Risk assessment after the Harmonia+ protocol of invasive alien vascular plant species in Luxembourg

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Abstract. A risk assessment of 62 invasive alien vascular plant species has been carried out for Luxembourg, using the Belgian Harmonia+ protocol that assesses the invasion process and the impacts on the environment, cultivated plants, domesticated animals, public health and on human infrastructure. In the list resulting from the ranking scheme (62 spp. = 100 %), two threshold values are proposed for listing species in a national list of invasive alien species pursuant to the EU Regulation 1143/2014 on Invasive Alien Species: (a) 29 species (47 %) having an overall impact score ≥ 0.50; (b) from the remaining list, 7 species (11 %) having an overall risk score ≥ 0.25. In total, 36 species (58 %) are thus potential candidates for listing in a national list of IAS of Luxembourg concern.

Keywords. IAS, ranking scheme.

1. Introduction

All EU Member States have – to a greater or lesser extent – problems with invasive alien species (IAS) in their territory (Kettunen et al. 2008). The EU Regulation 1143/2014 on IAS (Anonymous 2014) entered into force on 1st January 2015. This regulation seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimise and mitigate the human health or economic impacts that these species can have. The regulation foresees four types of interventions: prevention, early detection, rapid eradication and management.

Furthermore, as implementation of the regulation, the European Commission has adopted a list of IAS of Union concern (Anonymous 2016), which has been updated twice (Anonymous 2017, 2019). This list was drawn up together with the Member States, represented through a Scientific Forum and a Committee on IAS, based on risk assessments and scientific evidence.

Until recently, reliable knowledge concerning alien species in Luxembourg was quite patchy. For over a decade, studies have intensified on the topic and in recent years, Luxembourg-related information on IAS has been made available online at the web portal neobiota.lu (Ries & Pfeiffenschneider 2020a). Following the EU regulation on IAS, the Luxembourg government created in 2016 a coordination group for IAS in Luxembourg, under the name "Groupe de coordination sur les espèces exotiques envahissantes au Luxembourg" (Mémorial 2016). This coordination group helps to intensify studies and to supply policies about IAS in Luxembourg.

Risk assessments are efficient tools enabling decision makers to develop legislation, policy and risk management strategies resulting in import limitations, restrictions

in trade and use of concerned species, as well as control and eradication measures. Detailed risk assessment methods for IAS are quite labour-intensive and there is a wide range of scientific approaches. For the various existing black and watch lists the assessment criteria are more or less extensive, occasionally including economic impacts and/or health related aspects (Genovesi & Scalera 2007, Essl et al. 2008, 2011).

One of the approaches enabling an expert group to evaluate the potential risk of the different species in a reasonable amount of time is the Invasive Species Environmental Impact Assessment (ISEIA) elaborated by the Belgian Forum on Invasive Species - BFIS (Branquart 2009). This approach, commonly known as the ISEIA Protocol, has already been applied in Luxembourg to assess vascular plants (Ries et al. 2013), vertebrates (Ries et al. 2014) and invertebrates (Ries et al. 2017). Another approach is a risk assessment based on a protocol compliant with criteria of the EU regulation for risk assessments for listing IAS of EU concern. Such an assessment has to consider, besides environmental risks, further criteria like impacts on human health and infrastructure, impacts on ecosystem services as well as the potential effects of climate change on the species' invasive potential and the different risks.

From several protocols available throughout the EU (Roy et al. 2014: 100 ff.), we opted for the internet-based Harmonia+ protocol developed by the Belgian Biodiversity Platform and widely used in the Benelux countries and beyond (D'Hondt et al. 2015, Vanderhoeven et al. 2015). Using the same protocol enables territories sharing similar invasive species and eco-climatic conditions to exchange information and experiences on a comparable basis. The assessed species can be sorted according to the resulting scores for different purposes. A list of assessed IAS sorted according to the overall risk or impact score can be helpful to determine which species should be included on a national list of IAS pursuant to Article 12(1) of the EU Regulation 1143/2014 on IAS (Anonymous 2014).

