Bulletin OEPP/EPPO Bulletin (2016) **46** (3), 603–617 ISSN 0250-8052. DOI: 10.1111/epp.12336

A prioritization process for invasive alien plant species incorporating the requirements of EU Regulation no. 1143/2014

E. Branquart[1], G. Brundu[2], S. Buholzer[3], D. Chapman[4], P. Ehret[5], G. Fried[6], U. Starfinger[7], J. van Valkenburg[8] and R. Tanner[9]

[1]*Invasive Species Unit, Service Public de Wallonie, Gembloux (Belgium); e-mail: etienne.branquart@spw.wallonie.be*
[2]*University of Sassari, Sassari (Italy)*
[3]*Agroscope Institute for Sustainability Sciences, Zurich (Switzerland)*
[4]*NERC Centre for Ecology and Hydrology, Edinburgh (UK)*
[5]*Ministry of Agriculture, National Plant Protection Organization, Montpellier Cedex 2 (France)*
[6]*Anses, Laboratoire de la Santé des Végétaux, Unité Entomologie et Plantes Invasives, Montferrier-sur-Lez Cedex (France)*
[7]*Julius Kühn Institut (JKI), Federal Research Centre for Cultivated Plants, Institute for National and International Plant Health, Braunschweig (Germany)*
[8]*National Plant Protection Organization, Wageningen (The Netherlands)*
[9]*European and Mediterranean Plant Protection Organization, Paris, France*

When faced with a large species pool of invasive or potentially invasive alien plants, prioritization is an essential prerequisite for focusing limited resources on species which inflict high impacts, have a high rate of spread and can be cost-effectively managed. The prioritization process as detailed within this paper is the first tool to assess species for priority for risk assessment (RA) in the European Union (EU) specifically designed to incorporate the requirements of EU Regulation no. 1143/2014. The prioritization process can be used for any plant species alien to the EU, whether currently present within the territory or absent. The purpose of the prioritization is to act as a preliminarily evaluation to determine which species have the highest priority for RA at the EU level and may eventually be proposed for inclusion in the list of invasive alien species of EU concern. The preliminary risk assessment stage (Stage 1), prioritizes species into one of four lists (EU List of Invasive Alien Plants, EU Observation List of Invasive Alien Plants, EU List of Minor Concern and the Residual List) based on their potential for spread coupled with impacts. The impacts on native species and ecosystem functions and related ecosystem services are emphasized in line with Article 4.3(c) of the Regulation. Only those species included in the EU List of Invasive Alien Plants proceed to Stage 2 where potential for further spread and establishment coupled with evaluating preventative and management actions is evaluated. The output of Stage 2 is to prioritize those species which have the highest priority for a RA at the EU level or should be considered under national measures which may involve a trade ban, cessation of cultivation, monitoring, control, containment or eradication. When considering alien plant species for the whole of the EPPO region, or for species under the Plant Health Regulation, the original EPPO prioritization process for invasive alien plants remains the optimum tool.

Introduction

The European Union (EU) recently adopted Regulation no. 1143/2014 (EU, 2014) as a coherent regulatory framework aimed at preventing, minimizing and mitigating the adverse impacts of invasive alien species (IAS) on biodiversity and related ecosystem services, as well as adverse impacts on human health or the economy, which are considered as an aggravating factor. The core of this new Regulation is a list of invasive alien species of EU concern (the Union List) for which Member States have to take action to ensure that listed IAS are not intentionally brought into, sold and bred or cultivated within EU territory. In addition, such species should be carefully monitored through a dedicated surveillance system and subjected to management actions aimed at eradicating, containing or controlling their populations.

As potential IAS are numerous, it is important to ensure that priority is given to addressing species considered to be of EU concern based on: (i) the significance of their detrimental impacts and (ii) on the capacity of Member State(s) to put measures in place to prevent, minimize and mitigate those impacts in a cost-efficient manner. This means the two most important elements of risk analysis (IPPC, 2007; EFSA Scientific Committee, 2012), i.e. risk assessment and

risk management should be addressed to justify any inclusion in the EU List.

The significance of adverse impacts of IAS included in the Union List has to be justified by a risk assessment (RA) pursuant to the applicable provisions under the relevant Agreements of the World Trade Organization (WTO) on placing trade restrictions on species. The RA has to comply with common criteria described in Article 5.1 of the Regulation from which minimum standards for RA protocols have been derived (Roy *et al.*, 2014).

The production and endorsement of RA reports is a time- and resource-demanding exercise that cannot be conducted for every IAS that is a potential threat to the EU. This exercise should be restricted to those that best meet the criteria and principles addressed by the Regulation, for which a standardized and operational approach is still needed. The purpose of the prioritization process for EU invasive alien plant species is to determine which species have the highest priority for a RA at the EU level in order to be considered for inclusion in the Union List. The process is adapted from the EPPO prioritization process for invasive alien plants (EPPO Standard PM 5/6)[1] prepared under the umbrella of the International Plant Protection Convention. The adapted prioritization process has been specifically elaborated within the framework of the LIFE Project (LIFE15 PRE FR 001) 'Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014' (see http://www.iap-risk.eu), and is designed to assess alien plants which pose a threat to the EU, but its logical framework could be easily adapted for other taxonomic groups. According to the Regulation, the area taken into consideration in the process is the territory of the EU, excluding the outermost regions.

It should be noted that the prioritization process is designed to perform rapid prioritization and to provide structured and traceable information on specific aspects of a species. It does not in any way provide a substitute for a full RA.

The prioritization process may be summarized under the form of a decision scheme, as illustrated in Fig. 1, for which detailed guidance is provided in this paper. It follows a two-stage approach taking into account risk assessment (Stage 1) and risk management (Stage 2) issues.

Methods

The process can be used for any plant species, subspecies or lower taxa. It consists of compiling available information on the assessed alien species according to predetermined criteria.

The process produces lists of plant species compliant with the main principles and criteria of the Regulation, the most important being the EU List of Invasive Alien Plants and the List of Priority Invasive Alien Plants for performing a RA at the EU level. The process is summarized in Fig. 1.

Available sources of information to run the process include: the scientific literature, personal communications from scientists, NPPO data and websites and databases on invasive alien plants (e.g. the CABI Invasive Species Compendium, the EPPO Global Database and the IUCN Global Invasive Species Database). Information needs to be updated on a regular basis. All references and contacts need to be recorded to allow traceability.

Whenever possible, evidence should be obtained from previously observed invasive behaviour in Europe. However, information on invasive behaviour elsewhere in the world is of utmost importance for species that are not yet established in the EU. When contradictory information is found within the EU, the worst case should be considered (but see also the rules for uncertainty below). When documenting each species, as much information as possible should be included and references should be provided, indicating where the documented impacts have been observed, in order to be able to differentiate between impacts that actually occurred in the area under assessment and potential impacts. When describing the process in this document, for each question examples are provided for a given biogeographical area or country. Communication between experts may be organized to increase the quality of the outcome of this process. For questions that need a rating, a three-point scale (low, medium, high) is used.

Uncertainty should be recorded for the answers to questions on spread and impact, and should be summarized in an overall uncertainty rating of low, medium or high. The elements of uncertainty should be described. The assessor may consider an assessment as having some degree of uncertainty for the following reasons:

- the species is absent from the EU, newly arrived or of limited distribution, and the impacts are recorded for a different continent
- there is little or no data available on the species
- the species, although present in the EU, exhibits different behaviours in different places, or there is conflicting information available.

Uncertainty therefore depends on the presence or absence of the plant in the EU, the availability of data on its behaviour and possible conflicting information. A matrix indicating uncertainty ratings is provided in Table 1.

Outcomes

Stage 1 of the process addresses preliminary issues of RA and allocates species to different lists of alien plants within the EU.

- The EU List of Invasive Alien Plants contains species which comply with the IAS definition and criteria of Article 4 of the Regulation, i.e. alien species that would be capable of causing major detrimental impacts to

[1]EPPO (2012), PM 5/6(1) EPPO prioritization process for invasive alien plants, Guidelines on Pest Risk Analysis, *EPPO Bulletin* **42**: 463–474.

