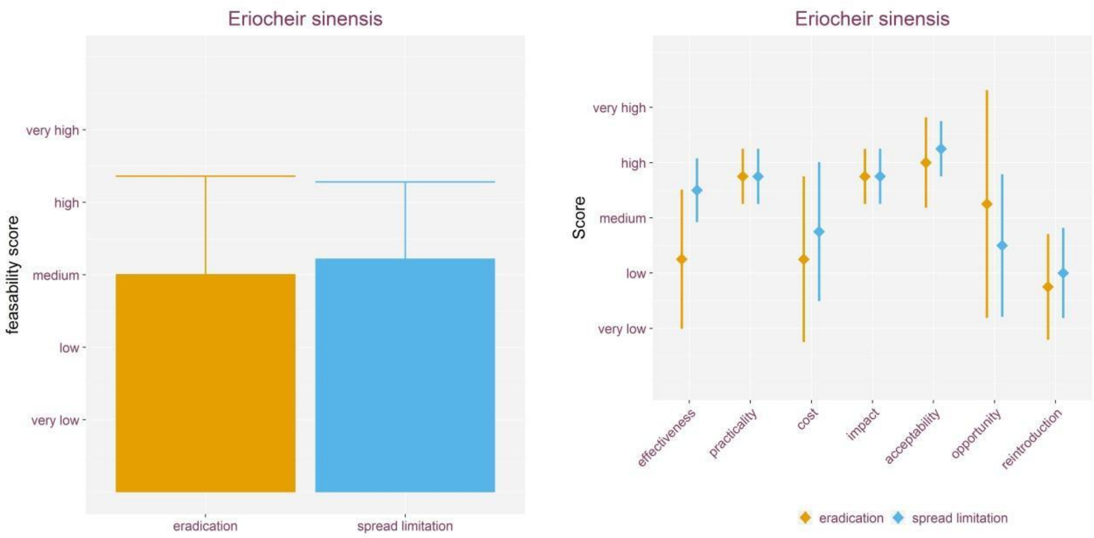
1. *Management strategy – spread limitation*

- Aim: *Option 2 Containment of populations in core area(s)*
  The spread limitation strategy includes trapping crabs in all rivers at the edge of the current range of the species in Belgium. This mostly coincides with the border region with the Netherlands and France, and southern edges of the Atlantic bioregion. Most notably, invasion through the Meuse basin has to be prevented so trapping efforts would be concentrated there. Populations in the core area (Scheldt basin) remain unmanaged.

- Methods and techniques: Trapping is performed using the methods described in the eradication strategy (fyke trapping). A permanent reduction of the water flow in rivers and water courses, which could decrease the intensity of upstream migration in spring and early summer is considered unrealistic and therefore not part of the spread limitation strategy.

- Post-intervention verification: fyke constructions remain in place at strategic migration barriers where mitten crabs are known to aggregate during, and are used as a monitoring tool to check for mitten crabs.

Assessment results



The average feasibility of both eradication and spread limitation scenarios was scored as medium by experts.
In general, the average scoring of the criteria is similar between strategies: reintroduction had the lowest score in both scenarios (low), whereas acceptability was scored high or above for both scenarios. Window of opportunity show a lot of variation around the mean in both scenarios (average score around medium), as did cost (scored between low and medium). Practicality and impact were scored between medium and high in both scenarios. The appreciation score of effectiveness, was, on average, judged to be higher in the spread limitation strategy than in the eradication strategy and also showed less variation in the former.

Output from the workshop

1. General considerations
Workshop participants acknowledge that effectiveness of management measures needs to be more studied and also more research is needed to know which area could be potentially managed with an eradication/spread limitation strategy. This

information is currently missing and are preventing the workshop participants to make concrete recommendations. It is thought that eradicating the species from small rivers / water bassins, using the fixed trapping constructions with a specific conduction system method, is possible but more research/testing is needed before any advice can be formulated. The option of targeting the river basin of the Scheldt was not suggested in any of the 2 strategy but some workshop participants stated that it would be good to target those rivers that are in direct connection to the River Scheldt as this is the main gateway for the species to colonize upstream rivers.

2. Recommendations for management

Workshop participants rejected the eradication strategy, since the eradication of the species from large rivers, such as Meuse and Scheldt is unrealistic. The spread limitation strategy presented involved the eradication of the species in the Meuse so it was also rejected. Control seemed the best / realistic option at the moment.

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3.5.6 Spiny-cheek crayfish *Orconectes (Faxonius) limosus* (gevlekte Amerikaanse rivierkreeft, écrevisse Américaine)

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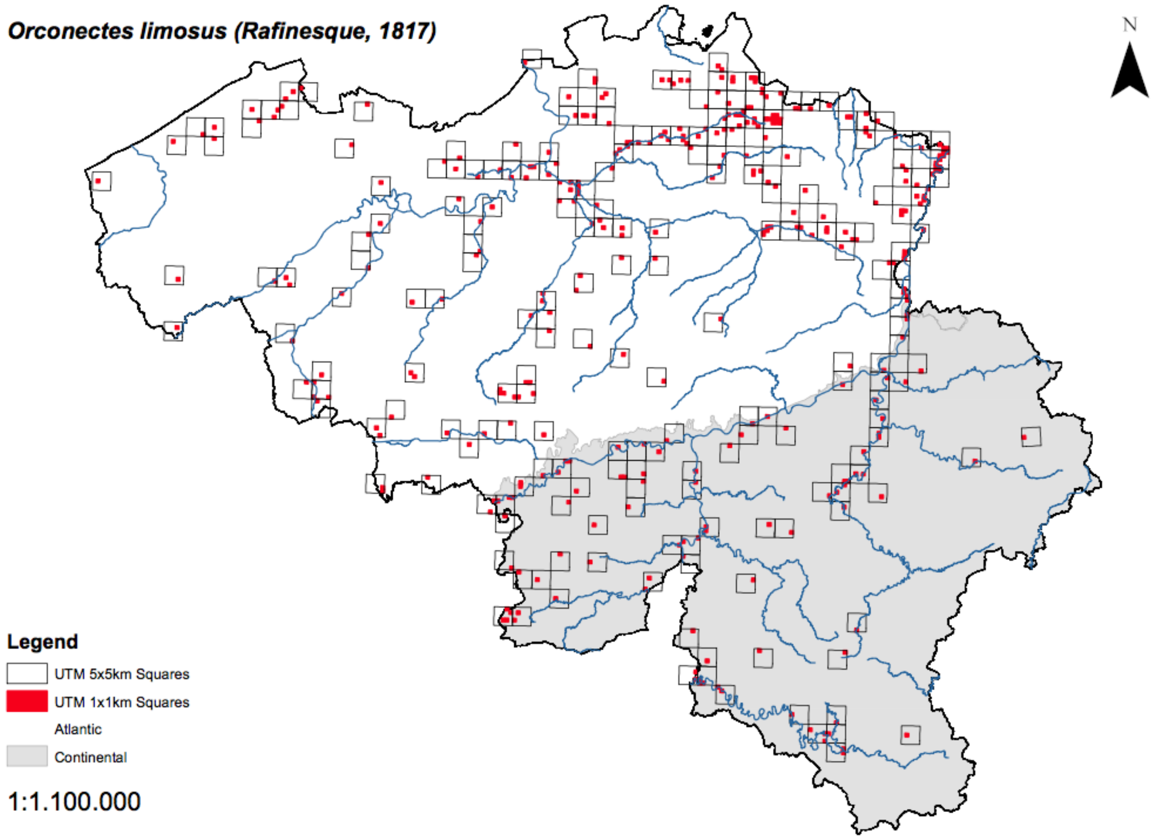
Invasion scenario