2. Methods

The risk assessment was performed using the Harmonia+ protocol on the online platform of the Belgian Biodiversity Platform (BFIS 2019, http://ias.biodiversity.be/protocols/). This protocol covers the complete invasion process (based on Blackburn et al. 2011) and refers to multiple kinds of impacts. It consists of 41 questions grouped in six categories: context, introduction, establishment, spread, impacts and future effects of climate change. The impact categories concern: 1) environment, 2) cultivated plants, 3) domesticated animals, 4) public health, 5) human infrastructure, 6) ecosystem services. A risk score and level of confidence is assigned to each question. Basically, risk scores are standardised as low, medium or high. As results are numerical scores between 0 and 1, they allow for a clear ranking of species' overall risks. The protocol can thus be used (1) for horizon scanning of emerging species or (2) for prioritisation schemes of already-present species (D'Hondt et al. 2015). Harmonia+ belongs to the risk-screening procedures which inherently deal with negative impacts only, and leave eventual positive impacts outside of scope.

The time expenditure for the assessment of a single species is estimated to be from 30 minutes to one hour, depending on the quantity and quality of available information about the species and on the expert's knowledge of the species. The following general sources were mainly used to back up expert knowledge: the nature conservation invasiveness assessments for Germany (Nehring et al. 2013), the online IAS datasheets from the Belgian Biodiversity Platform (BFIS 2019) and the Invasive Species Compendium by CABI (2019).

Concerning the assessment process, the optimal use envisioned by D'Hondt et al. (2015) was followed: (1) In 2018, the assessments were performed individually by three experts, thus allowing each of them to input personal views and appreciation; (2) an automated report was generated comparing the assessments in detail indicating major differences between the assessors on specific species and questions; (3) a consensus building process took place to make sure that experts

share a common understanding of criteria and definitions. Apparent disagreements were openly discussed to look whether these trace back to linguistic or epistemic uncertainties that can be solved, or persist as different opinions. In most cases, the assessors reconciled their differences and agreed upon common or similar assessment valuations. Due to lack of resources and time, we could not improve quality control of our risk assessments through formalised peer review with clear feedback between assessors and reviewers, as recommended by Vanderhoeven et al. (2017).

Concerning the assessment calculation process, default operation and weight settings (D'Hondt et al. 2015) were used to ensure comparability between the assessments of our neighbouring countries. This process produced rounded values for all modules and the resulting invasion, impact and overall risk scores presented in Table 1. A recalculation based on the values of individual modules in Table 1 will therefore produce slight differences.

The invasion score is calculated as the geometric mean of the scores for introduction, establishment and spread. According to the underlying unified framework for biological invasions (Blackburn et al. 2011: 336), the invasion score is zero as soon as any of its three constituent processes is insignificant, since the geometric mean is zero as soon as its dataset contains a zero. This is the case, for instance, with *Spiraea* ×*billardii* (cf. Table 1), for which the process of spread was scored 0.00 due to its very low active spread rates. In such a case, the overall risk score of a species is zero as well, according to the product of the invasion score (0.00) with the impact score (0.43).

The scores from the different impact modules (environment, plants, animals, humans and infrastructure) are by default aggregated into a global impact score taking the maximum value, considering the highest risk as decisive. Instead of taking the value of the module with the highest aggregated score, the general impact score is the arithmetic mean of the maximum impact value set of all assessors. This is the reason why, for several species, the overall impact score is slightly different to the maximum value of the individual aggregated impact scores listed in Table 1. In the case of *Asclepias syriaca* for example, "animal impact" is the module with the highest score (0.33). The general impact score is however 0.37 as it is the arithmetic mean of the three maximum scores given by the three assessors, independently of the module, i.e. (0.50 + 0.35 + 0.25) : 3 = 0.36666666666.

Finally, the overall risk score is calculated as the product of invasion score and general impact score, e.g. for *Asclepias syriaca*: 0.52 * 0.37 = 0.1924.

