Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium.

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1. Introduction

Harmonia is an information system on non-native invasive species in Belgium, which is developed at the initiative of scientists gathered within the Belgian Forum on Invasive Species (http://ias.biodiversity.be). This system aims at collecting standardised information on exotic species which are assumed to be detrimental to native biodiversity in Belgium. It aims to include a high diversity of taxonomic groups from terrestrial, freshwater and marine environments.

Species included in the system are allocated to different list categories based on a simplified environmental impact assessment protocol (ISEIA), and geographic distribution in Belgium (species invasion stage). Such categorisation offers a scientific background to prioritise actions to prevent introduction and mitigate the impact of invasive species, including the improvement of the legislative framework at the federal and the regional levels. This standard provides detailed instructions about the methodology used for this categorisation.

2. Data source

Information is provided to the system by scientists involved in the Belgian Forum on Invasive Species. As much as possible, data entered in the database refers to the available published literature, which include peer-reviewed journals, books, grey sources (reports, etc.) and on-line databases dedicated to invasive species in Europe. Data from field surveys are also used as they provide important information about the naturalisation of new exotic species in Belgium and their habitat preferences.

Scientific nomenclature refers either to national (e.g. Flora of Belgium and neighbour areas) or international standards (e.g. Fishbase).

3. Species classification in the BFIS list system

A list system designed as a two dimensional ordination (environmental impact x invasion stage) is used to categorise non-native alien species found in Belgium and in neighbour areas, based on the guidelines proposed by the CBD decision VI/7 and the European strategy on Invasive Alien Species (figure 1).

Environmental impact and invasion stage are assessed for each species by different scientists, based on the methodology described hereafter. Results are discussed afterwards within the group to find a consensus before being published on the internet.

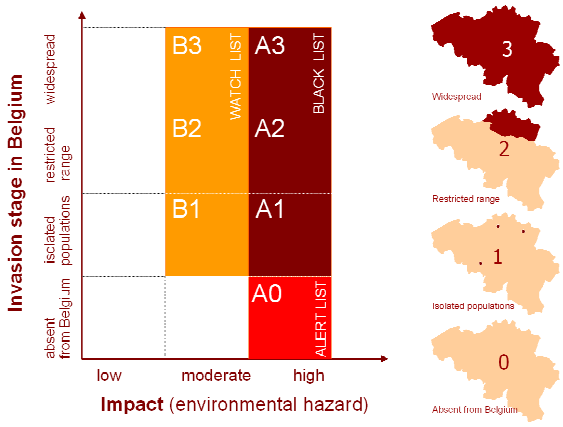

Figure 1 - List system proposed by the Belgian Forum on Invasive Species to identify organisms of most concern for preventive and mitigation actions.

4. Species screening

Not all non-native species are considered to be integrated in the *Harmonia* information system. Only organisms that are already established in Belgium or in neighbour areas characterised by similar eco-climatic conditions (Germany, Ireland, Luxembourg, Netherlands, Northern France, Switzerland and UK; hereafter Western Europe) are taken in consideration[1]. A species is considered as established or naturalised as soon as it is able to reproduce consistently in the wild and sustain populations over several life-cycles through sexual or asexual modes without direct intervention by man (= self-perpetuating populations).

Among the non-native species established in Western Europe, a special attention is given to:

(i) Non-native species that are known to cause adverse impacts on biodiversity and/or ecosystem functioning, including those that already colonised most of their potential habitats;

(ii) Species that recently expanded their geographic range, for which an adverse impact on biodiversity and/or ecosystem functioning is likely.

[1] Non-native species for which there is no evidence of establishment in Western Europe should be evaluated through a specific protocol to assess invasion likelihood. This protocol has to take into account both introduction pathways and potential for establishment in our eco-climatic conditions (see e.g. Baker et al. 2005 and EPPO 2006).

5. Methodology for environmental hazard assessment

A simplified hazard assessment methodology referred to as the Invasive Species Environmental Impact Assessment (ISEIA) was developed to classify non-native species into the BFIS list system and to identify those of most concern for preventive and mitigation actions.