- Invasion situation and history in Belgium: *Orconectes limosus* is widely distributed throughout both bioregions in Belgium. It was first reported in Belgium in 1962 from the River Meuse, in Flanders in 1977 (Boets et al., 2012). Since then, it rapidly invaded water courses and canals (Meuse, Sambre, Ourthe, Semois, Amblève, canaux du centre). It colonized the Atlantic bioregion from the east and since the 1990s has spread rapidly to the west. It showed a cumulative increase in its distribution area since 1977 of 12 5km grid cells per year. The species is the most eurytopic of all non-native crayfish in Belgium and occurs in all types of aquatic systems (rivers, lakes, ponds, canals, brooks, urban as well as natural areas). It is the most common crayfish species and can occur in muddy waters, polluted canals and organically-enriched ponds and lakes (Boets et al., 2016; Boets et al., 2014). It can occur together with other non-native crayfish such as *Procambarus clarkii* (Boets et al., 2009). *Orconectes limosus* is a burrower but likes to hide under stones, water plants and other forms of cover. It can be locally abundant, and is therefore presumably frequently harvested for recreational fishing (use as bait for larger fish) or for consumption. Native noble crayfish *A. astacus* went extinct in the Atlantic bioregion and was last recorded in Flanders 1945 in Lanaken. *Astacus astacus* prefers clean, well-oxygenated streams or ponds. It probably disappeared through eutrophication and habitat loss (Messiaen et al., 2010), competition with non-indigenous crayfish and/or crayfish plague. It is however still present in Wallonia on less than 50 isolated sites, mostly standing water but also some smaller streams, although its numbers have continued to decline since the 1990s. Several organisations in Belgium are currently trying to efficiently rear native crayfish with some success.

- Reliability of the BE distribution: The distribution is considered representative in the Atlantic bioregion due to a dedicated project. However, there are most probably gaps in the distribution in both bioregions due to insufficient monitoring (no dedicated monitoring in suitable habitat, crayfish are bycatch in the fish monitoring but are often not reported, water quality monitoring does not go to species level).

- Invasion situation in neighbouring countries: Widely established in the NL (Couperus 2015) and in all French departments neighbouring Belgium (site MNHN). In Luxemburg on Upper Sûre lake not far from the belgian border (neobiota.lu).



	ATL	CONT
Utm 10km	95	47
Utm 5km	150	72
Utm 1km	255	98
% 1km SAC	45%	88%
Clustering index	0.63	0.61

1. *Management strategy – eradication*

- Methods and techniques: To achieve eradication, an integrated approach is applied using a range of control and containment techniques to suit different habitats and multiple life stages as proposed by Stebbing et al. (2014) and Southy-Grosset et al. (2016). The strategy is a combination of different mechanical and biological methods: intense trapping using both baited and artificial refuge traps, biomanipulation by the release of native predatory fish species, the building of barriers around the invaded waterbodies to prevent recolonisation of the cleared area and limit further introductions, the destruction of boroughs (e.g. through dredging) and the draining of ponds which can only be applied provided it is accompanied by physical isolation of the pond (e.g. through the use of fencing). Acknowledging biocides are currently probably the only method with realistic potential of achieving eradication of crayfish populations, control with biocides cannot be part of the strategy because of legal restrictions regarding the use of biocides near water in Belgium. Innovative autocidal methods such as the use of sex pheromones or Sterile Male Release Technique (SMRT) by exposing crayfish to ionising radiation (Aquiloni et al. 2009) are still under development and have not yet been tested outdoors for this species which has also been reported to display facultative parthenogenesis (Buřič et al. 2011). Therefore, they are also not part of the strategy.

- Post-intervention verification: Once the species has been removed, the recovery of the ecosystem is monitored to ensure the target species does not recolonize. To this end, and because crayfish plague can be transmitted at very low densities, surveillance is necessary using a method which is capable of detecting spiny-cheek crayfish at very low densities (less than 1 adult per 500 m2) (Peay, 2001) i.e. environmental DNA.

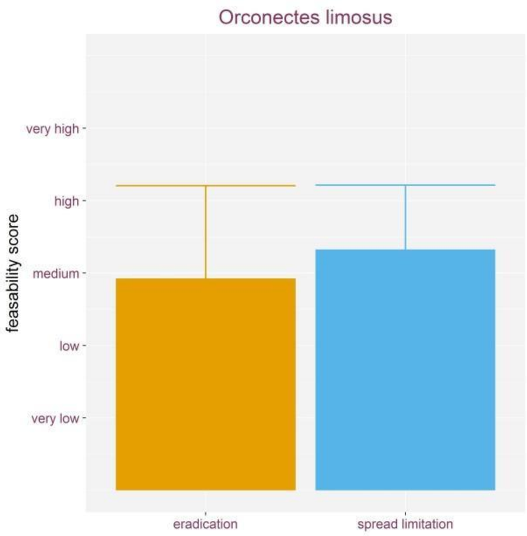
1. *Management strategy – spread limitation*

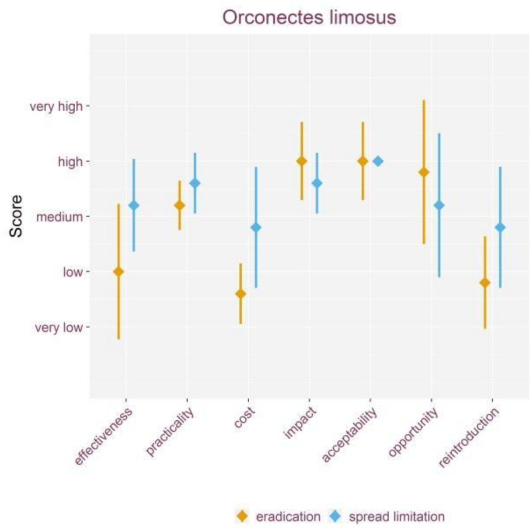
- Aim: *Option 4 Maintenance of pest free areas*
The spread limitation strategy aims at avoiding propagule propagation that would result in further dispersion of this widespread crayfish and in invading sites with relict populations of the native crayfish. Care is taken to avoid that it may reach uninvaded areas, especially upstream zones in river basins. The strategy is to eradicate new populations beyond the extent of the species current range and to restrict further upstream migration by installing physical barriers. In Wallonia, it is especially targeted towards areas in and around known native crayfish habitat.

- Methods and techniques: Uninvaded areas are managed as pest free areas; they are subjected to (i) dedicated biosecurity measures (e.g. awareness raising is performed with fishermen to not use crayfish as bait), (ii) increased surveillance effort and (iii) rapid eradication actions after crayfish detection using the methods described in the eradication strategy and (iv) populations of predatory fish are enhanced in invaded downstream zones nearby pest free areas to reduce dissemination risk (buffer zones). Fencing is considered unrealistic as a method for preventing dispersal at the scale of a large interconnected river valley. Installing barriers on rivers and streams is equally considered unrealistic because it counteracts measures for fish migration.

- Post-intervention verification: Once the species has been removed, the recovery of the ecosystem is monitored to ensure the target species does not recolonize. Surveillance is necessary using a method which is capable of detecting spiny-cheek crayfish at very low densities (less than 1 adult per 500 m2) (Peay, 2001) i.e. environmental DNA.

results





The average feasibility score of both eradication and spread limitation scenarios is around medium. Practicality, impact, acceptability and window of opportunity are scored relatively similar between scenarios, with averages between medium and high. Effectiveness, cost and reintroduction are -on average- appreciated better in the spread limitation scenario then in the eradication scenario.

Outcome of the workshop

1. General considerations
In Wallonia the species is thought to be underdetected. In Flanders, managers feel they have a good idea of the species presence in public waters (populations in single private ponds being most probably underrepresented).
Workshop participants stressed the fact that the feasibility, practicability and efficiency of the management measures are in great need of research.

2. Recommendations for management

Workshop participants recommend the Management strategy – spread limitation with the aim: Option 4 Maintenance of pest free areas. Buffer zones around the native species *Astacus astacus* last populations should be implemented. The eradication strategy is considered too costly and not feasible.

