

POLICY PERSPECTIVE

Making the EU Legislation on Invasive Species a Conservation Success

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Abstract

The European Union's (EU) new legislation concerning Invasive Alien Species (IAS) is a ground-breaking and commendable attempt to set a common standard for combating IAS across political jurisdictions at a multinational scale. However, the regulation, underpinned by a list of IAS of Union concern, affords Member States a degree of operational flexibility and its successful implementation will be dictated by appropriate national enforcement and resource use. In evaluating this EU legislation, we provide pragmatic recommendations based upon a geo-political analysis of the pan-European capabilities to combat IAS and discuss measures to avoid the risk that the regulation will promote a piecemeal response by stakeholders instead of a truly collaborative effort. We highlight a major deficit in the funding mechanisms to support a comprehensive implementation of the legislation and stress the importance of consultation with the broader scientific community, including with key stakeholders, businesses and the general public. Our recommendations will create incentives for industries, raise awareness among citizens and stakeholders, and help establish a social norm for the EU and further afield. The legislation offers a collaborative Europe the chance to demonstrate its commitment to tackling the problems of IAS and to achieve a successful conservation breakthrough of international importance.

Introduction

Invasive alien species (IAS), the subset of alien species that cause a negative impact to the environment or human wellbeing (Lockwood *et al.* 2013, Blackburn *et al.* 2014), are one of the greatest threats to biodiversity and represent a globally significant and rapidly growing economic cost (Vilà *et al.* 2009; CBD 2014). Approximately 1200 to 1800 IAS (see www.issg.org for examples) are established in the EU, costing up to €20 billion each year in threat mitigation and associated damage (Kettunen *et al.* 2009). Recognizing that both terrestrial and aquatic IAS pose a threat to Europe's economy, public health and bio-

diversity, a dedicated EU legislation (EU 2014a and b) was adopted in September 2014 that aims to harmonize and improve the currently disparate efforts of Member States (MS) to combat IAS. This was a timely piece of legislation as increases in global trade, coupled with the delayed responses of IAS to globalization (Essl *et al.* 2011) and human-induced climate change (Bellard *et al.* 2013) are predicted to further promote the introduction and establishment of IAS.

The legislation (EU Regulation no.1143/2014) entered into force on January 1st 2015 and is commendably underpinned by a consensus amongst scientists and policy-makers that prevention is better than cure.

It introduces some novel elements including the promotion of early-warning and surveillance systems (Articles 16 and 22), the development of action plans to address priority pathways (Article 13), rapid eradications to prevent establishment and long-term mitigation and control mechanisms (Article 17). A list of the IAS to be covered by this legislation (hereafter referred to as the “Union list”) will be completed by January 2016 and will include those species deemed of Union concern after scientifically robust risk assessments as laid down within the Regulation. The risk assessments must comply with a set of fourteen minimum standards which include quality assurance, documentation of information sources and uncertainty alongside relevant information on arrival, establishment, spread and impact (Roy *et al.* 2014a). To facilitate these ambitious objectives, the European Commission (EC) will be assisted by a Committee composed of representatives of each MS. An independent Scientific Forum, representing members of the scientific community appointed by each MS, will advise this decision-making Committee and provide scientific input relating to the application of the legislation, decisions concerning amendments to the Union list, risk assessments, emergency measures and rapid response eradications (Articles 27 and 28).

Building on a geopolitical analysis of the disparate legally-binding efforts to combat IAS in Europe (prior to the recent regulation) and examples from other OECD countries, we critically extend recent discussions (Genovesi *et al.* 2015, Beninde *et al.* 2015) by providing suggestions to optimize the implementation of the EU legislation. Specifically, we offer objective recommendations that focus on (i) the Union list, (ii) the funding mechanism, and (iii) regional cooperation, responsibility and surveillance. We conclude with a synopsis of the key policy elements required to ensure that the new EU regulation on IAS will become an effective instrument to curb their detrimental effects (Table 1), and identify areas where further research efforts are needed to support the implementation of the new EU regulation on IAS (Table 2).