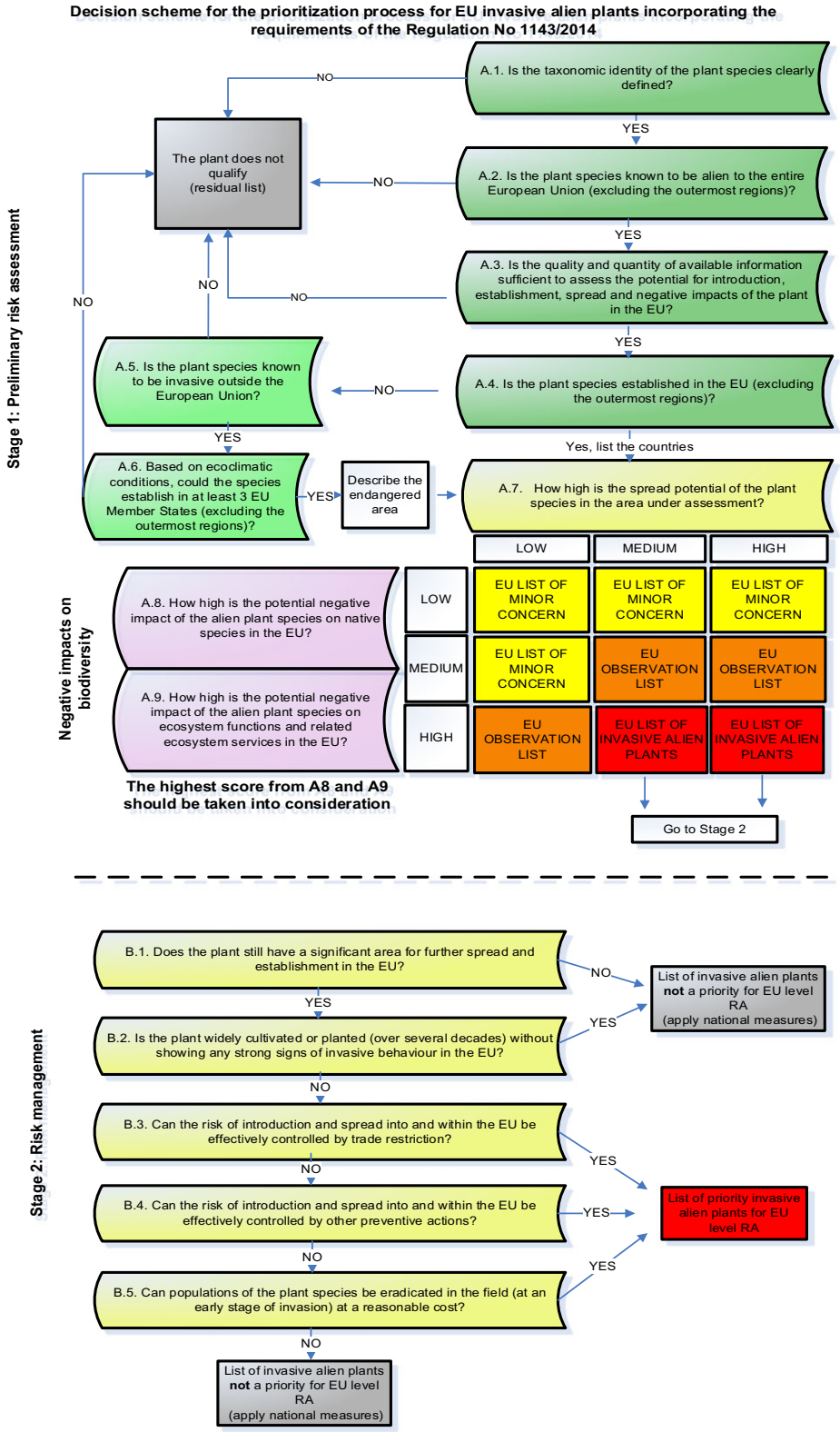

Fig. 1 Decision scheme summarizing the prioritization process for EU invasive alien plant species incorporating the requirements of Regulation (EU) no. 1143/2014.

Table 1. Matrix indicating uncertainty ratings

	Species absent from the EU	Newcomer to the EU (limited distribution)	Species widespread in the EU
Uncertainty	Medium uncertainty	Medium uncertainty	Low uncertainty
+ lack of data	High uncertainty	High uncertainty	Medium uncertainty
+ conflicting data	High uncertainty	High uncertainty	Medium uncertainty

biodiversity and associated ecosystem services after establishment and spread within EU territory. This list may include species that are already invasive within the EU, or species which are not yet present but likely to show invasive tendencies following their introduction. Most of the species may only establish in some of the biogeographical regions of Europe as defined by the European Environment Agency.

- The EU Observation List of Invasive Alien Plants contains species that are likely to cause only a moderate detrimental impact on biodiversity and associated ecosystem services and species for which additional information is needed to determine their invasive behaviour, either now or in the future. These species may become of concern if a shift in invasion behaviour occurs and if/when knowledge improves based on new information. Careful surveillance and field studies are advised to improve knowledge about these species. Early eradication actions may also be undertaken on a voluntary basis.
- The EU List of Minor Concern includes species associated with a very low environmental risk due to a limited capacity for spread and/or the low impacts they cause to biodiversity and/or the associated ecosystem services.
- A Residual List of species that do not qualify, and are therefore not included in any of the previous lists. This could be for various reasons, such as incorrect use of the botanical nomenclature, and can occur when a long list of species is assessed without a preliminary screening of the correct taxonomy; synonymy and nomenclature for all the taxa in the list (e.g. Question A1). The residual list also includes those species that will not pass the filters of Questions A2 (alien status), A3 (available information), A5 (invasive status) and A6 (potential establishment). If additional information is published that further clarifies the answers to the aforementioned questions, the species may be re-prioritized.

Only species from the EU List of Invasive Alien Plants should proceed to Stage 2 of the process. This stage addresses risk management questions designed to define whether actions can be taken to effectively prevent, minimize or mitigate their adverse impacts. This may only be the case when alien plant species are moved from country to country, primarily by human activities (intentional or unintentional), and still have a significant area suitable for further spread within the EU. Two outcomes are possible from Stage 2:

- The plant species is included in a List of Priority Invasive Alien Plants for an EU-level RA: this includes invasive alien plant species against which a concerted action at EU level is likely to effectively prevent, minimize or mitigate their adverse environmental impact. In this case, a RA should be performed according to minimum standards.
- The alien plant species is included in a List of Invasive Alien Plants that are not considered as a priority for an EU-level RA; this includes invasive alien plants where no effective action can be undertaken at EU level, either because they are already very widespread or because no action can be undertaken to effectively reduce their spread and their adverse impacts through pathway management or early eradication actions. In this case, conducting a detailed RA is a poor use of resources. In some cases, national measures should be recommended.

For each species a prioritization report can be generated from the information gathered during the process. The information collected would be detailed under the headings of the sections and specific questions. Key databases and information depositories used in the collection of information can be tabulated for the output of a prioritization report (for an example see Gordon *et al.*, 2010). The prioritization Scheme will be made available in an electronic version through the CAPRA software via the website http://www.iap-risk.eu.

Guidance notes for Questions A1–A9 (preliminary RA section)

***A.1:** Is the taxonomic identity of the plant species clearly defined?*

Having a clear understanding of the taxonomic identity of a species is an essential component in any prioritization and subsequent RA to ensure that the RA is performed on a distinct organism but also to ensure that information used in the RA is relevant to the organism under consideration. Without a clear understanding of taxonomy, problems can arise as impacts could potentially be reported for the plant under assessment when in reality they are caused by other taxa. Examples of current taxonomic uncertainty include the invasive purple-flowered alien rhododendrons in the British Isles, usually referred to as *Rhododendron ponticum*, which in most cases belong to a human-made hybrid swarm. In addition to the *R. ponticum* plants introduced from the Iberian Peninsula there are three North American species involved. The plants should better be referred to as *Rhododendron* × *superponticum* Cullen (Cullen, 2011). The taxonomic concept of naturalized and

casual blue-flowering lupin is treated differently in various flora of North-Western Europe. In the flora of the British Isles (Stace, 2010), *Lupinus polyphyllus* Lindl. is used for plants bearing unbranched inflorescences with blue flowers and the naturalized plants with mostly branched inflorescences with blue, pink, purple or white flowers are referred to as *Lupinus* × *regalis* Bergmans (a hybrid of *L. polyphyllus* and *Lupinus arboreus* Sims). *Lupinus arboreus*, commonly known as Russell hybrid, is the garden lupin as commercially available at present that has succeeded *L. polyphyllus* since the 1940s. In the Flora of the Netherlands *L. polyphyllus* is inclusive of the Russell hybrids. Whereas in the British Isles the naturalized and casual plants largely belong to *L.* × *regalis* and any backcrosses, in Scandinavia it is *L. polyphyllus* that predominates (Stace & Crawley, 2015; Stace *et al.*, 2015).

- If yes: go to A.2.
- If no: the plant does not qualify for further analyses. The species is included in the residual list.

A.2: *Is the plant species known to be alien to the entire EU (excluding the outermost regions)? [Article 4.3(a)]*

In the case of the EU, the area under assessment is large and is composed of different biogeographical regions; a species that has a native range overlapping part of the EU territory (e.g. *Pinus mugo* or *Acer pseudoplatanus*) does not qualify for further assessment. Species native only to the European outermost regions (including the Azores, Canary Islands and Madeira) are considered as alien plants to the EU and qualify for further assessment.

- If yes: go to A.3.
- If no: the plant does not qualify as an alien plant species to the EU. The species is included in the residual list.