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3.5.7 Virile crayfish *Orconectes (Faxonius) virilis* (geknobbelde Amerikaanse rivierkreeft, écrevisse à pinces bleues)

©Alan Schmierer (flickr)

Invasion scenario

- Invasion situation and history in Belgium: Not currently established in the wild in Belgium. Therefore, the invasion scenario is that at the point of detection several individuals are reported in the Dyle river. Subsequent crayfish surveys detected the species at a number of locations including the main river, tributaries and a few standing water bodies within the catchment, but not further downstream of Leuven. The introduction is the result of deliberate release into the wild due to the disposal of unwanted aquarium collections.

- Reliability of the BE distribution: Unlikely to have been overlooked in Flanders due to a dedicated project on crayfish samples from VMM monitoring. However, it cannot be ruled out that populations already occur on the Belgian territory due to insufficient monitoring (no dedicated monitoring in suitable habitat, crayfish are bycatch in the fish monitoring but are often not reported, water quality monitoring does not go to species level).

- Invasion situation in neighbouring countries: No populations known in the border region with neighbouring countries. In the Netherlands first reported in 2004 but probably introduced earlier and widely distributed around Vinkeveen-Woerden-Oudewater, more recently also Kromme Rijn and Flevoland (Koese and Soes 2011). Its core distribution roughly corresponds to the area between Rotterdam and Amsterdam.

1. *Management strategy – eradication*

- Methods and techniques: The eradication strategy of the virile crayfish populations, spread across a whole river catchment is a combination of several methods which mostly includes active trapping using baited traps and targeting all life stages equally. This requires the use of a combination of different trap designs used simultaneously supplemented by eel introduction. The proposed strategy is for baited traps to be set at a density of 1 trap every 100 m of river, or one trap per 100 square meters in lakes, each trap to be emptied at least twice per week all year round (Stebbing et al 2016). Trapping is integrated with predation by native fish such as Eel *Anguilla anguilla*, pike *Esox lucius* or perch *Perca fluviatilis*. Fish usually predate on juveniles and small sized crayfish, being complementary to trapping (Hein et al. 2006). This would have to be conducted in a controlled and progressive manner throughout the catchment, with measures taken to ensure reintroduction would not occur.
  Biological methods (White Spot Syndrome Virus and bacteria *Spiroplama penaeiled*) are not part of the strategy because of their potential non-target effects and because these methods need further research before implementation in the field (GISD, 2017; Davidson et al., 2010). Chemical methods such as the application of Pyblast, a pyrethrin based non-specific pesticide, is not part of the strategy due to its non-specific mode of action it is not suitable for use in fishing lakes and nature reserves or flowing water (Peay et al 2006). Innovative autocidal methods such as the use of sex pheromones or Sterile Male Release Technique (SMRT) by exposing crayfish to ionising radiation

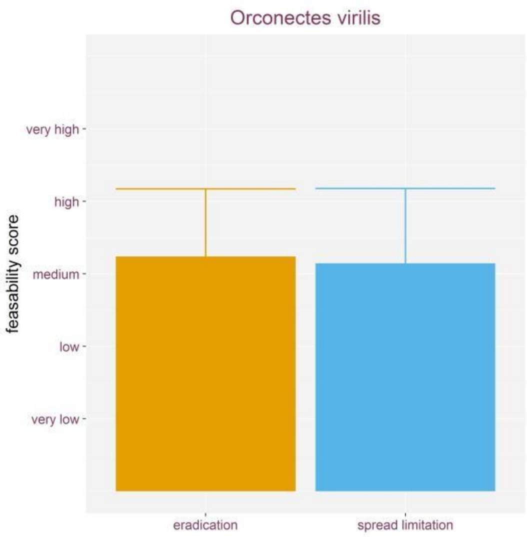
(Aquiloni et al. 2009) could greatly enhance the effectiveness of trapping,are species-specific, not harmful to the environment and acceptable. Yet, they have never been trialled for *O. virilis* so far. Therefore, they are also not part of the strategy.

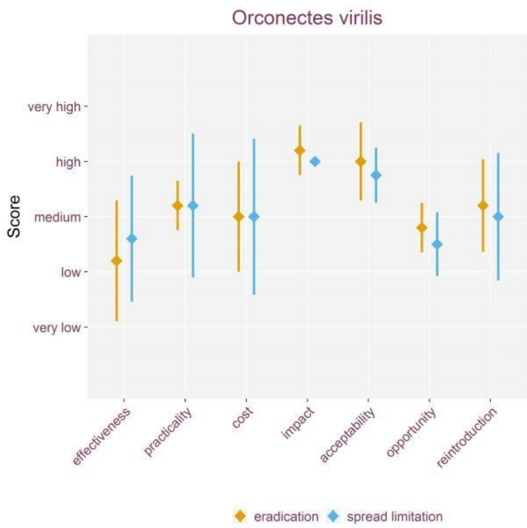
- Post-intervention verification: Once the species has been removed, the recovery of the ecosystem is monitored to ensure the target species does not recolonize. Surveillance is necessary using a method which is capable of detecting crayfish at very low densities (less than 1 adult per 500 m2) (Peay, 2001) i.e. environmental DNA, which is still under development for this species. Meanwhile, traps can be used as a monitoring tool.

1. *Management strategy – spread limitation*

- Aim: *Option 1 Stand-still principle with a single or a few patches*
- Methods and techniques: The spread limitation strategy aims at limiting the presence of the species in Belgium to the section of the Dyle upstream Leuven. Physical crayfish barriers are installed on strategic installations (structures such as fish ladders) that allow fish migration to prevent downstream migration in the Dyle basin (Frings et al. 2013; Rahel 2013; Rosewarne et al. 2013). The section below Leuven is regularly and continuously monitored in the long term by a professional team in order to react as quickly as possible if animals colonize it. In case animals are detected in this section or in other rivers or water bodies in Belgium, the strategy is to eradicate them using the methods described in the eradication strategy.
- Post-intervention verification: Once the species has been removed from newly colonised water bodies, the recovery of the ecosystem is monitored to ensure the species is not present anymore. Surveillance is necessary using a method which is capable of detecting crayfish at very low densities (less than 1 adult per 500 m2) (Peay, 2001) i.e. environmental DNA.

results





The average feasibility score given by experts is medium for the eradication scenario as well as for the spread limitation scenario. The average scoring of component criteria by experts is also very similar for both strategies. Scoring of impact and acceptability by experts is around high, effectiveness and window of opportunity are scored between low and medium and average scores of practicality, cost and window of opportunity center around medium, in both scenarios.

Outcome of the workshop

1. General considerations
In the invasion scenario, the species is, at the moment of detection, present in a small river. If the species was detected in ponds, it could be feasible to eradicate and the eradication strategy would have been chosen. But in a river the impression of the workshop participants was that it is not possible to eradicate.

Another remark was that a test phase should be done to check the management measures efficiency before a strategy is chosen. As for the other crayfishes, feasibility, practicability and efficiency of the management measures are in great need of research.

2. Recommendations for management

For the scenario presented above, workshop participants recommend the management strategy – spread limitation with the aim: Option 1 Stand-still principle with a single or a few patches. For an alternative scenario which would present the species detected in ponds and not in a river, workshop participants recommend the management strategy - eradication.