This protocol is intended to allocate non-native species within the different hazard categories of the *Harmonia* information system, as an attempt to minimise the use of subjective opinions and to warrant the transparency and the repeatability of the assessment process (Daehler et al. 2004). The ISEIA protocol consists of four sections matching the last steps of the invasion process, i.e. potential for spread, colonisation of natural habitats and adverse ecological impacts on native species and ecosystems. It has to be noted that this protocol aims to assess environmental risks only and that direct impacts of non-native species on human interests (public health, plant protection, etc.) are not explicitly taken in consideration in the *Harmonia* system, even if adverse ecological impacts frequently induce economic damages in the long term.

Contrary to predictive pest risk assessment protocols mainly based on species' intrinsic attributes for evaluating invasion likelihood (e.g. EPA, EPPO and IPCC standards), the ISEIA approach favours the use of documented invasion histories in previously invaded areas to assess properly their potential to cause adverse ecological effects on the Belgian territory (non native species are likely to cause significant impacts on native species and ecosystems in Belgium if they have already done so in neighbour areas).

The ISEIA protocol allows to allocate species in one of the three following risk categories:

- Category A (black list): includes species with a high environmental risk;
- Category B (watch list): includes species with a moderate environmental risk on the basis of current knowledge;
- Category C: includes other non-native species, that are not considered as a threat for native biodiversity and ecosystems (low environmental risk).

Scoring system

A three point scale is selected for the assessment as it is felt to provide an adequate balance between resolution and simplicity. Providing that information exists and is well documented in the literature (low level of uncertainty), the following scores are used as much as possible for the different parameters,:

- L = low, score = 1
- M = medium, score = 2
- H = high, score = 3

When the parameter is only poorly documented, leading assessment to be based only on expert judgement and field observations, the scoring system is adapted as follows:

- Unlikely, score = 1
- Likely, score = 2

At last, when nothing can be said about the parameter (no information):

- DD = deficient data, no score.

5.1 Dispersion potential or invasiveness

This section addresses the potential of an organism (individuals, seeds, propagules, etc.) to spread in the environment by natural means and/or by human assistance, as a function of dispersal mode, reproduction potential and human commensalism.

The three following situations are recognised:

Low risk. The species doesn't spread in the environment because of poor dispersal capacities and a low reproduction potential. Examples: *Aesculus hippocastanum*, *Zea mays*.

Medium risk. Except when assisted by man, the species doesn't colonise remote places. Natural dispersal rarely exceeds more than 1 km per year. The species can however become locally invasive because of a strong reproduction potential. Examples: *Ameiurus nebulosus, Arion lusitanicus, Robinia pseudacacia, Tamias sibiricus*.

High risk. The species is highly fecund, can easily disperse through active or passive means over distances > 1 km/year and initiate new populations. Are to be considered here plant species that take advantage of anemochory (*Senecio inaequidens*), hydrochory (*Ludwigia grandiflora*) and zoochory (*Prunus serotina*), insects like *Harmonia axyridis* or *Cameraria ohridella* and all the bird species.

5.2 Colonisation of high conservation value habitats

This addresses the potential for an exotic species to colonise habitats with a high conservation value (irrespective of its dispersal capacities), based on habitat preference information from native and invaded areas. This potential is mainly limited by the ability of the new species to establish in habitats with specific abiotic conditions and to outcompete native species that are already present ('biotic resistance').

Habitats with a high conservation value are those where disturbance by man is minimal, thus allowing specific natural communities and threatened native species to occur. Natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers and ponds provided with natural banks and estuaries (see e.g. the list of natural habitats in the Annex 1 of the 92/43/EEC Directive) are considered as habitats with a high conservation value. Parks, orchards, planted forests, fallow lands, road embankments are habitats with an intermediate value. At last, man-made habitats like channels, farmlands or urban areas are classified as sites with a low conservation value.