A.3: *Is the quality and quantity of available information sufficient to assess the potential for introduction, establishment, spread and negative impacts of the plant in the EU? [Articles 4.3, 4.4 and 5]*

Consider here the availability of information from scientific publications and international invasive alien species databases (the EPPO Global Database, CABI Invasive Species Compendium, IUCN Global Invasive Species Database, etc.). Species for which invasiveness is poorly documented in the scientific literature cannot be assessed properly and do not qualify for RA.

- If yes: go to A.4.
- If no: the plant cannot be assigned to a list based on the current information and does not qualify as a priority for RA. The species is included in the residual list.

A.4: *Is the plant species established in the EU (excluding the outermost regions)?*

- If yes: describe the area where the species is established, and the area of potential establishment, considering major factors such as climatic conditions and soil types. The world hardiness zones map (Magarey *et al.*, 2008), the world Köppen–Geiger climate classification map (Kottek *et al.*, 2006) and the map of the biogeographical regions of Europe (European Environment Agency, 2016) can be used to compare the areas where the species is recorded and the area under assessment. Go to the assessment of spread and impacts (Questions A.7–A.9).
- If no: the plant has never been observed in the wild in the area under assessment, or is recorded only as casual and may be in the process of establishment. Go to A.5.

Invasive behaviour outside the EU territory

A.5: *Is the plant species known to be invasive outside the EU?*

As the species is not established in the EU, it is only possible to retrieve information from its behaviour elsewhere (potential to spread easily in the environment and to affect native biodiversity and related ecosystem services). The fact that the species is reported as invasive elsewhere, at least in regions having similar ecological and climatic conditions, is considered one of the most relevant criteria in predicting the invasive behaviour of a species (e.g. Williamson, 1996; Kumschick & Richardson, 2013).

- If yes: go to A.6.
- If no: the plant does not qualify as a priority for RA. The species is included in the residual list.

Assessment of establishment

A.6: *Based on ecoclimatic conditions, could the plant species establish in at least 3 EU Member States (excluding the outermost regions)? [Article 4.3(b)]*

Aquatic plants might be less susceptible to climatic conditions than terrestrial plants, and this element should be taken into account when answering this question. The world hardiness zones map (Magarey *et al.*, 2008), the world Köppen–Geiger climate classification map (Kottek *et al.*, 2006) and the map of the biogeographical regions of Europe (European Environmental Agency, 2016) can be used to compare the areas where the species is recorded and the area under assessment. For example, the tropical plant *Psidium cattleianum* (Myrtaceae) is unlikely to establish in almost all parts of the EU (excluding the outermost regions).

- If yes: describe the area of potential establishment considering major factors such as climatic and soil conditions, go to assessment of spread and impacts. Go to Questions A.7–A.9.
- If no: explain why the species is not likely to establish. The plant does not qualify as a priority for RA. The species is included in the residual list.

Assessment of spread and impacts

Questions A.7 to A.9 all have to be assessed independently. The risk should be considered for the area where the species is able to establish and cause damage within the EU,

taking into account the worst-case scenario. The risk should not be downgraded by making an average for the entire EU territory, if it is different from the area of potential establishment.

As far as possible, evidence should be obtained from records of invasive behaviour in Europe. Information on invasive behaviour elsewhere may also provide guidance. It is important to ensure that suitable habitats are present in the EU; for instance, mangroves are not found within the territory of the EU and a species requiring this habitat would not establish.

A.7: *How high is the spread potential of the plant species in the area under assessment? [Article 4.3(b)]*
This section addresses the potential of an organism to spread to unintended habitats by natural means (water, birds, wind, etc.) or by unintentional human assistance (movement of soil, discarded aquarium plants, machinery, etc.) via seeds, plant fragments or any other propagules able to regenerate a plant. Intentional introduction is not taken into consideration here in order to focus on the intrinsic spread capacity of the species.

- Low: the plant does not spread because of poor dispersal capacity (e.g. gravity dispersal) and a low reproductive potential. Propagules are rarely found over distances exceeding a few metres from the mother plant. For example, *Aloe vera* and *Agave americana* reproduce vegetatively only at a slow rate and rarely produce seeds. Go to the assessment of impacts.
- Medium: the plant reproduces vigorously vegetatively and/or sexually and spreads mainly in the vicinity of the mother plant; dispersion capacity in the environment rarely exceeds 100–200 m from the mother plant. For example, *Lysichiton americanus* produces many seeds but most of them fall to the ground with the faded spadix and therefore germinate directly next to the mother plant. Occasionally seeds may be carried greater distances by water or animals, e.g. in mud adhering to feet. Examples of medium spread include species spread by ants or dispersed by wind but with diaspores lacking specific adaptation to long-distance dispersal like small seeds of *Rhododendron ponticum* or seed pots of *Robinia pseudoacacia* that are dispersed over distances of maximum 50–100 m (Stephenson *et al.*, 2007; Morimoto *et al.*, 2010; Harris *et al.*, 2011). Unintentional dispersal by humans is infrequent. Go to the assessment of impacts.
- High: the plant is highly fecund and is regularly observed to spread over distances >500–1000 m from the maternal plant, either:
  - by water: especially species invading riparian habitats that have diaspores with high buoyancy. This includes fruits, seeds or fragments of aquatic or riparian herbaceous plants such as *Heracleum mantegazzianum,* and *Ludwigia* spp., but also primarily wind-dispersed ornamental trees such as *Acer negundo*, *Ailanthus altissima* and *Fraxinus pennsylvanica* (Säumel & Kowarik, 2010);
  - by wind: especially species with light seeds and/or seeds with special adaptations to long-distance dispersal such as wings and pappus. For example, *Cortaderia selloana* produces thousands of seeds that are wind-dispersed over long distances;
  - by animals: especially species with edible fruits dispersed by birds and other highly mobile animals. For example, seeds of *Opuntia ficus-indica* and *Prunus serotina* are dispersed by birds feeding on fruits (Deckers *et al.*, 2005; Pairon *et al.*, 2006);
  - unintentional spread by human activities: by movement of soils, or dispersal by farm machinery or by vehicular traffic. For example, *Ambrosia artemisiifolia* is dispersed along roads by vehicles and by machines used to mow road verges; rhizomes of *Reynoutria* spp. are often dispersed with soil movements.

Uncertainty rating: low, medium, high

A.8: *How high is the potential negative impact of the alien plant species on native species in the EU? [Article 4.3(c)]*
This addresses the potential for an alien plant to induce long-term population loss of rare and threatened native plant species through competition and hybridization mechanisms.

The potential to displace native species by competitive interactions (including allelopathy, competition for pollinators, etc.) is unfortunately difficult to demonstrate and is rarely documented in the scientific literature, especially at the beginning of the invasion process. However, it could be estimated by considering the species' ability to form large, dense (cover >80%) and persistent (duration >10 years) populations, as already proposed by Brunel & Tison (2005), Branquart (2007) and Kenis *et al.* (2012).

Negative environmental impacts of alien plants are indeed typically density-dependent (Richardson *et al.*, 1989, 2000; Bímová *et al.*, 2004; Staska *et al.*, 2014; Fried & Panetta, 2016); the formation of dense populations occurs more with perennial than annual plants, especially tall perennials (Hejda *et al.*, 2009). There are, however, exceptions for alien species hybridizing with native species, which may pose a high risk even at low densities (Daehler & Strong, 1997; Huxel, 1999; Wolf *et al.*, 2001). The negative impacts of alien plants are exacerbated by the long persistence of the large populations they form, which typically last for more than 10 years (Yurkonis *et al.*, 2005) and may even exceed 30 years as recorded for *H. mantegazzianum* in the Czech Republic (Dostal *et al.*, 2013) and *R. pseudoacacia* in Germany (Cierjacks *et al.*, 2013). Persistence of clonal species like *Cornus sericea*, *Rhus typhina* or *Spiraea alba* is known to be very long and to strongly inhibit natural plant successions (Meilleur *et al.*, 1994).

The formation of large, dense and persistent populations may occur in habitats of value for nature conservation, where rare or threatened species are likely to occur, and in areas of high endemism density (e.g. islands). The natural habitats of EU importance in which the species may have negative impacts on native species should be listed according to the current version of Annex I of the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive).