The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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3.5.8 Signal crayfish *Pacifastacus leniusculus* (Californische rivierkreeft, écrevisse signal)

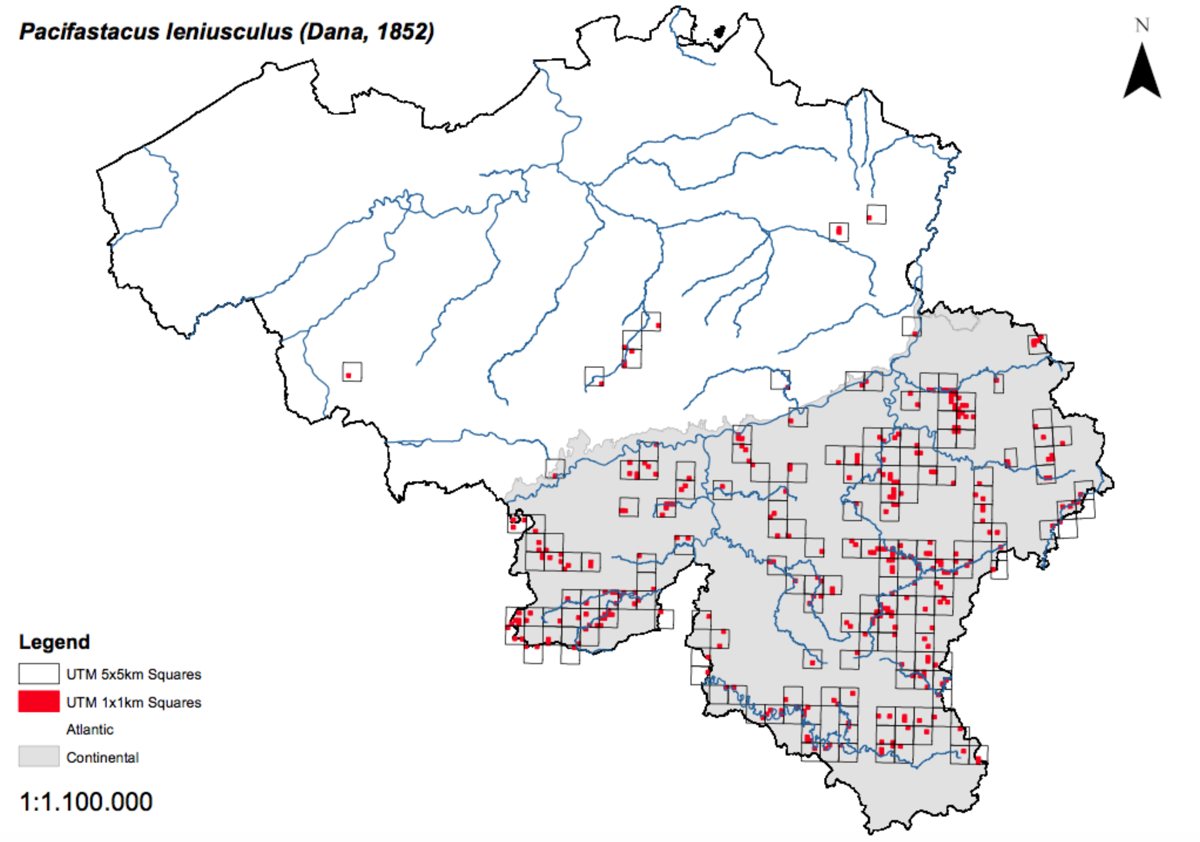
© Astacoides (Wikimedia commons)

Invasion scenario

- Invasion situation and history in Belgium: The signal crayfish is extremely widespread within the Continental bioregion, where it forms extensive populations in river systems. It is often found in permanent watercourses but also in ponds and lakes (i.e. habitats that were formerly occupied by the native noble crayfish). Local abundance is often very high, which leads to frequent recreational fishing. It was found in 325 1x1 km squares during the reference period 2000-2015. Establishment in the Atlantic bioregion is much less reduced so far, where its presence is limited to 11 squares; contagious distribution is however already observed in the upper part of the Dijle river basin. The species is also present in the Senne and Dyle valley in the Atlantic bioregion (not shown on map).

- Reliability of the BE distribution: The species could be more widespread in the Atlantic bioregion due to the absence of dedicated crayfish monitoring.

- Invasion situation in neighbouring countries: Signal crayfish is also poorly established in the Netherlands but one limited population is established in Tilburg close to the Belgian border (Koese and Soes 2011; Couperus 2015). In Northern France the species is spread in the Ardennes Natural Park in direct connection with the Belgian population (site MNHN). Extensive populations are also observed in Luxembourg (neobiota.lu).



	ATL	CONT
UTM 10km	7	93
UTM 5km	8	167
UTM 1km	11	325
% 1km SAC	36	81
Clustering index	1.15	0.56

1. *Management strategy – eradication*

- Methods and techniques: To achieve eradication, an integrated approach is applied using a range of control and containment techniques to suit different habitats and multiple life stages as proposed by Stebbing et al. (2014) and Southy-Grosset et al. (2016). Where possible, a combination of pond drawdown and fencing is implemented (Basilico et al 2013). Ponds are drained allowing water to pour out of water systems or by active pumping; drawdown is maintained during at least two successive years in order to kill burrowed animals by drought and especially frost during the wintertime. A barrier is installed around the drained ponds to avoid crayfish emigration and facilitate hand capture after drainage. At other sites, crayfish populations are controlled using a combination of intensive trapping with either eel predation (Müller & Frütiger 2001, Frütiger & Müller 2002) or sterile male release (SMRT) (Aquiloni & Zanetti 2014; Zanetti & Rucli 2014). Trapping is conducted during extensive periods using high trap density, high emptying frequency (at least every two days - http://www.life-rarity.eu/) and attractive baits as fish (Gherardi et al 2011, Stebbing et al 2014). Baited traps of various designs (Swedish traps, Evo-traps, collapsible traps, fyke nets, seine nets, etc.) or artificial refuge traps (ART) which are more efficient at catching subadult stages and gravid females

(Walter 2012), can be used. Most of the operations are coordinated and conducted by public water managers and/or specialised private companies commissioned by regional public authorities with the help of volunteers for trapping. The use of biocides, electrofishing and crayfish pathogens as biocontrol agents are not part of the strategy because of limited efficiency and/or legal limitations and/or strong non-target effects in the Belgian context (see e.g. Aldridge et al. 2015).

- Post-intervention verification: At locations where the species has been removed, monitoring is performed to ensure *P. leniusculus* does not recolonize. This is done using trapping systems and environmental DNA.

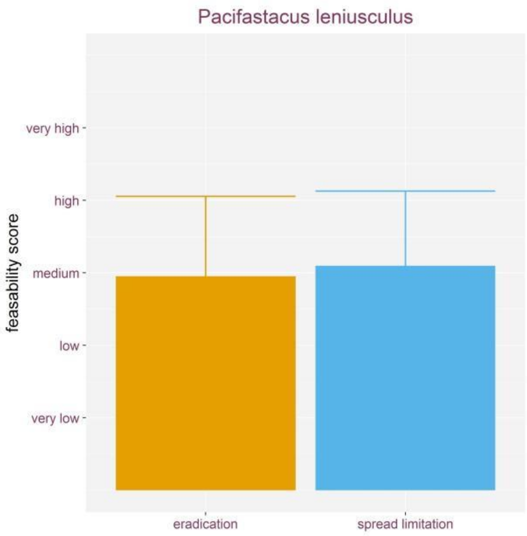
1. *Management strategy – spread limitation*

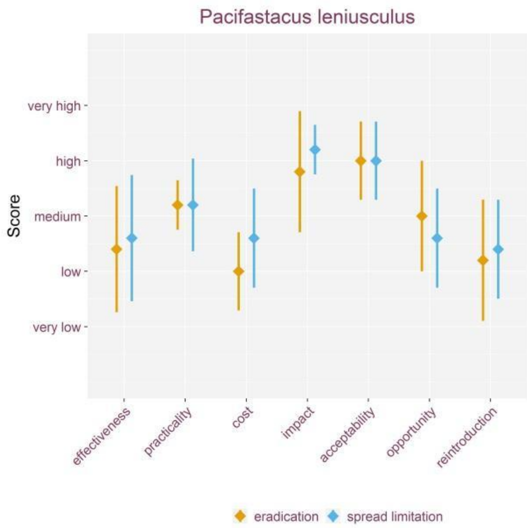
- Aim: *Option 2 Stand-still principle with core area(s)*
The strategy aims at limiting the spread out of the core area, the Continental bioregion. To this end, any new population found in the Atlantic bioregion is eradicated using the methods described in the eradication strategy. The few peripheral populations north of the Meuse basin are equally eradicated to maintain the core area.