The modules of questions related to ecosystem services and climate are not taken into consideration in the default evaluation of the Harmonia+ protocol.

Parthenocissus inserta and *P. quinquefolia* have been assessed together as *Parthenocissus* spp. thus showing identical scores for all modules.

As for the ISEIA risk assessment protocol, the impact score of some species had to be updated since the publication of Ries et al. (2013), e.g. for *Crassula helmsii*, first recorded in July 2020 in Luxembourg (Ries, & Pfeiffenschneider 2020b).

We follow the nomenclature of Luxembourg's current official Flora, the "Nouvelle Flore" by Lambinon & Verloove (2015).

3. Results

Table 1 presents the results of the risk assessment for 62 vascular plant taxa, of which 54 are present in Luxembourg. 8 species have not yet been documented for Luxembourg, but they were assessed as they are listed on the "Alert List" (Ries et al. 2013) and/or considered as invasive alien plants in at least one neighbouring country. Table 2 shows that score ranges for all modules and aggregated scores cover the full extension of values between 0 and 1.

48 species (77 %) have an overall invasion score higher than or equal to 0.50, while less than 50 % (29 species) have an overall impact score ≥ 0.50. This reflects the fact that although a majority of species are highly

Table 1. Risk assessment of 62 non-native vascular plant species for Luxembourg. Asterisks behind a species name indicate the year it has been included in the list of Union concern: * 2016, ** 2017, *** 2019. Harmonia+ values range from 0 to 1. ISEIA index: A = high impact, B = medium impact, C = low impact, 0 = absent from Luxembourg, 1 = isolated populations, 2 = restricted distribution, 3 = widespread (Ries et al. 2013).