- Low: the plant does not form dense, persistent populations and rarely colonizes habitats that have a value for nature conservation. For example, the ornamental plant *Amaranthus caudatus* can escape and colonize urban areas, cemeteries or river banks without forming dense populations in France (Antonetti *et al.*, 2006); the ornamental *Datura wrightii* can also escape in ruderal areas, roadsides and waste dumps in Corsica (France) (Jeanmonod & Gamisans, 2007); *Nicandra physaloides* escapes gardens and is sometimes found on roadsides and along river beds in France (Antonetti *et al.*, 2006).
- Medium: the plant forms large, dense, persistent populations only in habitats modified by human activities and/or occurs in habitats that have value for nature conservation, but does not form large, dense, persistent populations. For example, *Ambrosia artemisiiflora* and *Bidens subalternans* form dense, monospecific stands along roadsides, in fallow lands and in crops, but are rarely found to have detectable impacts in semi-natural or natural habitats in France (Fried, 2012); in Western Europe, *Veronica persica* is abundant only in cultivated fields (Lambinon *et al.*, 2004; Verloove, 2006; Fried, 2010); *Amelanchier lamarckii* is found in some habitats of high conservation value without forming dense populations (Muller, 2004; Branquart *et al.*, 2010a,b); *Juncus tenuis* is also typically found along wet forest roads and the edges of gravel ponds (Lambinon *et al.*, 2004; Rivière, 2007) but is usually at low densities when found in valuable and vulnerable natural communities (Verloove, 2012).
- High: the plant is reported to colonize habitats that have a value for nature conservation where it forms large, dense and persistent populations. For example *Crassula helmsii*, *Eichhornia crassipes* and *Ludwigia grandiflora* in water bodies in the United Kingdom, Spain and France, respectively (Langdon *et al.*, 2004; Muller, 2004; Ruiz Téllez *et al.*, 2008); *Baccharis halimifolia* in coastal wetlands and saltmarshes in Southern Europe (Caño *et al.*, 2013; Fried & Panetta, 2016), *Carpobrotus* spp. in dune ecosystems in the Mediterranean and Atlantic parts of France (Fried *et al.*, 2014); and *Rosa rugosa* in dune ecosystems in the Atlantic and boreal regions (Kollmann *et al.*, 2007; Isermann, 2008).

Alien plant species that may easily produce fertile hybrids with native congeneric species may pose a significant risk to the survival of these plant species by assimilation or introgression, even if they do not form dense populations. These types of species should be considered in this category. Examples include *Spartina alterniflora* × *Spartina foliosa* in salt marshes of San Francisco Bay (Daehler & Strong, 1997); *Hyacinthoides hispanica* × *Hyacinthoides non-scripta* in woodlands and semi-natural grasslands of Scotland (Kohn *et al.*, 2009); *Populus* × *canadensis* threatening *Populus nigra* in floodplains of Central Europe (Bleeker *et al.*, 2007; Smulders *et al.*, 2008).

Uncertainty rating: low, medium, high

A.9: *How high is the potential negative impact of the alien plant species on ecosystem functions and related ecosystem services in the EU? [Article 4.3(c)]*

This addresses the potential for an alien plant to significantly and persistently alter ecosystem functions and related ecosystem services in natural and semi-natural habitats as defined in The Economics of Ecosystems and Biodiversity (TEEB) classification (see http://www.teebweb.org). Functions and services that may be disrupted include: (i) provisioning processes (e.g. biomass, food and water production), (ii) regulating processes (e.g. erosion prevention, alteration of soil fertility, regulation of water flow, pollination, pest control, food web dynamics, etc.), (iii) habitat or supporting services (e.g. food and shelter for native plants and animals), and (iv) cultural services, including landscape and recreation values.

List ecosystem functions and related ecosystem services that are altered by the alien plant species in natural and semi-natural habitats.

- Low: the plant is not reported to significantly and persistently affect ecosystem functions, including losses to related ecosystem services. For example, despite a continuous influx as a contaminant of aquatic plant imports from South-East Asia, it is unlikely that the frost-sensitive alien duckweed (*Landoltia punctata*) will become a nuisance weed in The Netherlands, similar to the range of duckweed species already present in there (van Valkenburg & Pot, 2008).
- Medium: the plant is reported to significantly and persistently affect ecosystem functions, including losses to related ecosystem services, only in habitats modified by human activities. *Ambrosia artemisiifolia* is reported to compete strongly with crop plants for water and nutrients and to affect provisioning services of agricultural ecosystems in Southern and Central Europe, but rarely behaves in the same way in natural habitats (Muller, 2004).
- High: the plant is reported to significantly and persistently alter ecosystem functions, including losses to related ecosystem services, in habitats that have a value for nature conservation. Species that can significantly alter soil conditions should be considered here, for example nitrogen-fixing species that increase nitrogen content in oligotrophic soils such as *R. pseudoacacia* (Rice *et al.*,

2004), *Acacia* spp. (Marchante *et al.*, 2008) and *L. polyphyllus sensu lato* (Fremstad, 2006); as well as species modifying soil pH, nutrient availability organic matter dynamics and/or soil communities due, for example, to low decomposition rate, such as *Carpobrotus* spp. (Conser & Connor, 2009) or *Quercus rubra* (Kohyt & Skubala, 2013; Bonifacio *et al.*, 2015).

Uncertainty rating: low, medium, high

Responses to questions on impacts (A.8 and A.9) should be reported in the matrix in Fig. 2 in order to categorize the species. Only the highest impact score should be considered.

Those species that have both a high negative impact (either on native species or on ecosystem functions and related services) and a medium or a high spread potential are included in the EU List of Invasive Alien Plants. Species with a medium impact and a medium or a high spread potential are included in the EU Observation List of Invasive Alien Plants, as are those that have both a high detrimental impact and a low spread capacity. Species with a low impact are registered on the EU List of Minor Concern, as are those that have both a medium impact and a low spread capacity.

The overall uncertainty for Stage 1 of the prioritization process should be summarized.

Overall uncertainty rating: low, medium, high

The species included in the EU List of Invasive Alien Plants are those qualifying for the second stage of the process, i.e. the risk management section.

Guidance note for questions B1–B5 (risk management section)

B.1: *Does the plant species still have a significant area for further spread and establishment in the EU? [Articles 4.3 (d), 4.3(e) and 4.6]*

Consider the extent to which the species has colonized its potential distribution area in the EU (i.e. all suitable habitats in the areas where ecological factors favour its establishment) and plant frequency and density therein.

It is considered that a significant area is available for further spread and establishment when extensive territories suitable for plant establishment are not yet invaded or are poorly invaded and may be colonized in the absence of appropriate action, as it is the case for *B. halimifolia*, *L. americanus*, *Polygonum perfoliatum* or *Pueraria montana* within the EU. On the contrary, *R. japonica* and *I. glandulifera* are examples of plant species that occupy their current potential distribution range in the EU and may hardly extend it because unoccupied areas are either too dry or too cold to allow their development (Fig. 3); they already reach high densities in most sites suitable for their establishment (Beerling, 1993; Willis & Hulme, 2002). In these cases, it is unlikely that coordinated actions undertaken at EU level will effectively prevent, minimize or mitigate their adverse impacts at a reasonable cost.

- If yes: go to B.2.
- If no: the plant is not a priority for RA at EU level. Consider national measures such as national RA for listing IAS of Member State concern [Article 12].

B.2: *Is the plant widely cultivated or planted (over several decades) without showing any strong sign of invasive behaviour in the EU? [Articles 4.3 and 4.6]*

Consider the extent to which the species is planted, cultivated and used for gardening and landscaping purposes within the EU. The following uses should be taken into account: agriculture (bioenergy, fodder, food, windbreaks, etc.), agroforestry, apiculture, erosion control, ornamental purposes (parks and gardens), landscaping, soil remediation, silviculture, etc. Species represented by a suite of different horticultural cultivars like *Buddleja davidii* or *Lonicera* spp. can usually be considered as widely planted in parks and gardens.

For those species that are widely cultivated and have been planted over several decades in the EU, consider their establishment in the wild and their negative impacts on native species, ecosystem functions and the related services in the EU. If there is no data on negative impacts within

		A7 - Spread potential		
		Low	**Medium**	**High**
Negative impacts (maximum from questions A8 and A9)	**Low**	EU List of Minor Concern	EU List of Minor Concern	EU List of Minor Concern
	Medium	EU List of Minor Concern	EU Observation List of Invasive Alien Plants	EU Observation List of Invasive Alien Plants
	High	EU Observation List of Invasive Alien Plants	EU List of Invasive Alien Plants. **Go to B.**	EU List of Invasive Alien Plants. **Go to B.**

Fig. 2 Classification matrix combining spread potential and adverse impacts on native species, ecosystem functions and related services.