- Methods and techniques: The same methods for eradication of populations are used to eradicate any new populations outside the maintained core area. Along the edges of the core area, private pond owners are stimulated to introduce predatory fish for biomanipulation. An increased surveillance effort is required along the edge of the core area using systematic inventories by dedicated personnel of upstream and downstream areas adjacent to known populations.

- Post-intervention verification: At locations where the species has been removed, monitoring is performed to ensure *P. leniusculus* does not recolonize. This is done using trapping systems and environmental DNA.

Results





The average feasibility score given by experts is medium, for both scenarios. The average scores of the individual criteria are also similar. Impact and acceptability score high in both scenarios, practicality scores between medium and high, effectiveness, cost, opportunity and reintroduction score on average from low to medium.

Outcome of the workshop

1. General considerations
Workshop participants agreed that in Flanders the populations might be still possible to manage and eradicate but that the invasion level in Wallonia is so high that it can't be eradicated successfully anymore.

2. Recommendations for management
Workshop participants recommended different strategies for the two main regions of Belgium. In Flanders the aim of the management should be eradication, in Wallonia the aim should be control or to limit spread (to be defined by the regional

authority). Conclusion: consensus for Belgium on spread limitation option 2 - containment of population in the continental region and eradication of any new population in the Atlantic region. In the continental region long term control is implemented.

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3.5.9 Red swamp crayfish *Procambarus clarkii* (rode Amerikaanse rivierkreeft, écrevisse de Louisiane)

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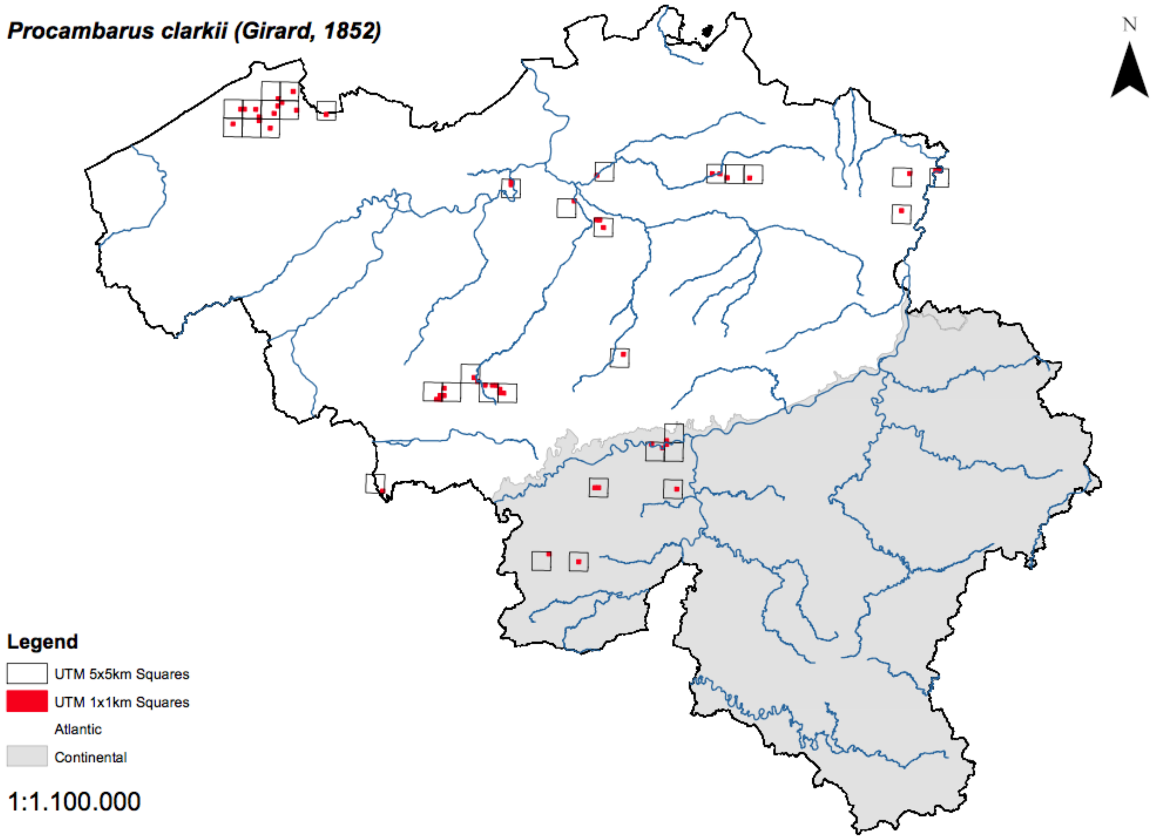
Invasion scenario

- Invasion situation and history in Belgium: During the reference period 2000-2015, the red swamp crayfish was observed in 44 1km squares in the Atlantic bioregion and 9 squares in the Continental bioregion. Most populations originate from recent (> 2008) introductions and this pattern is still visible in the distribution. It is known to occur in a few private isolated fishery ponds from both Atlantic and Continental bioregions with low to medium densities. In addition, distribution nuclei with high densities are observed at several locations in the Atlantic region, i.e. in a pond network along tributaries of the Dendre river near Soignies, several canals with slow flowing water in the polders area around Brugge (e.g. Damse Vaart), kasteelbeek (Ruddervoorde), Mechelen, Laakdal etc. Captive holding of *P. clarkii* by pet owners in Belgium is highly likely as it is one of the most popular crayfish species in pet shops.

- Reliability of the BE distribution: The species is in expansion (Boets et al. 2009), hence a growing number of recent records, and probably meanwhile has a much larger distribution e.g. in Antwerp and Limburg. Population numbers may be underestimated due to difficulties to record crayfish in private ponds and the absence of dedicated crayfish monitoring.

- Invasion situation in neighbouring countries: The center of distribution in the Netherlands is located in the randstad and around some big cities out there but the species is expanding rapidly (Couperus 2015). Established populations are present near the Belgian border, i.e. in Baarle-Hertog, in Roermond and in Maastricht in the Netherlands (Atlantic bioregion) and in France, in the Avesnois region and around Montmédy (Continental bioregion). So far not reported for Luxemburg (neobiota.lu).



	ATL	CONT
UTM 10km	20	6
UTM 5km	27	7
UTM 1km	44	9
% 1km SAC	11%	57%
Clustering index	0.37	1.00

1. *Management strategy – eradication*

- Methods and techniques: To achieve eradication, an integrated approach is applied using a range of control and containment techniques to suit different habitats and multiple life stages as proposed by Stebbing et al. (2014) and Southy-Grosset et al. (2016). Where possible, a combination of pond drawdown and fencing is implemented (Basilico et al 2013). Ponds are drained allowing water to pour out of water systems or by active pumping; drawdown is maintained during at least two successive years in order to kill burrowed animals by drought and especially frost during the wintertime. A barrier is installed around the drained ponds to avoid crayfish emigration and facilitate hand capture after drainage. At other sites, crayfish populations are controlled using a combination of intensive trapping with either eel predation (Müller & Frütiger 2001, Frütiger & Müller 2002) or sterile male release (SMRT) (Aquiloni & Zanetti 2014; Zanetti & Rucli 2014). Trapping is conducted during extensive periods using high trap density, high emptying frequency (at least every two days - http://www.life-rarity.eu/) and attractive baits as fish (Gherardi et al 2011, Stebbing et al 2014). Baited traps of various designs (Swedish traps, Evo-traps, collapsible traps, fyke nets, seine nets, etc.) or artificial refuge traps (ART) which are more efficient at catching subadult stages and gravid females

(Walter 2012), can be used. Most of the operations are coordinated and conducted by public water managers and/or specialised private companies commissioned by regional public authorities with the help of volunteers for trapping.
The use of biocides, electrofishing and crayfish pathogens as biocontrol agents are not part of the strategy because of limited efficiency and/or legal limitations and/or strong non-target effects in the Belgian context (see e.g. Aldridge et al. 2015)

- Post-intervention verification: Once the species has been removed, the location is monitored to ensure *P. clarkii* does not recolonize. This is done using trapping systems and environmental DNA.