Create an inclusive and dynamic list of IAS of Union concern

The core instrument of the EU regulation is the Union list (Article 4). The list will be pivotal in defining the success of this policy and its creation represents a pioneering attempt to standardize policy across taxa and sectors on a regional scale, which has never been attempted in combating IAS (BIO-IS 2011). The number of species on the Union list will not be limited, despite initial proposals (Beninde *et al.* 2015). The list will underpin the entire prevention, early-warning and management framework,

and should include species which present both current threats (species already present) and potential threats (species not yet present in the EU that demonstrate significant negative impacts elsewhere). Because MS will only be obliged to create pathway action plans for and apply management strategies to those IAS that are included in the Union list, it should be as inclusive as possible in order to promote the consensus that prevention is better than cure. National or regional lists are recommended but not mandatory, while the Union list will only incorporate species considered a threat to “one biogeographical region shared by more than two Member States or one marine subregion excluding their outermost regions” (Article 4.3b). The legislation directives require that each IAS proposed for inclusion in the Union list is properly risk assessed, i.e., based on a number of minimum standard criteria (see Roy *et al.* 2014a). Such a robust “black-list” approach is a sensible choice for Europe given its unique geopolitical structure and its long history of introductions (Essl *et al.* 2011). However, we present three main concerns:

- (1) There is some risk that already widespread IAS may not be included on the list (or otherwise affected by the legislation), even if causing substantial damage, because the prevention or control of adverse impacts is considered unfeasible and not cost-effective by some MS. The absence of a compulsory framework for national or regional threats is a specific concern as this may lead to future European-level issues.
- (2) The list is foreseen to be dynamic, allowing MS to request the addition or deletion of species. Since the financial burden associated with any subsequent action will be met by each MS, there is a risk that the list will be insufficiently dynamic, nonrepresentative, and at risk from lobbying from industries that use the General Agreement on Tariffs and Trade (GATT) to reduce trade barriers, thereby reducing the chances of identifying potential threats. Yet it is for those species not currently present that a prevention approach can be the most cost-effective and efficient because prevention is likely to cost less than long-term management and control.
- (3) Creating and updating the Union list will require careful consideration of scientific, political and economic incentives. The Committee of MS representatives, after consultation with the Scientific Forum, will be responsible for selecting those species that appear on the final list but the legislation does not clearly define the specific criteria by which species will be chosen, only that the Committee should “focus on species whose inclusion on the Union list would effectively prevent, minimize or mitigate the adverse impact of those species in a cost efficient

Table 1 Synopsis of the key policy elements required to ensure that the new EU regulation on IAS will become an effective instrument to curb the detrimental effects of IAS

Create an inclusive and dynamic Union list

- Develop guidance for ensuring synergy between the committee of MS representatives, the Scientific forum, or other stakeholder panels to be developed to select a representative and inclusive Union list
- Frequently update the Union list
- Promote the desire for MS to suggest new species (create incentives, develop communication strategy)

Conquering budgetary constraints

- Dedicate calls for IAS within Horizon 2020 and the LIFE programme, including calls targeting Union listed species
- Publication of EU guidance on funds that can be used for IAS and creation of an information system flagging all IAS projects
- Increase direction of EU funds for IAS control and management in agriculture, aquaculture fishery and forestry sectors, and improve relevant data storage and circulation

Strengthen regional cooperation, responsibility and observation on corporate and social levels

- Identify common strategies and promote cost-sharing associated with IAS on a biogeographical basis
- Implement the existing voluntary codes of conduct and best practice guidance for industry and develop new ones as required
- Implement strict penalties and environmental liability insurances
- Increase collaboration and cooperation with pan-European organizations, such as the Council of Europe
- Dedicate funds for fast reaction
- Raise awareness of social responsibility both at the public and corporate level
- Enhanced surveillance, monitoring and information sharing across borders

Table 2 Areas where further research efforts are needed to support the implementation of the new EU regulation on IAS

Research needs

- Cost-benefit analyses of IAS, including ecological, social, economic aspects
- Pathway analyses
- Establish robust risk assessment methods and associated management decision pathways
- Assess the cost-effectiveness of prevention, early-warning and management measures
- Assess the conservation impact of the new EU regulation
- Develop citizen science initiatives and horizon scanning for monitoring and early-warning

manner.” This raises a concern that the list will be short and driven by incentives that do not consider simultaneously the costs and benefits to multiple stakeholders; a consideration that we acknowledge is highly complex. The difficult task of the Committee here is to select species for the list that deliver this “cost efficiency” to society as a whole without appearing to favor a specific stakeholder group.