	Harmonia +											
	Invasion				Impact							
Species	Introduction	Establishment	Spread	Invasion (geometric)	Environment	Plants	Animals	Humans	Infrastructure	Impact (maximum)	Overall Risk (Invasion x Impact)	ISEIA
Acer negundo	0.67	0.50	0.46	0.53	0.30	0.00	0.17	0.33	0.00	0.43	0.23	C1
Ailanthus altissima ***	0.89	0.75	0.63	0.74	0.57	0.25	0.00	0.50	0.50	0.57	0.42	C1
Ambrosia artemisiifolia	0.39	0.83	0.50	0.54	0.13	0.25	0.50	1.00	0.00	1.00	0.54	C1
Amelanchier lamarckii	0.56	0.75	0.50	0.57	0.07	0.13	0.00	0.00	0.00	0.13	0.07	C1
Asclepias syriaca **	0.50	0.75	0.38	0.52	0.22	0.21	0.33	0.00	0.00	0.37	0.19	B0
Aster lanceolatus	0.50	0.75	0.25	0.36	0.40	0.13	0.00	0.00	0.00	0.40	0.15	C1
Aster novi-belgii	0.39	0.75	0.21	0.31	0.30	0.04	0.00	0.00	0.00	0.30	0.08	C1
Atriplex micrantha	0.22	0.67	0.54	0.36	0.03	0.02	0.00	0.00	0.25	0.25	0.09	C2
Azolla filiculoides	0.67	0.75	0.58	0.66	0.33	0.00	0.00	0.00	0.08	0.33	0.22	C1
Bidens frondosa	0.50	1.00	0.54	0.64	0.28	0.10	0.00	0.00	0.00	0.28	0.18	C2
Buddleja davidii	0.83	0.92	0.71	0.81	0.47	0.08	0.00	0.00	0.50	0.50	0.41	C2
Bunias orientalis	0.61	1.00	0.50	0.67	0.35	0.35	0.00	0.00	0.00	0.44	0.30	C1
Claytonia perfoliata	0.33	0.83	0.38	0.46	0.03	0.04	0.00	0.00	0.00	0.08	0.04	C1
Cochlearia danica	0.22	0.83	0.42	0.42	0.07	0.00	0.00	0.00	0.00	0.07	0.02	C1
Conyza canadensis	0.67	0.92	0.67	0.74	0.15	0.31	0.00	0.00	0.00	0.31	0.24	C3
Cornus sericea	0.39	0.75	0.46	0.50	0.63	0.08	0.00	0.00	0.17	0.60	0.30	B1
Cotoneaster horizontalis	0.56	0.92	0.63	0.68	0.43	0.25	0.00	0.50	0.42	0.50	0.34	C1
Crassula helmsii	0.83	0.92	0.58	0.76	0.50	0.00	0.00	0.00	0.33	0.57	0.44	B1
Duchesna indica	0.56	0.75	0.50	0.59	0.07	0.02	0.00	0.00	0.00	0.09	0.05	C1
Egeria densa	0.39	0.75	0.54	0.53	0.57	0.03	0.00	0.00	0.58	0.62	0.32	A1
Elodea canadensis	0.78	1.00	0.58	0.77	0.60	0.03	0.00	0.00	0.42	0.60	0.46	A3
Elodea nuttallii **	0.72	0.92	0.54	0.71	0.60	0.03	0.00	0.00	0.42	0.60	0.42	A3
Epilobium ciliatum	0.56	1.00	0.58	0.69	0.15	0.19	0.00	0.00	0.00	0.22	0.15	B3
Epimedium alpinum	0.22	0.83	0.04	0.12	0.00	0.02	0.00	0.00	0.08	0.10	0.03	C1
Erigeron annuus	0.44	0.67	0.17	0.28	0.10	0.08	0.00	0.00	0.00	0.13	0.03	C1
Fallopia ×bohemica	0.83	0.92	0.79	0.84	0.60	0.19	0.00	0.00	0.67	0.70	0.59	B1
Fallopia japonica	0.83	0.92	0.79	0.84	0.60	0.25	0.00	0.00	0.75	0.75	0.63	A3
Fallopia sachalinensis	0.83	0.92	0.79	0.84	0.60	0.25	0.00	0.00	0.67	0.70	0.59	B1
Helianthus tuberosus	0.83	1.00	0.83	0.88	0.53	0.23	0.00	0.00	0.08	0.53	0.47	B2
Heracleum mantegazzianum **	0.78	1.00	0.58	0.77	0.42	0.13	0.58	0.83	0.08	0.83	0.64	A3
Hydrocotyle ranunculoides *	0.61	0.83	0.54	0.65	0.57	0.03	0.00	0.00	0.42	0.58	0.38	A0
Impatiens balfourii	0.50	0.83	0.13	0.17	0.18	0.04	0.00	0.00	0.25	0.30	0.09	B1
Impatiens glandulifera **	0.83	1.00	0.79	0.87	0.60	0.13	0.00	0.00	0.42	0.60	0.52	A3
Impatiens parviflora	0.61	0.92	0.46	0.63	0.20	0.08	0.00	0.00	0.00	0.20	0.13	C3
Lagarosiphon major *	0.67	0.58	0.58	0.60	0.63	0.03	0.00	0.00	0.58	0.65	0.39	A0
Lemna minuta	0.67	1.00	0.46	0.67	0.35	0.03	0.00	0.00	0.17	0.35	0.24	B1
Ludwigia grandiflora *	0.50	0.58	0.38	0.46	0.60	0.03	0.08	0.08	0.42	0.62	0.28	A0

Table 1. (Continued)