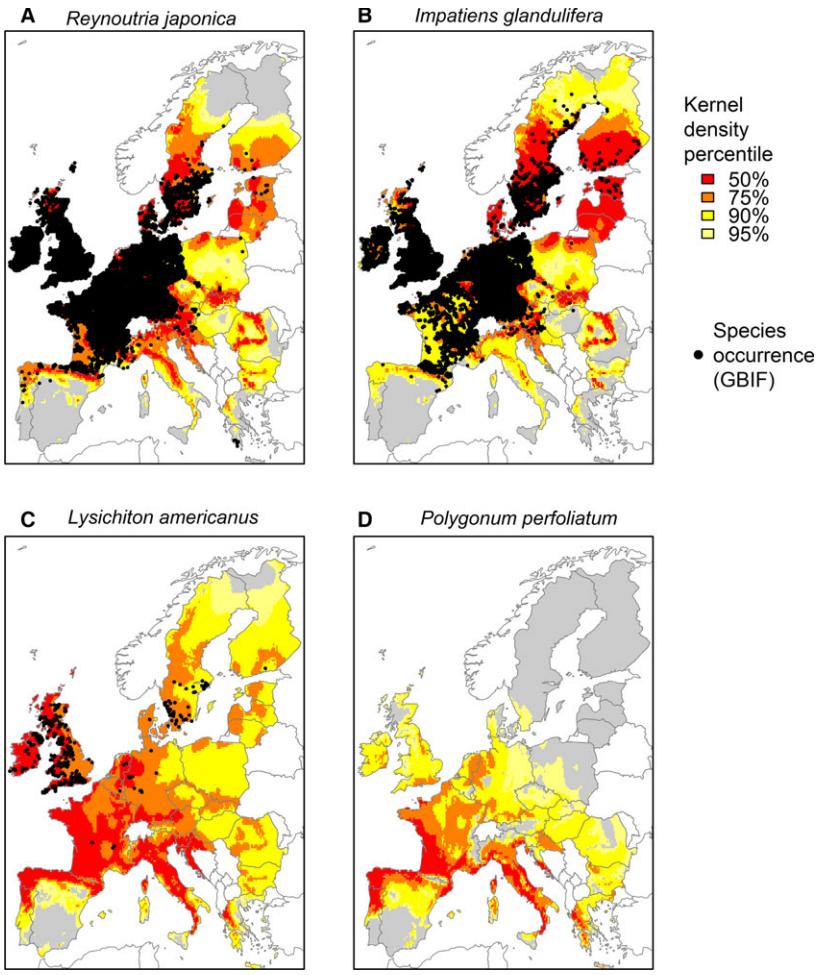

Fig. 3 Crude estimates of the climatically suitable regions of the EU for (A) *Reynoutria japonica*, (B) *Impatiens glandulifera*, (C) *Lysichiton americanus* and (D) *Polygonum perfoliatum*. Global occurrence locations were obtained from the Global Biodiversity Information Facility (GBIF). The authors acknowledge that GBIF occurrence data are not exhaustive, especially for *R. japonica* and *I. glandulifera*. The global climate was summarized as two principal components analysis (PCA) axes on the 19 WorldClim layers (Hijmans *et al.*, 2005). Species occurrences were plotted in this climate space and a bivariate normal kernel density model (Calenge, 2006) was used to estimate 'climate envelopes' at different percentiles. These envelopes were then projected onto geographical space in the EU. Shading indicates these percentiles, with smaller numbers indicating higher density of occurrences. Species with regions inside the smaller kernel density percentiles without species occurrences (black points) may have a significant area for further spread and establishment in the EU.

the EU, those plants are not considered as a priority for RA because: (i) it is assumed that there is no strong evidence to demonstrate that they may cause environmental damage in European conditions and (ii) consequences of species listing are likely to cause huge economic costs, especially when extensive plantations have to be destroyed on a large scale. This is the case for *Euonymus japonicus* that has been widely planted in the form of several cultivars for ornamental purposes for several decades and rarely establishes wild populations and shows no signs of invasiveness in the EU, contrary to the behaviour observed in North America.

- If yes: the plant is not a priority for RA at the EU level. Consider national measures such as monitoring programmes to detect plant establishment or invasion in the wild.
- If no: go to B3.

Cost-effectiveness of prevention and management measures [Articles 4.3(d), 4.3(e) and 4.6]

A positive ('yes') answer has to be provided to at least one of the three following questions (B3–B5) to consider that the species assessed is a high priority for RA. If this is not possible, this means that no adequate answer can be proposed to effectively reduce the spread and adverse impacts of the species.

B.3: *Can the risk of introduction and spread into and within the EU be effectively controlled by trade restrictions?*

Trade restriction may be considered as an effective preventive action when it is considered that the plant is traded and intentionally introduced for ornamental, agricultural, silvicultural or other purposes which are significant pathways of plant introduction and spread within the EU. *Eichhornia crassipes*, for example, is widely traded within the EU as an ornamental plant often introduced into garden ponds from which escape in the wild is still limited, making trade limitation an effective action to prevent the risk of further spread of the plant (EPPO PRA 08-14407; http://www.eppo.int). A trade restriction for *Senecio inaequidens* is, on the contrary, considered inadequate to prevent plant invasion as it is rarely sold and purposely introduced while natural dispersal by wind-dispersed achenes is assumed to be the major pathway for plant movement (EPPO PRA 06-12954; http://www.eppo.int).

A number of databases, websites and catalogues provide information on plant species imported and traded within the EU. The following list provides examples of such websites and further examples can be found for individual countries:

http://www.ppp-index.de (Europe-wide coverage, in German)

https://www.rhs.org.uk/ (Royal Horticultural Society, GB, focus in English)

http://www.jardinsdugue.eu/trouver-une-plante/?foire=Indifferent (in French)

http://www.aquabase.org/ (aquatic plant focus, in French)

http://www.datiopen.it/it/opendata/Registro_delle_variet_vegetali_ortive (In Italian)

http://cpvo.europa.eu (contains information on registers of more than 60 countries, in English)

- If yes: the plant is a high priority for RA at the EU level.
- If no: go to B4.

B.4: *Can the risk of introduction and spread into and within the EU be effectively controlled by other preventive actions?*

The species may also be imported unintentionally as a contaminant of consignments of grain, seeds, wool, soil as a growing medium, etc. or as a hitchhiker on travellers or machinery. Effective control of unintentional introduction and spread pathways, as intended by Article 13 of the EU Regulation, may only be conducted when plant propagules may easily be detected within consignments. Rhizomes of *Reynoutria* spp. are often spread with soil, wherein they can be easily detected due to their bright orange section (Environment Agency, 2010). On the contrary, the tiny seeds (<2 mm) of *Polygonum perfoliatum* are difficult to detect within imported contaminated soils or growing media (EPPO PRA 07-13387).

- If yes: the plant assessed is a high priority for RA at the EU level.
- If no: go to B5.

B.5: *Can populations of the plant be eradicated in the field (at an early stage of invasion) at a reasonable cost?*

When pathway management is not recognized as an effective way to reduce the risk of plant introduction and spread, as described above for *S. inaequidens* and *P. perfoliatum*, consider the extent to which new incursions of the species can be cost-effectively controlled through the active surveillance of nurseries, plantation sites, natural habitats and other sites where the species may start to establish.

In this case, the feasibility of local eradication depends highly on detectability of the plant in the field, the window of opportunity for eradication and the availability of best practices to eliminate it (i.e. management effectiveness). The eradication of plant species of a large size, with a long juvenile period, short-lived seeds and a limited capacity for regrowth such as *H. mantegazzianum* and *L. americanus*, is usually considered to be easier to achieve than that of plant species with the opposite suite of traits (Panetta & Timmins, 2004; Panetta, 2015).

- If yes: the plant assessed is a high priority for RA at the EU level.
- If no: the plant is not a priority for RA at the EU level and national measures should be considered. Management actions can, for example, be undertaken locally to reduce species abundance and slow down invasion rate.

Discussion

When faced with a large species pool of invasive or potentially invasive alien plants, prioritization is an essential prerequisite to focus limited resources on species which inflict high impacts, have a high rate of spread and can be cost-effectively managed within the EU (Kumschick *et al.*, 2012). The prioritization process detailed in this paper is the first tool specifically designed to prioritize alien plants for RA on the basis of the requirements of Regulation (EU) no. 1143/2014. It can be used for any plant species alien to the EU, whether currently present within the territory or absent (see Roy *et al.*, 2015).

The first questions of Stage 1 allow species that are unsuitable for RA to be filtered out because of taxonomic uncertainty, lack of scientific information or other issues that may lead to potential problems encountered when compiling a RA report. The remaining species are afterwards prioritized on the basis of their establishment capacity, their potential to spread and their impacts. Impacts on native species and ecosystem functions and related ecosystem services are emphasized in line with Article 4.3(c) of the Regulation. Only those species with a medium or high potential for spread and a high impact are included within the EU List of Invasive Alien Plants and proceed to the second, risk management stage. Those species with a low potential for spread or a low or medium impact are included in the EU Observation List of Invasive Alien Plants or the EU List of Minor Concern and should be re-evaluated periodically if and when additional information comes to light.

The inclusion of risk management criteria (Stage 2) in horizon scanning for invasive species is not usually considered in other prioritization tools (e.g. Branquart, 2007; Sandvik *et al.*, 2013; Roy *et al.*, 2014; but see the pre-evaluation scheme of Weber & Gut, 2004, and Brunel *et al.*, 2010). However, those criteria are explicitly integrated into the prioritization process presented here and are in line with the requirements of international trade-related agreements (EFSA Scientific Committee 2012, Lopian & Stephen, 2013) that are reflected in the risk management elements defined in Articles 4.3(d), 4.3(e) and 4.6 of the Regulation.