Furthermore, MS will have three years to address priority pathways identified on the basis of a comprehensive analysis of the pathways of unintentional introduction and spread of those species that are considered of Union concern. However, procedures for risk assessments of pathways and commodities are almost completely missing in the EU, except for commendable but embryonic steps in the United Kingdom, Belgium and Spain (Fig. 1a). In the absence of further EU guidance, much

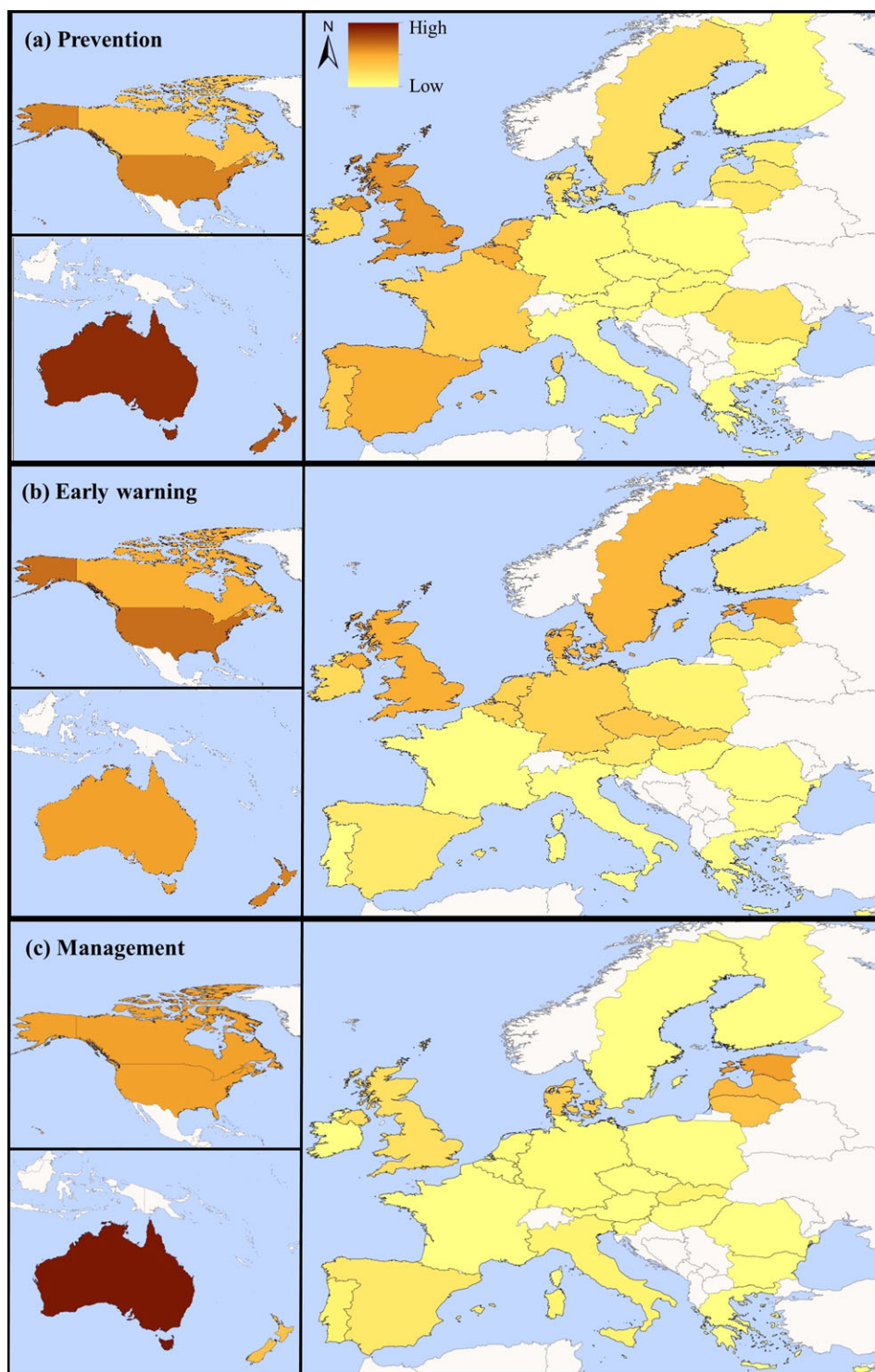


Figure 1 Level of development of Invasive Alien Species (IAS) regulation in the EU27 (before Croatia acceded in 2013) and four OECD countries known to have well-developed IAS policies: EU27 in the main panel, United States and Canada in the top left, Australia and New Zealand in the bottom left. The maps are based on data from the comparative analysis of all IAS policy instruments in each country (BIO Intelligence Service 2011). Altogether 35 criteria were used, 19 for prevention, 9 for Early-warning and 7 for Management; each criteria was then assigned a weight based on its rating in the assessment carried out by BIO Intelligence Service (2011) (0 = criterion not fulfilled to 3 = criterion fully fulfilled). The legislation index represents the sum of these scores in each MS and is mapped for: (a) Prevention; (b) Early-Warning and (c) Management. Further details on index calculation are given in online supplementary material.

could be learnt from Australia and New Zealand, countries that have used such approaches for several years. They are currently developing risk analysis procedures to identify high risk areas or commodities while reducing the administrative and financial burdens for industries that actively mitigate IAS risks (DAFF 2012).

The Union list is likely to set a standard for several years to come and its importance cannot be understated. We support the EC's intention to frequently update the list under the Scientific Forum's guidance, and to take into account inputs from the wider scientific community, and suggest updates on at least an annual basis. A further challenge is to adopt an informed list that sets a strong benchmark through its inclusivity, which reflects the number of IAS already established in the EU and the full set of priority pathways, whilst avoiding the exclusion of IAS associated with marginal and localized socio-economic benefits. Achieving this goal requires a sensitive balance between the opinions and knowledge of scientists and the considerations of wider society. In its decision-making role the newly appointed Committee of MS representatives will, after consultation with the Scientific Forum, compile the list. Nevertheless, despite the definition of dedicated rules of procedures for both the Committee and the Scientific Forum, the legislation provides only limited guidelines regarding this synergy. Given that much remains unknown regarding the costs and benefits of taking action against IAS, one of the main challenges is to develop guidelines that enable productive and respectful communication between these two bodies. Therefore, both the Committee of MS representatives and the Scientific Forum should consist of experts in the field of biological invasions, whose collective knowledge represents the breadth of taxonomic groups, ecological issues and socio-economic implications.