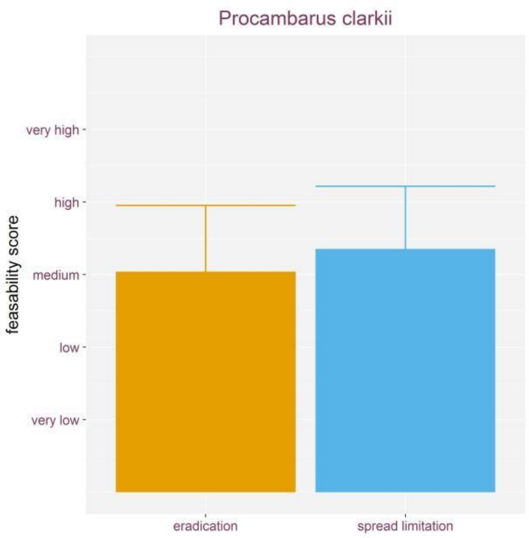
1. *Management strategy – spread limitation*

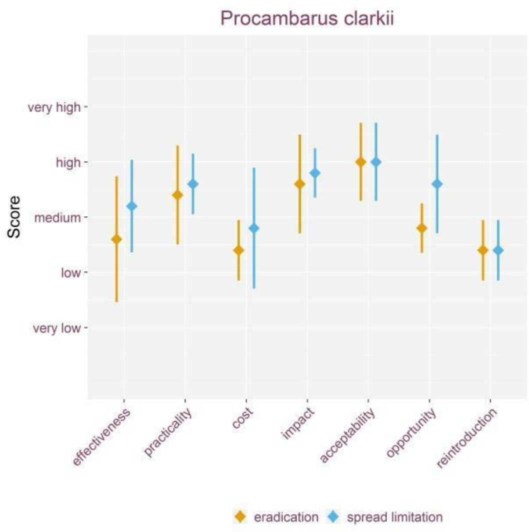
- Aim: *Option 2 Stand-still principle with core area(s)*
To this end, any new population found out of the core areas is eradicated using the methods described in the eradication strategy.

- Methods and techniques: Containment measures aiming to prevent further spread of *Procambarus clarkii* to new localities are applied. The spread limitation strategy aims at confining the crayfish into two core areas, i.e. along the Dendre river system and in the polders area around Brugge; those two populations are subjected to environmental managements techniques in order to decrease crayfish invasiveness, including reduction of water nutrients and enhancement of predatory fish populations. Downstream migration is also reduced as much as possible through the use of barriers and flow management as suggested by Kerby et al (2005). Any other population is eradicated using the same IPM approach as proposed in the eradication strategy. Surveillance, prevention and verification of the success of pest control is implemented as in the eradication strategy with a strong focus on any population found outside the two core areas.

- Post-intervention verification: At locations where the species has been removed, monitoring is performed to ensure *P. clarkii* does not recolonize. This is done using trapping systems and environmental DNA.

Results





Experts attributed an average feasibility score of medium to the eradication and the spread limitation scenario. The average scoring of the criteria is also similar for the two different scenarios, with the largest difference appearing to be the appreciation of the window of opportunity and to lesser extent the effectiveness (both score medium to high in the spread limitation strategy and between low and medium in the eradication scenario). Cost and practicality are scored between low and medium in both scenarios. practicality and impact are scored between medium and high in both scenarios. Acceptability is scored high in both scenarios.

Output of the workshop

1. General considerations

According to the workshop participants, complete eradication is not feasible at the national level, also reintroduction can't be avoided from neighbouring countries. Nevertheless, it seems to be the crayfish species that we can still act on for Belgium. The workshop participants could not make a clear recommendation for this species because of lack of information. They indicated more research, especially on the feasibility of methods, is needed before a decision can be taken.

2. Recommendations for management

The workshop participants could not indicate clearly the strategy to aim for. The general idea is that the spread limitation strategy would be feasible but in a less strict approach than the one presented in the assessment. A study should be pointing which populations could be eradicated and which could not.

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3.5.10 Marbled crayfish *Procambarus fallax* f. *virginalis* (marmerkreeft, écrevisse marbrée)

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Invasion scenario

- Invasion situation and history in Belgium: Not currently established in the wild in Belgium. Therefore, the invasion scenario is that at the point of detection there will be several individuals reported in connected artificial fishing ponds (closed system) in the river basin of the Dyle. This introductions is the result of the dumping of excess animals from an aquarium.

- Reliability of the BE distribution: The species is widely present and very popular in the aquarium culture (Pakota et al. 2015) yet has never been reported in the wild in Belgium. Whether it is really absent is difficult to say in the absence of dedicated crayfish monitoring.

- Invasion situation in neighbouring countries: In the Netherlands only known from Dordrecht where the species was found in 2004 but has not been reported since despite dedicated sampling (Koese and Soes 2011). Therefore it is assumed the species is not established in the Netherlands (Couperus, 2015). In Germany, established populations are known in Nordrhein-Westfalen and Baden-Wurttemberg and new populations continue to be discovered (Chucholl et al. 2012).

1. *Management strategy – eradication*

- Methods and techniques: In the context of a close system, the best method is a combination of pond drawdown, liming and fencing (Basilico et al 2013). The artificial fishing ponds are drained in allowing water to pour out of water systems or by active pumping; drawdown is maintained during at least 2 successive years in order to kill burrowed animals by drought and especially frost during the wintertime. A barrier is installed around the drained ponds to avoid crayfish emigration and facilitate hand capture after drainage. The use of sexual pheromones, pesticides, electrofishing and crayfish pathogens as biocontrol agents are not part of the strategy because of limited efficiency and/or legal limitations and/or strong non-target effects in the Belgian context (see e.g. Aldridge et al. 2015).

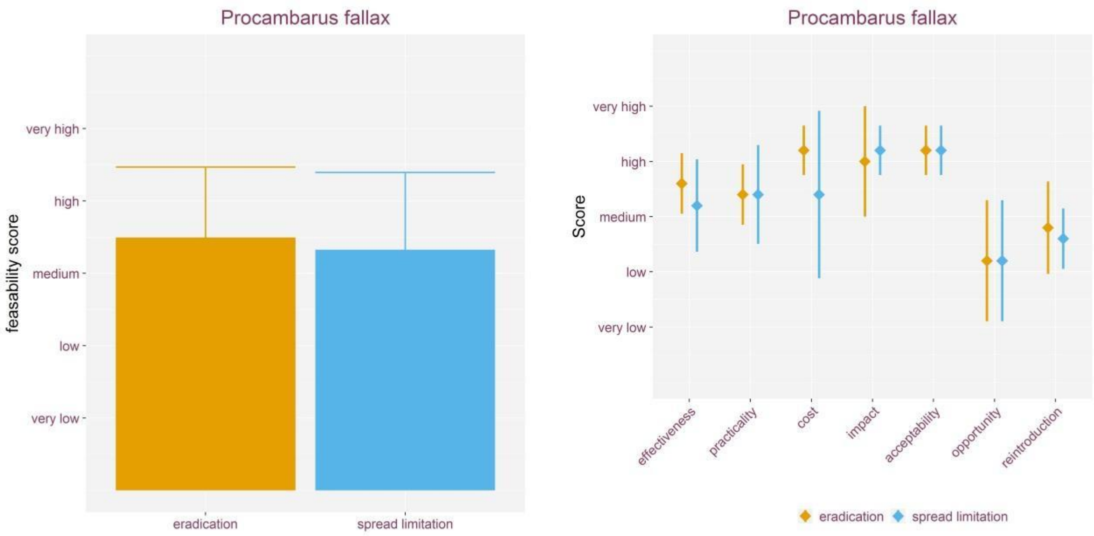
- Post-intervention verification: Once the species has been removed, the location including upstream and downstream areas are monitored by a dedicated team to ensure *P. fallax* does not recolonize. This is done using trapping systems and environmental DNA.