Scoring system (adapted from the invasive categories of Cronk & Fuller 1995):

Low risk. Populations of the non-native species are restricted to man-made habitats (low conservation value). Examples: *Linepithema humile*, *Setaria verticillata*;

Medium risk. Populations of the non-native species are usually confined to habitats with a low or a medium conservation value and may occasionally colonise high conservation value habitats. Examples: *Lepomis gibbosus, Sander lucioperca, Solidago gigantea*;

High risk. The non-native species often colonises high conservation value habitats (i.e. most of the sites of a given habitat are likely to be readily colonised by the species when source populations are present in the vicinity) and makes therefore a potential threat for red-listed species. Examples: *Ludwigia grandiflora*, *Lysichiton americanus*, *Procyon lotor*, *Spartina townsendii*, *Umbra pygmaea*.

5.3 Adverse impacts on native species

This section addresses the potential of exotic species to cause species replacement through different mechanisms. Impacts may include (i) predation/herbivory, (ii) interference and exploitation competition (including competition for plant pollinators), (iii) transmission of diseases to native species (parasites, pest organisms or pathogens) and (iv) genetic effects such as hybridisation or introgression with native species. Such interactions may lead to change in native population abundance or in local extinction. They should be documented from invasion histories within Belgium or other regions characterised by similar eco-climatic conditions.

Exotic species that act as generalist predators or those which have native congeners showing similar eco-morphological traits are especially on target. The different types of interactions are considered separately for each non-native species. Their severity is scored as follows:

Low risk. Data from invasion histories suggest that the negative impact on native populations is negligible;

Medium risk. The non-native species is known to cause local changes (< 80%) in population abundance, growth or distribution of one or several native species, especially among common and ruderal species. This effect is usually considered as reversible. Examples: transmission of sublethal diseases to native species (*Crassostrea gigas, Mustela vison, Sander lucioperca*), predation/herbivory pressure leading to abundance decrease of native species (*Branta canadensis, Nysius huttoni*), moderate competition with native species (*Alopochen aegyptiacus, Pimephales promelas, Senecio inaequidens*);

High risk. The development of the non-native species often cause local severe (> 80%) population declines and the reduction of local species richness[2]. At a regional scale, it and can be considered as a factor precipitating (rare) species decline. Those non-native species form long-standing populations and their impacts on native biodiversity are considered as hardly reversible. Examples: strong interspecific competition in plant communities mediated by allelopathic chemicals (*Fallopia japonica, Prunus serotina, Solidago spp*., etc.), intraguild predation leading to local extinction of native species (*Dikerogammarus spp., Harmonia axyridis, Neogobius melanostomus, Rana catesbeiana*), transmission of new lethal diseases to native species (*Pacifastacus leniusculus, Pseudorasbora parva, Rana catesbeiana, Sciurus carolinensis*).

Species impact score = maximal score recorded for predation/herbivory, competition, disease and genetic interaction sections.

5.4 Alteration of ecosystem functions

This section addresses the potential of an exotic species to alter native ecosystem processes and structures in ways that significantly decrease native species ability to survive and reproduce. Ecosystem impacts may include (i) modifications of nutrient cycling or resources pools (e.g. eutrophication), (ii) physical modifications of the habitat (changes or hydrologic regimes, increase of water turbidity, light interception, alteration of river banks, destruction of fish nursery areas, etc.), (iii) modifications of natural successions and (iv) disruption of food webs, i.e. a modification of lower trophic levels through herbivory or predation (top-down regulation) leading to ecosystem imbalance.

[2] Exotic plants that are known to often form large and dense monospecific stands are considered as a high risk for native plant communities when the potential for species replacement is poorly documented.

Scoring system:

Low risk. The impact on ecosystem processes and structures is considered as negligible.

Medium risk. The impact on ecosystem processes and structures is moderate and considered as easily reversible. Examples: temporary modification of soil or water properties (*Lemna spp*.), decrease or increase of the rate of colonisation of open habitats by shrubs and trees (*Pinus nigra*);

High risk. The impact on ecosystem processes and structures is strong and difficult to reverse. Examples: alteration of physico-chemical properties of water by invasive aquatic plants (*Hydrocotyle randunculoides, Ludwigia spp., Myriophyllum aquaticum*), facilitation of river bank erosion (*Impatiens glandulifera*), prevention of natural regeneration of trees (*Lonicera japonica, Prunus serotina, Rhododendron ponticum*), destruction of river banks, reed beds and/or fish nursery areas (*Eriocheir sinensis, Myocastor coypus, Ondatra zibethicus*), food web disruption (*Crassostrea gigas*, *Lates niloticus*).