The output of Stage 2 is to prioritize those species which have a high priority for a RA at the EU level or should be considered under national measures which may involve a trade ban, cessation of cultivation, monitoring, containment or eradication as foreseen for the establishment of a

national list of IAS of Member State concern (Article 12 of the Regulation). Wherever trade will be affected by national measures, a RA will have to be conducted at the national scale in order to select the most appropriate measures to reduce the risk to an acceptable level; those measures will have to be notified to the European Commission in agreement with the rules of the Treaty on the Functioning of the European Union (TFEU).

The risk management stage has been carefully constructed to assess the potential of species for further spread and establishment coupled with the evaluation of preventative and management actions. Hence, invasive alien plants that already occupy most of their potential range within the EU, as well as emerging invasive alien plants whose spread cannot be efficiently limited through pathway management or local control actions, will also be filtered out. In addition, when invasive plants are already widespread, natural spread is likely to contribute much more to plant invasion than dispersal by human activities, which makes pathway management poorly effective. In this case, a trade ban may be considered as disproportionate according to WTO agreements and rules of the TFEU (Shine *et al.*, 2008; Lopian & Stephen, 2013).

Question B2 is included to filter out those species which have been present within the EU as ornamentals without showing any strong signs of invasive behaviour. For example, *Euonymus fortunei* and *Lonicera maackii* are highlighted as species with a high risk to the EU within the next 10 years (Roy *et al.*, 2015) though both are widely cultivated within the EU and as of now show no signs of invasive behaviour. Although this type of species should be generally monitored, in the absence of any invasive behaviour action at a national or regional level is not warranted.

The cost-effectiveness of coordinated actions in Europe against widespread species is rather limited, as shown with the example of *Reynoutria japonica*. In the UK, the total annual cost of this species to the economy is estimated at 166 million GBP (209 million EUR) (Williams *et al.*, 2010) and it could cost an estimated 1.5 billion GBP (1.8 billion EUR) to eradicate the species from the country (DEFRA, 2003). Such high control costs mean that action will be unlikely, especially if replicated throughout all Member States. High figures are quoted for the eradication of *Impatiens glandulifera* in the UK, where the UK Environment Agency estimated in 2003 it would cost between 150 and 300 million GBP (189–378 million EUR), to eradicate the species from the UK; however, eradication is now practically impossible (Cockel & Tanner, 2012). Often these control costs make no provisions for restoration of degraded areas after control, and thus costs are likely to be significantly elevated if restoration practices are included (Tanner & Gange, 2013).

It should be noted that figures on control costs in Europe are often cited based on traditional control options (chemical and manual options) with little attention to classical biological control, which has been shown to be a cost-effective management method for widespread species (McConnachie *et al.*, 2003; McFadyen, 2008). Although a detailed discussion on this aspect is outside the scope of this paper, consideration should be given to novel management practices (including biological control) for widespread species which are not included in the Union List.

In conclusion, the prioritization process for EU invasive alien plant species incorporates the requirements of Regulation (EU) no. 1143/2014 and has been specifically designed within the framework of the LIFE Project (PRE FR 001) 'Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014'. It is intended to be a simple and flexible tool which follows a logical step-wise process. Although the process has been designed for alien plants, the scheme could be adapted to suit other taxonomic groups with slight modifications to the decision scheme and associated examples and text. For example, alien animal species could be considered by modifying the impact questions (A8 and A9) to including predation and disease transmission impacts, amongst others, and modifying or omitting question B2.

When considering alien plant species for the whole of the EPPO region, or for species under the Plant Health Regulation, the original prioritization process for invasive alien plants (Brunel *et al.*, 2010) remains the optimum tool. This scheme is more conservative than the prioritization process presented here as it focuses on plants that are absent or poorly established in their introduced range as requested by the definition of a quarantine pest according to IPPC (Lopian & Stephen, 2013). The EPPO prioritization process is also to be preferred to address socio-economic impacts (e.g. on agriculture and forestry) of invasive alien plants.

Acknowledgements

This research was funded in part by the European Commission, DG Environment LIFE funding under the project LIFE15 PRE FR 001: Mitigating the threat of invasive alien plants in the EU through pest risk analysis to support the Regulation (EU) No 1143/2014. Authors acknowledge Wolfgang Rabitsch, Sonia Vanderhoeven, Montserrat Villà and other members of the scientific forum dedicated to this Regulation for useful suggestions and comments.

Un processus de priorisation pour les plantes exotiques envahissantes, intégrant les exigences du Règlement UE No 1143/2014

Face à un grand nombre d'espèces de plantes exotiques envahissantes, ou potentiellement envahissantes, prioriser est un pré-requis afin de concentrer des ressources limitées sur les espèces à forts impacts, ayant un potentiel important de dissémination, et pouvant être gérées de façon efficace. Le processus de priorisation, tel que décrit dans le présent article, est le premier outil permettant d'évaluer le besoin

de réaliser, en priorité, pour une espèce, une évaluation du risque pour l'Union Européenne (UE), et ce en cohérence avec les exigences du Règlement UE No 1143/2014. Ce processus de priorisation peut être appliqué à toute plante exotique au territoire de l'UE, qu'elle soit présente ou non sur ce territoire. L'objectif est de déterminer, lors d'une étape préliminaire, les espèces prioritaires pour lesquelles une évaluation du risque doit être conduite au niveau de l'UE, et qui pourraient éventuellement être proposées à l'inscription au sein de la liste des espèces exotiques envahissantes préoccupantes pour l'UE. L'évaluation du risque préliminaire (étape 1), classe les espèces au sein de l'une des quatre listes (liste des plantes exotiques envahissantes pour l'UE, liste d'observation des plantes exotiques envahissantes pour l'UE, liste d'importance réduite pour l'UE et liste résiduelle) sur la base de leur capacité de dissémination et de leurs impacts. Pour les impacts, l'accent est mis sur les espèces autochtones, sur les fonctions écosystémiques, ainsi que les services écosystémiques, en cohérence avec l'article 4.3(c) du Règlement UE. Seulement les espèces classées dans la liste des plantes exotiques envahissantes pour l'UE passent à la seconde étape. Au cours de cette étape sont analysés les risques de dissémination et d'établissement, ainsi que les mesures prophylactiques ou mesures de gestion possibles. L'étape 2 classe les espèces les plus prioritaires pour la réalisation d'une évaluation du risque au niveau de l'UE, ou qui devraient faire l'objet de mesures nationales telles que l'interdiction du commerce, l'arrêt de la culture, la surveillance, le contrôle, l'enrayement ou l'éradication. Le processus de priorisation OEPP d'origine reste néanmoins l'outil optimal lorsque le processus est à réaliser sur l'ensemble de la région OEPP, ou pour des espèces réglementées dans le cadre phytosanitaire.

Процесс установления приоритетов в отношении инвазивных чужеродных видов растений, включающий требования Регламентации ЕС № 1143/2014

При наличии большого разнообразия видов инвазивных или потенциально инвазивных чужеродных растений, установление приоритетов представляет собой важное предварительное условие, позволяющее сосредоточить ограниченные ресурсы на тех видах, которые оказывают сильное воздействие, обладают высокой скоростью распространения и могут подвергаться управлению с достаточной экономической рентабельностью. Процесс установления приоритетов, детально рассматриваемый в статье, представляет собой первый инструмент оценки вида при определении приоритета для оценки риска (ОР) в ЕС, специально разработанный таким образом, чтобы включать требования Регламентации ЕС № 1143/2014. Процесс установления приоритетов может использоваться для любых чужеродных для Европейского союза видов растений, независимо от того, присутствуют ли они в настоящий момент на его территории. Цель установления приоритетов заключается в том, чтобы сделать предварительное исследование, позволяющее определить, какие конкретные виды имеют наивысший приоритет для ОР на уровне ЕС и могут в конечном итоге быть предложены для включения в список инвазивных чужеродных видов, вызывающих беспокойство ЕС. Предварительная стадия оценки риска (Стадия 1) заносит виды в зависимости от приоритета в один из четырех списков (Список инвазивных для ЕС чужеродных растений, Список наблюдения ЕС, Список незначительного беспокойства для ЕС и Остаточный список), основанных на потенциале их распространения в сочетании с воздействием. Воздействие на аборигенные виды и на функции экосистем, а также на связанные с ними услуги экосистем отмечаются особо, в соответствии со Статьей 4.3 (c) Регламентации ЕС. Только виды, включенные в Список инвазивных для ЕС чужеродных растений, проходят на вторую стадию предварительной оценки управления рисками, когда оценке подвергается потенциал дальнейшего распространения и акклиматизации вместе с возможными профилактическими и управленческими действиями. На выходе Стадии 2 должны быть выделены виды, которые имеют приоритет для ОР на уровне ЕС или должны рассматриваться в рамках национальных мер, которые могут включать запрет на торговлю, прекращение возделывания, мониторинг, борьбу, локализацию или ликвидацию. При рассмотрении чужеродных видов растений для всего региона ЕОКЗР или для видов согласно Фитосанитарным регламентациям оригинальный процесс ЕОКЗР по установлению приоритетов для инвазивных чужеродных растений является оптимальным средством.

