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

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1. Introduction

Harmonia is a new 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 (see a beta version of the system at 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 to the following international standards:
- Flora Europaea (http://rbg-web2.rbge.org.uk/FE/fe.html)
- Fauna Europaea (http://www.faunaeur.org/)
- Fishbase (www.fishbase.org/)

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).

Those two parameters 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.

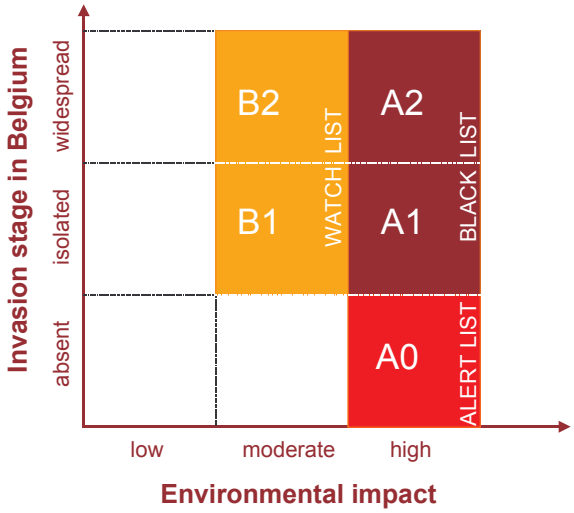

Figure 1 - List system proposed by the Belgian Forum on Invasive Species to identify organisms of most concern for preventive and mitigation actions.

4. Species screening

Not all non-native species are considered to be integrated in the *Harmonia* information system. Only organisms that are already established Belgium or in neighbour areas characterised by similar eco-climatic conditions (Denmark, Germany, Ireland, Luxembourg, Netherlands, Northern France 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).

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 potential and established non-native species into the BFIS list system and to identify non-native species of most concern for preventive and mitigation actions. The ISEIA protocol is adapted from the EPPO pest risk analysis guidelines, the Invasive Fish Risk Assessment system and other risk assessment schemes (see list of references).

This protocol is intended to replace the current methodology used to allocate species in the list system of the BFIS website, as an attempt to take more quantitative information into account, to improve data accuracy, standardisation and objectiveness 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 model proposed by Lockwood et al. (2007), i.e. potential for spread, colonisation of natural habitats and adverse ecological impacts of non-native species and ecosystems. It has to be noted that this protocols aims to assess environmental risks only and that direct impacts on human interests (public health, plant protection, etc.) are not taken in consideration in the *Harmonia* system.

ISEIA parameters are estimated through a pragmatic approach where organism's history of impact in previously invaded areas, life-history traits and results of laboratory experiments are used to make tentative prediction of its environmental impact in Belgium (= potential to cause adverse effects).

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, that should be managed through adequate action plans in the field;
- Category B (watch list): includes species with a moderate environmental risk on the basis of current knowledge, that deserve to be in the focus of monitoring programmes and studies on impacts;
- 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 based 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 and reproduction potential.

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.

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.

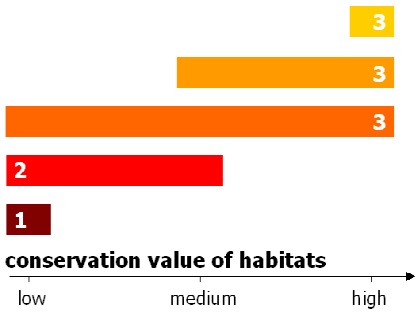

Figure 2 – Characterisation of species potential to colonise high conservation value habitats (1-3).

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: *Dikerogammarus spp.*, *Linepithema humile*, *Setaria verticillata*;

Medium risk. Populations of the non-native species are able to establish in habitats with a low or a medium conservation value. Examples: *Cameraria ohridella, Robinia pseudacacia.*, *Solidago gigantea*, *Sander lucioperca*;

High risk. The non-native species is known to colonise sites with a good conservation value 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, (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 can be documented in Belgium or in neighbour areas characterised by similar eco-climatic conditions.

Exotic species that act as generalist predators or those which have native congeners showing similar eco-morphologicall 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. Impact on non-native species through a specific interaction is considered as negligible and has no impact on native species at population or species level;

Medium risk. The development of the non-native species can induce local changes in population abundance, growth or distribution of native species. This impact 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 can cause local extinction and the reduction of local native species richness. Such impacts are considered as irreversible. 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 (*Dikerogammarus spp., Harmonia axyridis, Neogobius melanostomus, Rana catesbeiana*), transmission of lethal diseases for native species (*Pacifastacus leniusculus, 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 functions. 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. strong impact on lower trophic levels through herbivory or predation leading to ecosystem imbalance.

Scoring system:

Low risk. The impact on ecosystem functions is considered as negligible.

Medium risk. The impact on ecosystem functions 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 functions 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 (see figure 1).

A distinction is made between:

(i) Alert list species: species that are not yet present in Belgium but are invasive in neighbour areas. Note that only species with a high environmental impact are taken in consideration, e.g. species 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, which are located in the

immediate vicinity of their introduction points. 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 (widespread): species whose populations are in strong expansion in the wild and form new populations far away from their introduction points after an active dispersion.

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	medium	high	high	medium	DD	likely	**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	low	low	low	low	low	low	**8**	**C**