Ecosystem impact score = maximal score recorded for nutrient cycling, physical alteration, natural successions and food web sections.

Note: When impact is strongly dependent on the type of ecosystem, one should consider the worst case scenario, with a special focus on vulnerable ecosystems.

5.5 Global environmental risk

Consistent with other risk assessment standards, equal weight is assigned to each of the four sections, i.e. dispersion potential, colonisation of natural habitats, species and ecosystem impacts. The global ISEIA score is the sum of risk rating scores from the four previous sections (global score is between 4 and 12). It is used to allocate species to the different risk categories (see table).

ISEIA score	List category
11-12	A (black list)
9-10	B (watch list)
4-8	C

6. Invasion stage in Belgium

In addition to species classification in risk categories, invasion stage is also taken in consideration in the list system as it provides important information to prioritise actions in the field, especially for invasive species which are highly detrimental.

As illustrated in figure 1, a distinction is made between:

(i) Alert list species: species that are not yet naturalised in Belgium but are invasive in neighbour areas. Note that only species with a high environmental impact among non established species are taken in consideration, e.g. organisms from the list of worst invasive alien species threatening biodiversity in Europe (SEBI 2010) or from the priority list of invasive alien plants to be managed in EPPO member countries. Importation and trade regulation are the adequate tools to avoid intentional introduction of alert list species in our country;

(ii) Species under naturalisation (isolated populations): species that are at the prime stage of the invasion process in Belgium, that only form recent and small isolated populations located in the immediate vicinity of

their introduction points, resulting in a non contagious or random distribution of the observations. These species only colonised few of their potential habitats in the country and can still be eradicated at a national scale at a very low cost corresponding to the damage they can cause in the future if no action is undertaken;

(iii) Naturalised species with a restricted range: species whose populations are in strong expansion in the wild and form new populations far away from their introduction points after an active dispersion phase, but whose distribution is still limited to some biogeographic areas in Belgium. Those species are likely to be contained in some regions of the country providing that active control measures are undertaken;

(iv) Widespread naturalised species: species that are widely distributed in the country and that already colonised most of suitable sites for their establishment.

7. List of contributors

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Appendix – List allocation of some non native species through the ISEIA protocol

	5.1	5.2	5.3 – Impact on native species				5.4 – Impact on ecosystems				ISEIA	LIST
	Spread	Natural habitats	Predation	Competition	Disease transm.	Hybridisation	Nutrient cycling	Physical alter.	Successions	Food webs	SCORE	
Aix galericulata	high	high	low	likely	DD	low	low	low	low	low	**9**	**B**
Cameraria ohridella	high	medium	low	low	low	low	low	low	low	DD	**7**	**C**
Carassius gibelio	high	high	low	high	low	high	medium	high	low	high	**12**	**A**
Crassostrea gigas	high	high	low	high	medium	likely	likely	high	low	high	**12**	**A**
Epilobium ciliatum	high	high	low	unlikely	low	medium	DD	low	low	low	**9**	**B**
Eriocheir sinensis	high	high	high	likely	DD	low	DD	high	low	likely	**12**	**A**
Harmonia axyridis	high	high	high	high	low	low	low	low	low	likely	**11**	**A**
Ludwigia grandiflora	high	high	low	high	low	low	high	high	high	low	**11**	**A**
Ondatra zibethicus	high	high	high	DD	DD	low	medium	high	high	likely	**12**	**A**
Pacifastacus leniusculus	high	high	medium	high	high	low	low	low	low	likely	**11**	**A**
Procyon lotor	high	high	likely	DD	DD	low	low	low	low	low	**9**	**B**
Robinia pseudacacia	medium	medium	low	high	low	low	high	high	high	low	**10**	**B**
Sciurus carolinensis	high	high	medium	high	high	low	low	medium	low	likely	**11**	**A**
Tamias sibiricus	medium	high	medium	likely	DD	low	low	low	low	likely	**9**	**B**
Umbra pygmaea	medium	high	low	medium	DD	low	low	low	low	low	**8**	**C**