Moreover, the list should remain unyielding to conflicts of interests since MS will be permitted to apply for derogations to maintain secure, captive populations of IAS where they provide socio-economic benefits of "compelling public interest" (See EU Statement 13266/14). The American mink (*Neovison vison*) is one such example. Despite causing negative effects on small mammal populations and avian breeding success across Europe (Nordström *et al.* 2003; Bonesi & Palazon 2007), it remains an important economic species for Denmark, accounting for an estimated €0.5 billion in annual exports (Kopenhagen Fur 2012). Just how compelling the public interest needs to be for derogation to be justified rests on a set of unknown probabilities including the risk of escape, likely impact, and the likelihood that damage can be avoided by curtailing the industry. Therefore, it is critical that MS define a strong and consistent position on such problematic IAS to maximize the strengthening effect of legislative unity.

Conquering budgetary constraints

The lack of a dedicated funding mechanism raises concern about how effectively the IAS regulation will be implemented (Beninde *et al.* 2015; Genovesi *et al.* 2015). The success of IAS policies in other OECD countries is undoubtedly linked to substantial governmental funding. In the United States, over €1 billion was invested annually for IAS activities, at least an order of magnitude more than reported MS budgets combined (BIO-IS 2011). Our main concern is that short-term, socio-economic limitations may provide MS with arguments against action, although long-term costs of doing nothing ought to provide sufficient motivation. For instance, managing common ragweed (*Ambrosia artemisiifolia*), an agricultural and ecological pest species notorious for its highly allergenic pollen (Bullock *et al.* 2010), with an annual budget of €30 million, is predicted by models to yield savings of up to €365 million associated with managing the costs of providing allergy remediation in southern Germany and Austria alone (Richter *et al.* 2013). Therefore, MS can benefit from developing and actively enforcing new financial instruments, drawing from experiences in other OECD countries. For instance, improved cost-recovery could be obtained by making a wider use of fines linked to the volume and/or risk of commodities, supported by intelligence and risk-profiling to prioritize resource allocation, such as in Australia to help maximize return on investment (DAFF 2012). There is a lack of data to suggest that damage by IAS is enough to warrant the costs of management, and the potential damage of future IAS may not be comprehended. Furthermore, the comparison of biological damage against monetary values calls for some value choices: for example, how does one decide when a prevention mechanism is cheaper than losing a native species that has no direct economic implications? Thus, while the potential damage of future IAS may not be realized the economic cost of prevention measures may seemingly far outweigh the current damage costs, comprehensive cost benefit analyses including future (unknown) damage and social values still need to be developed. Furthermore, each MS may have different values and vastly different budgets in place to implement any prevention despite the benefits that preventative measures may provide at both the MS and regional level.