References

Antonetti P, Brugel E, Kessler F, Barbe J-P & Tort M (2006) *Atlas De La Flore D'Auvergne*. Conservatoire botanique national du Massif central, Chavaniac-Lafayette (FR).

Beerling DJ (1993) The impact of temperature on the northern distribution limits of the introduced species Fallopia japonica and *Impatiens glandulifera* in north-west Europe. *Journal of Biogeography* **20**, 45–53.

Bímová K, Mandák B & Kašparová I (2004) How does *Reynoutria* invasion fit the various theories of invasibility? *Journal of Vegetation Science* **15**, 495–504.

Bleeker W, Schmitz U & Ristow M (2007) Interspecific hybridisation between alien and native plant species in Germany and its consequences for native biodiversity. *Biological Conservation* **137**, 248–253.

Bonifacio E, Petrillo M, Petrella F, Tambone F & Celi L (2015) Alien red oak affects soil organic matter cycling and nutrient availability in low-fertility well-developed soils. *Plant and Soil* **395**, 215–299.

Branquart E (2007) Guidelines for environmental impact assessment and list classification of non-native organisms in Belgium. Version 2.4. Harmonia. Belgian Forum on Invasive species. http://

ias.biodiversity.be/ias/documents/ISEIA_protocol.pdf [accessed 24 May 2016]

Branquart E, Hill M, Maguire C, Starfinger U, Van Valkenburg J & Brunel S (2010a) Harmonising the invasiveness concept: the EPPO prioritization scheme as a tool to identify the most invasive plant species in Europe. Abstracts of the NOBANIS conference on IAS early warning systems, Waterford, June 1st and 2nd 2010. http://www. nobanis.org/files/Wed%209.30_Harmonising%20the%20invasiveness%20concept_Etienne%20Branquart.pdf [accessed on 1 June 2015].

Branquart E, Vanderhoeven S, Van Landuyt W, Van Rossum F & Verloove F (2010b) Invasive Species in Belgium, Amelanchier lamarckii. http://ias.biodiversity.be/species/show/35 [accessed on 1 June 2015]. Bruin

Brunel S & Tison JM (2005) A method of selection and hierarchization of the invasive and potentially invasive plants in continental Mediterranean France. In: Invasive Plants in Mediterranean Type Regions of the World. Proceedings of the International Workshop, 25–27 May 2005 (ed. Brunel S). pp. 27–36. Council of Europe Publishing, Mze, France

Brunel S, Branquart E, Fried G, van Valkenburg J, Brundu G, Starfinger U *et al.* (2010) The EPPO prioritization process for invasive alien plants. *EPPO Bulletin* **40**, 407–422.

Calenge C (2006) The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. *Ecological Modelling* **197**, 516–519.

Caño L, Campos JA, Garcia-Magro D & Herrera M (2013) Replacement of estuarine communities by an exotic shrub: distribution and invasion history of *Baccharis halimifolia* in Europe. *Biological Invasions* **15**, 1183–1188.

Cierjacks A, Kowarik I, Joshi J, Hempel S, Ristow M, von der Lippe *et al.* (2013) Biological flora of the British Isles: *Robinia pseudoacacia*. *Journal of Ecology* **101**, 1623–1640.

Cockel CP & Tanner RA (2012) *Characteristics, problems, and management of a highly successful alien species– Impatiens glandulifera Royle. A Handbook of Global Freshwater invasive Species*. Earthscan, London.

Conser C & Connor EF (2009) Assessing the residual effects of *Carpobrotus edulis* invasion, implications for restoration. *Biological Invasions* **11**, 349–358.

Cullen J (2011) Naturalised rhododendrons widespread in Great Britain and Ireland. *Hanburyana* **5**, 11–29.

Daehler CC & Strong DR (1997) Hybridization between introduced smooth cordgrass (*Spartina alternifolia*; Poaceae) and native California cordgrass *(S. foliosa*) in San Francisco Bay, California USA. *American Journal of Botany* **84**, 607–611.

Deckers B, Verheyen K, Hermy M & Muys B (2005) Effects of landscape structure on the invasive spread of black cherry *Prunus serotina* in an agricultural landscape in Flanders, Belgium. *Ecography* **28**, 99–109.

DEFRA (2003) Review of non-native species policy. Report of the working group. DEFRA Publications. London, UK. http://jncc.defra.gov.uk/pdf/BRAG_NNC_DefraReviewofNon-NativeSpeciesPolicy.pdf [accessed 24 July 2016].

Dostal P, Müllerova J, Pysek P, Pergl J & Klinerova T (2013) The impact of an invasive plant changes over time. *Ecology Letters* **16**, 1277–1284.

EFSA Scientific Committee (2012) Scientific Opinion on Risk Assessment Terminology. *EFSA Journal 2012* **10**, 2664.

Environment Agency (2010) *Guidance for the Control of Invasive Weeds in or Near Fresh Water*. Environment Agency, London, UK.

European Environment Agency (2016) http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1 [accessed 26 May 2016].

EU (2014) Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species http://eur-lex.europa.eu/legalcontent/EN/TXT/?qid=1468913651345&uri=CELEX:32014R1143 [accessed 22 August 2016].

Fremstad E (2006) NOBANIS – Invasive Alien Species Fact Sheet – *Lupinus polyphyllus*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species – NOBANIS http://www.nobanis.org [accessed on 09 March 2010]

Fried G (2010) Prioritization of potential invasive alien species in France. In: 2nd International Workshop Invasive Plants in the Mediterranean Type Regions of the World, 2010-08-02/06, Trabzon, Turkey (eds Brunel S, Uludag A, Fernandez-Galiano E & Brundu G), pp. 120–138.

Fried G (2012) Guide des plantes invasives. In: *Collection "L'indispensable guide des… Fous de Nature!* (ed. Eyssartier G), pp. 272. Editions Belin, Saint-Just-la-Pendue, France

Fried G, Laitung B, Pierre C, Chagué N & Panetta FD (2014) Impact of invasive plants in Mediterranean habitats: disentangling the effects of characteristics of invaders and recipient communities. *Biological Invasions* **16**, 1639–1658.

Fried G & Panetta FD (2016) Comparing an exotic shrub's impact with that of a native life form analogue: *Baccharis halimifolia* L. vs *Tamarix gallica* L. in Mediterranean salt marsh communities. *Journal of Vegetation Science* **27**, 812–823.

Gordon DR, Mitterdorfer B, Pheloung PC, Ansari S, Buddenhagen C, Chimera C *et al.* (2010) Guidance for addressing the Australian weed risk assessment questions. *Plant Protection Quarterly* **25**, 56–74.

Harris CM, Standford HL, Edwards C, Travis JMJ & Park KJ (2011) Integrating demographic data and a mechanistic dispersal model to predict invasion spread of *Rhododendron ponticum* in different habitats. *Ecological Informatics* **6**, 187–195.

Hejda M, Pyšek P & Jarošík V (2009) Impact of invasive plants on the species richness, diversity and composition of invaded communities. *Journal of Ecology* **97**, 393–403.

Hijmans RJ, Cameron SE, Parra JL, Jones PG & Jarvis A (2005) Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* **25**, 1965–1978.

Huxel GR (1999) Rapid displacement of native species by invasive species: effects of hybridization. *Biological Conservation* **89**, 143–152.

IPPC (2007) Pest Risk Analysis for Quarantine Pests Including Analysis of Environmental Risks and Living Modified Organisms. ISPM no. 11 in International Standards for Phytosanitary Measures, pp. 135–160. IPPC Secretariat, FAO, Rome (IT). https://www.ippc.int/IPP/En/default.jsp [accessed on 1 June 2016]

Isermann M (2008). Effects of Rosa rugosa invasion in different coastal dune vegetation types. In: *Plant Invasions: Human Perception, Ecological Impacts and Management* (eds JH Brock, G Brundu, L Child, CC Daehler & P Pysek). pp. 289–306. Backhuys, Leiden, The Netherlands.

Jeanmonod D & Gamisans J (2007) *Flora Corsica*. Edisud, Aix-en-Provence (FR).

Kenis M, Bacher S, Baker RHA, Branquart E, Brunel S, Holt J *et al.* (2012) New protocols to assess the environmental impact of pests in the EPPO decision-support scheme for pest risk analysis. *Bulletin OEPP/EPPO Bulletin* **42**, 21–27.

Kohn DD, Hulme PE, Hollingsworth PM & Butler A (2009) Are native bluebells (*Hyacinthoides nonscripta*) at risk from alien congenerics? Evidence from distributions and co-occurrence in Scotland. *Biological Conservation* **142**, 61–74.