	Harmonia +											
	Invasion				Impact							
Species	Introduction	Establishment	Spread	Invasion (geometric)	Environment	Plants	Animals	Humans	Infrastructure	Impact (maximum)	Overall Risk (Invasion x Impact)	ISEIA
Ludwigia peploides *	0.56	0.83	0.46	0.59	0.60	0.03	0.08	0.08	0.75	0.75	0.44	A0
Lupinus polyphyllus	0.56	0.83	0.38	0.55	0.43	0.23	0.25	0.00	0.00	0.47	0.26	C1
Lysichiton americanus *	0.17	0.92	0.25	0.34	0.40	0.08	0.00	0.00	0.00	0.40	0.14	B0
Mahonia aquifolium	0.83	0.75	0.63	0.72	0.48	0.15	0.08	0.00	0.08	0.48	0.35	B1
Mimulus guttatus	0.67	0.92	0.58	0.71	0.22	0.10	0.00	0.00	0.00	0.23	0.16	C1
Myriophyllum aquaticum *	0.83	0.75	0.50	0.68	0.63	0.03	0.08	0.08	0.75	0.75	0.51	B1
Myriophyllum heterophyllum **	0.78	0.75	0.46	0.63	0.63	0.03	0.08	0.08	0.75	0.75	0.47	B0
Parthenocissus inserta	0.72	0.92	0.50	0.69	0.37	0.13	0.00	0.33	0.33	0.50	0.34	B1
Parthenocissus quinquefolia	0.72	0.92	0.50	0.69	0.37	0.13	0.00	0.33	0.33	0.50	0.34	B1
Pinus nigra	0.67	0.92	0.33	0.58	0.43	0.10	0.00	0.00	0.00	0.43	0.25	A2
Populus ×canadensis	0.50	1.00	0.58	0.66	0.30	0.13	0.00	0.25	0.17	0.37	0.24	C3
Prunus laurocerasus	0.67	0.83	0.63	0.70	0.47	0.27	0.58	0.50	0.00	0.63	0.45	C1
Prunus serotina	0.44	0.92	0.46	0.56	0.58	0.31	0.17	0.08	0.08	0.58	0.32	B1
Quercus rubra	0.50	1.00	0.50	0.63	0.47	0.25	0.00	0.00	0.00	0.47	0.29	C1
Rhus typhina	0.50	0.92	0.42	0.57	0.47	0.04	0.25	0.42	0.33	0.50	0.28	B1
Robinia pseudoacacia	0.89	1.00	0.79	0.89	0.60	0.35	0.08	0.08	0.17	0.60	0.53	A3
Rosa rugosa	0.56	0.42	0.42	0.45	0.38	0.02	0.08	0.25	0.00	0.38	0.18	C1
Rudbeckia laciniata	0.44	0.75	0.42	0.51	0.33	0.04	0.00	0.00	0.00	0.33	0.17	C1
Senecio inaequidens	0.67	0.83	0.79	0.76	0.25	0.04	0.33	0.33	0.00	0.38	0.29	B2
Solidago canadensis	0.78	1.00	0.46	0.71	0.55	0.17	0.00	0.00	0.00	0.55	0.39	A2
Solidago gigantea	0.56	1.00	0.46	0.63	0.42	0.15	0.00	0.00	0.00	0.42	0.26	A2
Spiraea ×billardii	0.11	0.92	0.00	0.00	0.43	0.04	0.00	0.00	0.08	0.43	0.00	B1
Spiraea alba	0.22	0.92	0.21	0.34	0.47	0.08	0.00	0.00	0.08	0.47	0.16	C1
Spiraea douglasii	0.22	0.92	0.08	0.18	0.47	0.10	0.00	0.00	0.08	0.47	0.10	B0
Syringa vulgaris	0.61	0.83	0.46	0.60	0.43	0.06	0.00	0.00	0.17	0.57	0.34	C1

invasive, less than half of the species have a strong impact in some way or another.