1. *Management strategy – spread limitation*

- Aim: *Option 1 Stand-still principle with a single or a few patches*

- Methods and techniques: The spread limitation strategy aims at limiting the presence of the species in Belgium to this artificial fishing pond system. Upstream and downstream migration is also reduced as much as possible through the use of barriers and flow management as suggested by Kerby et al (2005). Upstream and downstream areas adjacent to the site are regularly and continuously monitored in the long term by a professional team in order to react as quickly as possible if animals colonize it. In case animals are detected in these adjacent areas or in other water bodies in Belgium, the strategy is to eradicate them. To reach this objective, a range of control and containment techniques to suit different habitats and multiple life stages is conducted as proposed by Stebbing et al (2014) and Southy-Grosset et al (2016). Where possible, a combination of pond drawdown, liming and fencing is implemented (Basilico et al 2013). Ponds are drained in allowing water to pour out of water systems or by active pumping; drawdown is maintained during at least 2 successive years in order to kill burrowed animals by drought and especially frost during the wintertime. A barrier is installed around the drained ponds to avoid crayfish emigration and facilitate hand capture after drainage. In other sites, crayfish populations are controlled using a combination of intensive trapping with either eel predation (Müller & Frütiger 2001, Frütiger & Müller 2002) and/or sterile male release (Aquiloni & Zanetti 2014). Trapping is conducted during extensive periods using high trap density, high emptying frequency (at least twice a week) and attractive baits as fish (Gherardi et al 2011, Stebbing et al 2014). Most of the operations are coordinated and conducted by public water managers and/or specialised private companies commissioned by regional public authorities with the help of volunteers for trapping. The use of sexual pheromones, pesticides, electrofishing and crayfish pathogens as biocontrol agents are not part of the strategy because of limited efficiency and/or legal limitations and/or strong non-target effects in the Belgian context (see e.g. Aldridge et al. 2015)
- Post-intervention verification: Once the species has been removed, the location including upstream and downstream areas are monitored by a dedicated team to ensure *P. P. fallax* does not recolonize. This is done using trapping systems and environmental DNA.

Results



The average feasibility score of the eradication and the spread limitation scenario is medium. In both strategies, the average scoring of 5 out of 7 criteria is above medium (for effectiveness, practicality, cost, impact, acceptability). The average score given for reintroduction is close to medium. Window of opportunity is scored - on average - as low, with a lot of variation around the mean. Variation around the mean is large for 4 criteria of the spread limitation strategy.

Output of the workshop

1. General considerations
No general recommendations were made during the workshop

2. Recommendations for management
The workshop participants agreed on the eradication strategy as a guiding principle of the EU Regulation for species not yet present in Belgium.

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Annex 1: Criteria used for scoring the eradication strategy (adapted from Booy et al. 2017)

Effectiveness

This part of the assessment scores how effective the defined strategy would be regardless of other issues, such as the practicality of deploying methods, costs, acceptability of methods, etc. which are taken into account elsewhere. For example, the eradication strategy for a non-native fish in a river could be to flood it with the pesticide rotenone – this would likely score 'very effective' despite low scores associated with practicality, impact and acceptability.

Points to consider:

- How effective has this approach proven to be in the past or in an analogous situation?
- How effective is the approach despite the biology / behaviour of the target organism?

Practicality

How practical is it to deploy the described strategy? In particular, consider barriers that might prevent the use of the strategy such as issues gaining access to relevant areas, obtaining appropriate equipment, skilled staff, chemicals, etc. If there are any legal barriers to undertaking the work these should be assessed here.

Points to consider:

- How available are the methods in the EU?
- How accessible are the areas required to deploy the strategy?
- How easy would it be to obtain relevant licences or other approvals / permissions (e.g. access permission) to undertake the approach?
- How easy would it be to overcome legal barriers?
- How safe are the methods used in this approach (are there health and safety barriers)?

Cost

Cost relates to the total direct cost of the strategy. Total cost includes the cost of staff, resources, materials, etc. over the entire time period involved in the eradication and any required post surveillance and follow-up. Note indirect costs (e.g. loss of business) are considered an impact and not recorded here.

In your comment, indicate the period over which costs would be occurred (i.e. number of years) and, if possible, indicate whether the cost would be evenly spread, frontloaded or back loaded.

Impact

Impact relates to the impact of the strategy itself. It is important to note that any indirect economic impacts (i.e. economic consequences of the eradication strategy rather than the cost of the strategy itself) are recorded here and not under 'cost'.

Points to consider:

- How significant is the environmental harm caused by this approach?
- How significant is the economic harm caused by this approach? Examples of economic harm might include: reduction in the ability to trade or do business as a result of the management method, loss of earnings, reduction in tourism, reduction in house prices, etc.

- How significant is the social harm, including to human health, caused by this approach (note that this is different from acceptability below)? Examples of social harm might be a reduction in a person's use or enjoyment (e.g. preventing them walking in a woodland or fishing in a river), disruptions of communities, etc.

Acceptability

Acceptability relates to significant issues that could arise as a result of disapproval or resistance from individuals, groups or sectors. This does not include regulatory or legislative barriers which are considered under practicality.

- How acceptable is the approach likely to be based on environmental / animal welfare grounds? Note this question relates to likely criticism / resistance that the approach would meet based on environmental / animal welfare grounds.

- How acceptable is the approach likely to be to the general public?

- How acceptable is the approach likely to be to other stakeholders?

Assessing the window of opportunity

The window of opportunity relates to how quickly the species will spread beyond the point that the defined strategy would be effective. It is linked to the mechanism and rate of spread, which is considered during the risk assessment.

Assessing the likelihood of reintroduction

Assuming the strategy is successful, how likely is it that reintroduction will occur?

Annex 2: Guidance for scoring the feasibility of management of Union List species in Belgium.

Scoring

The scoring is done in an online system where all criteria are explained for convenience. It is highly advised to read this carefully before answering. Taking this information into account, the assessor always needs to follow his/her personal opinion when answering a question. Answers should be provided as much as possible based on evidence, and not on a purely hypothetical or speculative basis. Since appropriate data is very often lacking, cases that are similar (in dispersal capacity, biology, ...) may be used as a source of information (the higher the similarity, the better), but this should however be reflected in the uncertainty scores. It is advised to always employ the precautionary approach: when doubting among two options, the most 'pessimistic' option would be the option of choice.

An answer is required for every single question. The response score is a 5 point scale from 1-5. In all cases 1 is the least favourable and 5 the most. For example, a very effective eradication strategy scores 5, a very ineffective strategy scores 1, whereas a very inexpensive strategy (i.e. the cost favours taking action) scores 5, a very expensive one scores 1.