Kohyt J & Skubala P (2013) Communities of mites (Acari) in litter and soil under the invasive red oak (Quercus rubra L.) and native pedunculate oak (Q. robur L.) *Biological Letters* **50**, 111–124.

Kollmann J, Frederiksen L, Vestergaard P & Bruun HE (2007) Limiting factors for seedling emergence and establishment of the invasive non-native *Rosa rugosa* in a coastal dune system. *Biological Invasions* **9**, 31–42.

Kottek M, Grieser J, Beck C, Rudolf B & Rubel F (2006) World map of the Köppen-Grieser climate classification updated. *Meteorologische Zeitschrift* **15**, 259–263.

Kumschick S, Bacher S, Dawson W, Heikkilä J, Sendek A, Pluess T *et al.* (2012) A conceptual framework for prioritization of invasive alien species for management according to their impacts. *NeoBiota* **15**, 69–100.

Kumschick S & Richardson DM (2013) Species-based risk assessments for biological invasions: advances and challenges. *Diversity and Distributions* **19**, 1095–1105.

Lambinon J, Delvosalle L & Duvigneaud J (2004) *Nouvelle Flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des Régions Voisines*. Editions du Patrimoine du Jardin botanique national de Belgique, Meise (BE).

Langdon SJ, Marrs RH, Hosie CA, McAllister HA, Norris KM & Potter JA (2004) *Crassula helmsii* in U.K. Ponds: effects on plant biodiversity and implications for newt conservation. *Weed Technology* **18**, 1349–1352.

Lopian R & Stephen C (2013) International trade and invasive alien species. Standards and Trade Development Facility, 52 pp.

Magarey RD, Borchert DM & Schlegel JW (2008) Global plant hardiness zones for phytosanitary risk analysis. *Scientia Agricola* **65**, 54–59.

Marchante E, Kjoller A, Struwe S & Freitas H (2008) Short- and long-term impacts of *Acacia longifolia* invasion on the belowground processes of a Mediterranean coastal dune ecosystem. *Applied Soil Ecology* **40**, 210–217.

McConnachie AJ, Wit MP & Hill MH (2003) Economic evaluation of the successful biological control of *Azolla filiculoides* in South Africa. *Biological Control* **28**, 25–32.

McFadyen REC (2008) Return on investment: determining the economic impact of biological control programmes. In: *Evans HC XII International Symposium on Biological Control of Weeds* (eds Julien MH, Sforza R & Bon MC), pp. 67–74. CABI Publishing Wallingford, UK.

Meilleur A, Véronneau H & Bouchard A (1994) Shrub communities as inhibitors of plant succession in southern Quebec. *Environmental Management* **18**, 907–921.

Morimoto J, Kominami R & Koike T (2010) Distribution and characteristics of the soil seed bank of the black locust (Robinia pseudoacacia) in the headwater basin in northern Japan. *Landscape and Ecological Engineering* **6**, 193–199.

Muller S (2004) Plantes invasives en France. (Patrimoines naturels, 62).Museum National D'Histoire Naturelle, Paris, 168 p.

Panetta FD & Timmins SM (2004) Evaluating the feasibility of eradication for terrestrial weed incursions. *Plant Protection Quarterly* **19**, 5–11.

Panetta FD (2015) Weed eradication feasibility: lessons of the 21st century. *Weed Research* **55**, 226–238.

Pairon M, Jonard M & Jacquemart A-L (2006) Modelling seed dispersal of black cherry, an invasive forest tree: how microsatellites may help? *Canadian Journal of Forest Research* **36**, 1385–1394.

Rice SK, Westerman B & Federici R (2004) Impacts of the exotic, nitrogen-fixing Black Locust (*Robinia pseudoacacia*) on nitrogen-cycling in a pine-oak ecosystem. *Plant Ecology* **174**, 97–107.

Richardson DM, Macdonald IA & Forsyth GC (1989) Reduction in plant species richness under stands of alien trees: concepts and definitions. *Diversity and Distributions* **6**, 93–107.

Richardson DM, Pysek P, Rejmanek M, Barbour MG, Panetta D & West CJ (2000) Naturalization and invasion of alien plant: concepts and definitions. *Diversity and Distributions* **6**, 93–107.

Rivière G (2007) *Atlas de la Flore du Morbihan*. Siloe Editions, Nantes (FR).

Roy H, Schonrogge K, Dean H, Peyton J, Branquart E, Vanderhoeven S *et al*. (2014) Invasive alien species- framework for the identification of invasive alien species of EU concern ENV. B. 2/ETU/2013/0026. http://ec.europa.eu/environment/nature/invasivealien/docs/Final%20report_12092014.pdf [accessed 23 May 2016]

Roy HE, Peyton J, Aldridge DC, Bantock T, Blackburn TM, Britton R *et al.* (2014) Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. *Global Change Biology* **20**, 3859–3871.

Roy HE, Adriaens T, Aldridge DC, Bacher S, Bishop JDD, Blackburn TM *et al.* (2015) Invasive Alien Species - Prioritising prevention efforts through horizon scanning ENV.B.2/ETU/2014/0016. European Commission.

Ruiz Téllez T, Martı′n de Rodrigo Lo′pez E, Lorenzo Granado G, Albano Pérez E & Sánchez Gurzmán JM (2008) The Water Hyacinth, *Eichhornia crassipes*: an invasive plant in the Guadiana River Basin (Spain). *Aquatic Invasions* **3**, 42–53.

Sandvik H, Sæther B, Holmern T, Tufto J, Engen S & Roy HE (2013) Generic ecological impact assessments of alien species in Norway: a semi-quantitative set of critera. *Biodiversity and Conservation* **22**, 37–62.

Säumel I & Kowarik I (2010) Urban rivers as dispersal corridors for primarily wind-dispersed invasive tree species. *Landscape and Urban Planning* **94**, 244–249.

Shine C, Kettunen M, Genovesi P, Gollasch S, Pagad S & Starfinger U (2008) Technical support to EU strategy on invasive species (IAS) - Policy options to control the negative impacts of IAS on biodiversity in Europe and the EU. (Final module report for the European Commission). Institute for European Environmental Policy (IEEP). Brussels, Belgium.

Smulders MJM, Beringen R, Volosyanchuk R, Vanden Broeck A, van der Schoot J, Arens P *et al.* (2008) Natural hybridisation between *Populus nigra* L. and *P.* x canadensis Moench. Hybrid offspring competes for niches along the Rhine river in the Netherlands. *Tree Genetics & Genomes* **4**, 1614–2942.

Stace CA (2010) *New Flora of the British Isles*, 3rd edn. Cambridge University Press, Oxford.

Stace CA & Crawley MJ (2015) *Alien Plants*. 626 pp. The New Naturalist Library, Glasgow, UK.

Stace CA, Preston CD & Pearman DA (2015) *Hybrid Flora of the British Isles*. 501 pp. BSBI Publication, Bristol, UK.

Staska B, Essl F & Samimi C (2014) Density and age of invasive *Robinia pseudoacacia* modulate its impact on floodplain forests. *Basic and Applied Ecology* **15**, 551–558.

Stephenson CM, Kohn DD, Park KJ, Atkinson R, Edwards C & Travis JM (2007) Testing mechanistic models of seed dispersal for the invasive *Rhododendron ponticum* (L.). *Perspectives in Plant Ecology, Evolution and Systematics* **9**, 15–28.

Tanner RA & Gange AC (2013) The impact of two non-native plant species on native flora performance: potential implications for habitat restoration. *Plant Ecology* **3**, 423–432.

van Valkenburg JLCH & Pot R (2008) *Landoltia punctata* (G. Mey.) D.H.Les & D.J.Crawford (Smal kroos), Nieuw Voor Nederland. *Gorteria* **33**, 41–79.

Verloove F (2006) Catalogue of the Neophytes in Belgium (1800–2005). *Scripta Botanica Belgica* **39**, 89.

Verloove F (2012) Manual of the Alien Plants of Belgium, National Botanic Garden of Belgium. http://alienplantsbelgium.be/node/3478 [accessed on 1 June 2012].

Weber E & Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. *Journal for Nature Conservation* **12**, 171–179.

Willis SG & Hulme PE (2002) Does temperature limit the invasion of Impatiens glandulifera and Heracleum mantegazzianum in the UK? *Functional Ecology* **16**, 530–539.

Williams F, Eschen R, Harris A, Djeddour D, Pratt C, Shaw RS *et al.* (2010) *The economic Cost of Invasive Non-Native Species on Great Britain*. CABI, Wallingford UK.

Williamson MH (1996) *Biological Invasions*. 244 pp. Chapman & Hall, London.

Wolf DE, Takebayashi N & Rieseberg LH (2001) Predicting the risk of extinction through hybridization. *Conservation Biology* **15**, 1039–1053.

Yurkonis K, Meiners SJ & Wachholder BE (2005) Invasion impacts diversity through altered community dynamics. *Journal of Ecology* **93**, 1053–1061.