EU financing has been pivotal in supporting management and research on IAS since the 1990s (Scalera 2010), but currently there are no dedicated funding opportunities in relation to most aspects of the new policy provided within the programming period 2014–2020. The LIFE work program for 2014–2020 identifies management, prevention and communication measures related to IAS as priority topics and recently opened a call for

proposals for developing risk assessments on invasive alien plant species absent from or at low numbers in the EU in compliance with the criteria in the regulation. But it would remain up to MS to play a key role to provide potential beneficiaries with the needed guidance and a co-funding of 40% of the costs. A meaningful synergy would be to consider the species on the Union list as priorities for funding management actions under LIFE (thus entitling MS to receive a higher co-financing rate from the EU) thereby encouraging MS to list the most threatening IAS. In terms of research activities, the Horizon 2020 work program (the EU framework aimed at securing Europe's global competitiveness) has no "programmable" topics dedicated to IAS in the near future. We thus strongly recommend the development of targeted calls within both EU funding schemes to focus on the implementation of the regulation. The prompt and sound implementation of the IAS regulation would clearly benefit from a strategic use of all EU financial resources. EU-level guidance on how to make the most of the current funding instruments (e.g., structural funds) and an *ad hoc* strategy for the harmonized use of such funding opportunities would enable MS to take action. For example, the establishment of an EU wide system to flag all EU funded projects targeting IAS would also support the development of dedicated response indicators to track the effectiveness of the new measures (Rabitsch *et al.* 2012).

Strengthen regional cooperation, responsibility and surveillance on corporate and social levels

Talk to your neighbors

Any policy that aims to combat IAS at a continental scale can only be as effective as the least vigilant MS involved in implementation and therefore strong, cross-border European governance and considerable country-level buy-in is pivotal for its success. Consistency of prevention and mitigation attempts between two or more neighboring countries is essential (Essl *et al.* 2011). For instance, the absence of a determined eradication campaign to halt the incipient invasion of the emerald ash borer (*Agrilus planipennis*) in Russia has placed ash (*Fraxinus* spp.) trees across Europe in imminent danger (Orlova-Bienkowskaja 2013) likely causing huge economic costs and biodiversity impacts. Similar concerns exist for aquatic ecosystems, where ballast water and fouling associated with shipping account for 80% of unintentional introductions of marine species (Molnar *et al.* 2008).

The regulation will help overcome these issues for IAS on the Union list, since MS will be required to manage them effectively (Article 22). MS will also be able

to maintain existing stringent regulations on any IAS (Article 11). In that sense, the EU approach reflects a simplified version of Australia's comprehensive declaration system, which has several classes of IAS according to risk and spread, with associated control or eradication requirements (BIO-IS 2011). This is an enviable model since overall, the EU is doing poorly in terms of IAS control and management (Fig. 1c) with only few occasions where MS have defined management end-points and requirements to monitor spread and restoration of damaged or degraded ecosystems (BIO-IS 2011). However, in the absence of guidance and coordination these policies risk missing their objectives. We argue that MS will have to talk to their neighbors, including countries beyond the EU 28 to identify common strategies, facilitate collaboration and cost-sharing.