The species with the highest impact score on humans (≥ 0.50) are *Ambrosia artemisiifolia* (allergenic pollen), *Heracleum mantegazzianum* (contains furocoumarins that reduce the skin's natural protection against UV radiation), *Prunus laurocerasus* (contains cyanolipids) and *Ailanthus altissima* (causes dermatitis and pollen allergy). 31 species present a greater than or equal to average risk (≥ 0.29; ordered by descending risk score from 0.64 to 0.29): *Heracleum mantegazzianum*, *Fallopia japonica*, *F. sachalinensis*, *F. ×bohemica*, *Ambrosia artemisiifolia*, *Robinia pseudoacacia*, *Impatiens glandulifera*, *Myriophyllum aquaticum*, *M. heterophyllum*, *Helianthus tuberosus*, *Elodea canadensis*, *Prunus laurocerasus*, *Ludwigia peploides*, *Crassula helmsii*, *Elodea nuttallii*, *Ailanthus altissima*, *Buddleja davidii*, *Lagarosiphon major*, *Solidago canadensis*, *Hydrocotyle ranunculoides*, *Mahonia aquifolium*, *Syringa vulgaris*, *Cotoneaster horizontalis*, *Parthenocissus inserta*, *Parthenocissus quinquefolia*, *Egeria densa*, *Prunus serotina*, *Cornus sericea*, *Bunias orientalis*, *Quercus rubra* and *Senecio inaequidens*. Among these

Table 2. Score ranges, mean scores, number (#) and percentage (%) of species ≥ 0.50 and ≥ (arithmetic mean).

Modules and aggregated scores	Minimum score	Minimum score > 0	$\bar{x}$ (Arithmetic mean)	Maximum score	# (%) species ≥ 0.50	# (%) species ≥ $\bar{x}$
Introduction	0.11	0.11	0.58	0.89	47 (76)	31 (50)
Establishment	0.42	0.42	0.85	1.00	61 (98)	32 (52)
Spread	0.00	0.04	0.49	0.83	34 (55)	34 (55)
Overall Invasion	0.00	0.12	0.59	0.89	48 (77)	38 (61)
Environmental	0.00	0.03	0.39	0.63	20 (32)	36 (58)
Plant	0.00	0.02	0.11	0.35	0 (0)	26 (42)
Animal	0.00	0.08	0.06	0.58	3 (5)	16 (26)
Human	0.00	0.08	0.10	1.00	5 (8)	12 (19)
Infrastructure	0.00	0.08	0.20	0.75	10 (16)	22 (35)
Overall Impact	0.07	0.07	0.46	1.00	29 (47)	34 (55)
Overall Risk	0.00	0.02	0.29	0.64	8 (12)	31 (50)

31 species, 4 are considered as being not yet present in Luxembourg (*Hydrocotyle ranunculoides*, *Lagarosiphon major*, *Ludwigia peploides* and *Myriophyllum heterophyllum*), all of them being aquatic alien plants.

4. Discussion

A risk assessment protocol resulting in numerical scores is suitable for ranking a list of IAS with the purpose of identifying those who present the strongest impact and/or the highest risks, and are thus likely species to be included in an IAS list of national concern.

In the list resulting from the ranking scheme (62 spp. = 100 %), we identified two threshold values estimated to be fit for identifying potential candidates for a national IAS list of Luxembourg concern pursuant to the EU Regulation 1143/2014 on IAS:

(a) 29 (47 %) species with an overall impact score ≥ 0.50: *Ambrosia artemisiifolia*, *Heracleum mantegazzianum*, *Fallopia japonica*, *Ludwigia peploides*, *Myriophyllum aquaticum*, *Myriophyllum heterophyllum*, *Fallopia ×bohemica*, *Fallopia sachalinensis*, *Lagarosiphon major*, *Prunus laurocerasus*, *Egeria densa*, *Ludwigia grandiflora*, *Cornus sericea*, *Elodea canadensis*, *Elodea nuttallii*, *Impatiens glandulifera*, *Robinia pseudoacacia*, *Hydrocotyle ranunculoides*, *Prunus serotina*, *Ailanthus altissima*, *Crassula helmsii*, *Syringa vulgaris*, *Solidago canadensis*, *Helianthus tuberosus*, *Buddleja davidii*, *Cotoneaster horizontalis*, *Parthenocissus inserta*, *Parthenocissus quinquefolia* and *Rhus typhina*.

(b) From the remaining list, 7 (11 %) species with an overall risk score ≥ 0.25: *Mahonia aquifolium*, *Bunias orientalis*, *Quercus rubra*, *Senecio inaequidens*, *Lupinus polyphyllus*, *Solidago gigantea* and *Pinus nigra*.