Criteria	**Score**				
	1	**2**	**3**	**4**	**5**
Effectiveness	Very ineffective	Ineffective	Moderate effectiveness	Effective	Very effective
Practicality	Very impractical	Impractical	Moderate practicality	Practical	Very practical
Cost	> € 10M	€ 1-10M	€ 200k - 1M	€ 50-200k	< €50k
Negative impact	Massive	Major	Moderate	Minor	Minimal
Acceptability	Very unacceptable	Unacceptable	Moderate acceptability	Acceptable	Very acceptable
Window of opportunity	< 2 months	2 months - 1 year	1 – 3 years	4-10 years	>10 years
Likelihood of reintroduction	Very likely	Likely	Moderate likelihood	Unlikely	Very unlikely
Conclusion (overall feasibility of eradication)	Very low	Low	Medium	High	Very high

Confidence scoring

A confidence rating should be provided for every response score. Confidence is recorded on a 3 point scale: 1-low, 2-medium, 3-high. Even where evidence is lacking, assessors should make best guess judgements and use the confidence rating score to reflect uncertainty. Confidence scoring is in line with the assessment of uncertainty used in the Harmonia+ protocol (D'hondt et al. 2015) which follows the IPCC guidelines on how to combine the quality of evidence with agreement among experts (Figure 2) (Mastrandrea et al. 2010). The degree of certainty associated with a given answer is scored as a level of confidence, evaluated as a function of two dimensions: evidence and agreement. The former more specifically deals with the type, amount, quality and internal consistency of available evidence, and is summarized as either 'limited', 'medium' or 'robust'. The latter more specifically deals with the degree of agreement between different pieces of evidence, and is summarized as either 'low', 'medium' or 'high'. Here too, the assessor always needs to follow his/her personal opinion when answering questions.

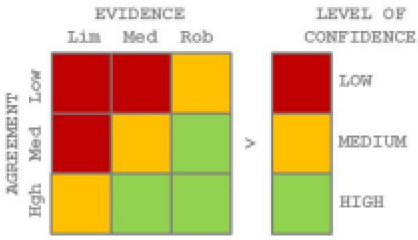

Figure 5: Uncertainty framework following IPCC guidelines (Mastrandrea et al. 2010).

Comments

Assessors are required to individually submit their feasibility and confidence scores with clear argumentation. This will allow the facilitator to track and understand potential dissensus among experts.

Consensus building

Consensus building offers the advantage of tracking and documenting differences in opinion throughout several rounds of consensus building e.g. by reducing linguistic uncertainty. Although consensus is desirable, lasting disagreements can occur. These should however not distract from the value of the consultation process and from explicitly documenting the underlying reasons for disagreement in transparent ways (Essl et al. 2016).

Annex 3: Main authors of strategies, number of assessments and names of assessors who provided assessments on the feasibility of management for the Union List species in Belgium.

Species	Main author scenario and strategies	Assessors	# assessments
Alopochen aegyptiaca	TA	Dido Gosse, Diederik Strubbe, Frank Huysentruyt	3
Asclepias syriaca	DG	Arnaud Monty, Bart Vandevoorde, Bram Dhondt, Quentin Groom, Wouter Van Landuyt	5
Baccharis halimifolia	TA	Anne-Laure Jacquemart, Bram Dhondt, Marijke Thoonen, Sam Provoost, Wouter Van Landuyt	5
Cabomba caroliniana	TA	Etienne Branquart, Iris Stiers, Johan van Valkenburg, Luc Denys	4
Callosciurus erythraeus	TA	Jim Casaer, Tim Adriaens, Vinciane Schockert	3
Corvus splendens	DG	Dido Gosse, Diederik Strubbe, Frank Huysentruyt	3
Elodea nuttalii	TA	Etienne Branquart, Iris Stiers, Jo Packet, Johan van Valkenburg	4
Eriocheir sinensis	TA	Adrien Latli, Elena Tricarico, Paul Stebbins, Pieter Boets	4
Gunnera tinctoria	DG	Bram Dhondt, Marijke Thoonen, Sam Provoost, Sonia Vanderhoeven, Wouter Van Landuyt	5
Heracleum mantegazzianum	EB	Arnaud Monty, Etienne Branquart, Filip Verloove, Sam Provoost, Sonia Vanderhoeven, Wouter Van Landuyt	6
Heracleum persicum	DG	Arnaud Monty, Bart Vandevoorde, Filip Verloove, Quentin Groom, Sonia Vanderhoeven	5
Heracleum sosnowsky	DG	Bart Vandevoorde, Filip Verloove, Marijke Thoonen, Quentin Groom, Sonia Vanderhoeven	5
Hydrocotyle ranunculoides	EB	Etienne Branquart, Iris Stiers, Jo Packet, Koen van Roeyen, Luc Denys	5
Impatiens glandulifera	EB	Bart Vandevoorde, Etienne Branquart, Filip Verloove, Marijke Thoonen, Sonia Vanderhoeven	5
Lagarosiphon major	TA	Etienne Branquart, Jo Packet, Johan van Valkenburg, Luc Denys	4
Lithobathes catesbeianus	TA	Gerald Louette, Hugo Verreycken, Sarah Descamps	3
Ludwigia grandiflora	EB	Etienne Branquart, Iris Stiers, Luc Denys	3
Ludwigia peploides	EB	Etienne Branquart, Iris Stiers, Luc Denys	3
Lysichiton americanus	EB	Arnaud Monty, Bart Vandevoorde, Bram Dhondt, Marijke Thoonen, Quentin Groom, Wouter Van Landuyt	6
Microstegium vimineum	DG	Arnaud Monty, Bram Dhondt, Filip Verloove, Quentin Groom, Sonia Vanderhoeven	5
Muntiacus reevesii	TA	Dido Gosse, Jim Casaer, Tim Adriaens	3
Myocastor coypus	EB	Jane Reniers, Jim Casaer, Luc Baufay	3
Myriophyllum aquaticum	EB	Etienne Branquart, Jo Packet, Johan van Valkenburg	3
Myriophyllum heterophyllum	EB	Etienne Branquart, Jo Packet, Johan van Valkenburg	3
Nyctereutes procyonoides	EB	Jim Casaer, Luc Baufay	2

Ondatra zibethicus	TA	Jane Reniers, Luc Baufay, Tim Adriaens	3
Orconectes limosus	TA	Adrien Latli, Denis Parkinson, Elena Tricarico, Paul Stebbins, Pieter Boets	5
Orconectes virilis	DG	Adrien Latli, Denis Parkinson, Dido Gosse, Elena Tricarico, Paul Stebbins	5
Oxyura jamaicensis	TA	Frank Huysentruyt, Jim Casaer, Tim Adriaens	3
Pacifastacus leniusculus	EB	Adrien Latli, Denis Parkinson, Elena Tricarico, Paul Stebbins, Pieter Boets	5
Perccottus glenii	DG	Alain De Vocht, Gerald Louette, Hugo Verreycken	3
Persicaria perfoliata	DG	Dido Gosse, Etienne Branquart, Jane Reniers, Sonia Vanderhoeven, Tim Adriaens	5
Procambarus clarkii	EB	Adrien Latli, Denis Parkinson, Elena Tricarico, Paul Stebbins, Pieter Boets	5
Procambarus fallax	DG	Adrien Latli, Denis Parkinson, Elena Tricarico, Paul Stebbins, Pieter Boets	5
Procyon lotor	EB	Frank Huysentruyt, Luc Baufay, Vinciane Schockert	3
Pseudorasbora parva	TA	Alain De Vocht, Gerald Louette, Hugo Verreycken	3
Sciurus carolinensis	TA	Jane Reniers, Tim Adriaens, Vinciane Schockert	3
Sciurus niger	TA	Jane Reniers, Tim Adriaens, Vinciane Schockert	3
Tamias sibiricus	TA	Luc Baufay, Tim Adriaens, Vinciane Schockert	3
Threskiornis aethiopicus	TA	Dido Gosse, Diederik Strubbe, Frank Huysentruyt	3
Trachemys scripta	EB	Gerald Louette, Hugo Verreycken, Sarah Descamps	3
Vespa velutina	DG	Etienne Branquart, Quentin Rome, Tim Adriaens	3