This approach results in a total of 36 species (58 %) being potential candidates for listing on a national level.

Several of these are, however, popular garden plants, i.e. *Buddleja davidii*, *Cotoneaster horizontalis*, *Helianthus tuberosus*, *Mahonia aquifolium*, *Parthenocissus* spp., *Prunus laurocerasus*, *Rhus typhina*, *Solidago canadensis* and *Syringa vulgaris*. A discussion with the stakeholders of the horticultural sector has therefore to take place before listing them. Such an approach has been undertaken in our neighbouring countries, e.g. the LIFE project AlterIAS (ALTERnatives to Invasive Alien Species), a Belgian communication project that aims to raise awareness in the horticultural sector of the problem of invasive alien plants. The ultimate objective is to reduce the voluntary introduction of these plants into gardens, parks, pleasure ponds, green spaces and roadsides, which are commonly the starting points for invasions into the wild. It is a biodiversity conservation project that aims to change the attitude of horticultural professionals and gardeners towards the use of invasive plants (Halford et al. 2014, http://www.alterias.be/en/). This

does, however, not apply to the park and avenue tree *Ailanthus altissima* which is listed as an IAS of Union concern since 2019 (Anonymous 2019) and is thus banned from trade and planting.

In relation to a potential listing of the tree species *Quercus rubra* and *Pinus nigra*, discussions have to be held with the nature and forest agency (Administration de la nature et des forêts) as well as with the association of private forest owners (Groupement des Sylviculteurs asbl).

As part of a political decision-making process to establish a national list, it is useful to keep in mind, above the overall scores, the detailed results of the risk assessments for each invasion stage and each impact target. These details can be important in the discussion about specific species traits and behaviour that might influence the political decision upon listing in the national list of Luxembourg concern with its consequences according to the EU regulation, namely several obligations on a national level concerning e.g. management and reporting.

Of the ten species presenting the highest risk, at least three are considered widespread in Luxembourg: *Fallopia japonica*, *Impatiens glandulifera* and *Robinia pseudoacacia*. Due to an insufficient differentiation of *Fallopia japonica* and *F.* ×*bohemica* in the past, the latter has probably to be considered as being widespread too. On the other hand, *Heracleum mantegazzianum*, the species with the highest assessed risk, was still considered widespread a few years ago, but a common management effort by a range of national and regional stakeholders has led to a considerable decline of that invasive species (e.g. Krippel & Richarz 2013). Its distribution status in Luxembourg might therefore have to be reevaluated. While the risk of *Ambrosia artemisiifolia* (0.54), whose impact has been assessed with the maximum value 1.00, is reduced somewhat due to its limited invasiveness (0.54), it is the other way around with *Robinia pseudoacacia,* considered as being the most invasive in our list (0.89), and whose risk (0.53) is lessened because of its reduced impact (0.60).

Table 1 also shows the impact on the environment as assessed using the ISEIA Protocol (Branquart 2009, Ries et al. 2013). If we compare these ISEIA scores with the corresponding environmental impact factor resulting from the Harmonia+ assessment, a similar picture emerges: we have calculated the average of the environmental impact values from Harmonia+ for the three ISEIA list categories A, B and C; averages that reflect the different categories very well (Table 3).

Table 3. Comparison of the Risk Assessment protocols ISEIA and Harmonia+ regarding the impact of IAS on the environment. Harmonia+ values are arithmetic means of single species within the same ISEIA list category: A (highest score, black list), B (medium score, watch list) and C (low score, no listing).

Number of species	ISEIA	HARMONIA+
14	A	0,56
19	B	0,43
29	C	0,29

5. Conclusions

The risk assessment of 62 invasive alien vascular plants based on the Harmonia+ protocol should be used as a ranking scheme for establishing a national list. The final list should be drawn up in consultation with stakeholders in order to be able to successfully implement the necessary measures within the framework of EU legislation.

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