- (1) By visualizing Europe's heterogeneous, legislative landscape MS should identify "hotspots" where consolidation efforts can be focused. Less experienced MS can build on the prevention experience to control pathways in some Western European countries (Fig. 1a) or the management policies existing in Baltic States for some species (Fig. 1c). Latvia for example has already defined some mandatory requirements to control or eradicate species as well as some management requirements for certain species (e.g., giant hogweed), although no standard protocols are in place and requirements to restore damaged ecosystems are already in place in Spain (BIO-IS 2011).
- (2) For species that fail to be listed as IAS of Union concern, lists of IAS of "MS concern" or "regional concern" may be useful, as long as responses are harmonized and experiences shared. A first step toward regional cooperation would be to collectively identify IAS of high concern on a biogeographical basis. The implementation of the EU Habitats Directive has shown that regional expert panels (cf. "biogeographical seminars on IAS") may support such a process efficiently, a responsibility that should be delegated to the Scientific Forum.
- (3) Information regarding IAS at the national level is often collected and exchanged among scientists but a similar mechanism to communicate effectively with regional neighbors at the MS level is lacking. Exchanges and networking activities between scientific institutions, NGOs and relevant authorities are being successfully implemented at the EU level thanks to a number of specific initiatives funded by the European Cooperation in Science and Technology (COST) including "Alien Challenge," "SMARTER," and "ParrotNet." These highly valuable and successful COST "Actions" are currently at threat from funding cuts.

Talk to your businesses

The EU regulation does not foresee a joint platform of discussion with industry, despite the fact that prevention is inevitably tied to trade issues. Risk assessments and emergency measures, however, have to comply with the applicable provisions of the relevant Agreements of the WTO. The regulation is strengthened by the “polluter pays” principle (Article 21), enforcing accountability and fairness in instances where an industry might perceive little risk but will not have to deal with the associated long-term costs of unintentional release or escape. However, applying diligent enforcement of this principle can be difficult, due to the irreversible, cumulative effects (Genovesi *et al.* 2015) and the explicit identification of the polluter. Instructions or interpretation guidance how to apply the polluter pays principle in reality from the legal and administrative perspectives are urgently needed. In addition, environmental liability insurances need to become acceptable and standard for polluters to pay in advance of any possible action.

Identifying and prioritizing the main vectors and pathways for the spread of IAS should be a priority for MS, and should be viewed as beneficial to all trade partners in the long-term, as exemplified by the success of risk-based biosecurity approaches in Australia and New Zealand. As noted by Genovesi *et al.* (2015) existing voluntary codes of conduct or best-practice guidance (e.g., pet trade and ornamental plant trade) should complement action to withdraw IAS from circulation by providing alternatives or incentives to the market. New Zealand has recently pioneered a partnership-based approach with the industry to provide a framework for decision-making and financing on the prevention and management of IAS to try and improve and generalize these voluntary involvements across sectors (GIA 2014). Since the implementation of voluntary countermeasures may not be sufficient to prevent introductions of IAS (Hulme 2011), strict penalties (e.g., fines) associated with the breach of those pathways should be enforced, and the revenue generated could fund targeted IAS monitoring around key pathways.

Watch the horizon and react fast

Reacting rapidly to IAS requires consideration of potential IAS and early-warning of new introduction events. Accordingly, the EU regulation requires that priority shall be given to species not yet in Europe (Article 4(6a)), but provides no guidance about how to achieve this. Currently, in contrast to other OECD countries such as United States and Australia, very few MS have surveillance or emergency response measures in place (Fig. 1b). The main priority for MS is therefore to install mandatory and collaborative surveillance and rapid response

procedures, building on the experience of those countries that score highly in prevention and early warning (Fig. 1). A key to the early-warning and rapid response system in the United States is the National Invasive Species Information Centre (NISIC), a joint information system that encourages information sharing among existing databases. In Europe, a similar system will be developed, possibly through the European Alien Species Information Network (EASIN) that aims to facilitate the exploration of existing alien species information in Europe (Katsanevakis *et al.* 2015). This will complement the existing “AquaNIS” information system which addresses aquatic IAS (Olenin *et al.* 2014). Requirements to survey key entry points and high risk areas for target species (already in place in some countries, at least for target species, e.g., Denmark and Estonia) would benefit from being generalized across Europe. Similarly, ensuring each control option has associated budget lines, as is mandatory in Estonia (BIO-IS 2011), seems a key component of successful rapid response. Cost-sharing agreements between the public and private sectors according to the level of public benefits gained from controlling the invasive alien species as in Australia (Plant Health Australia, 2010) could also ensure there is no delay in reporting spread.

Three additional recommendations could help MS achieve this goal:

- (1) Implementing horizon-scanning techniques, which have proven to be a useful approach to identify these species (Roy *et al.* 2014b). This responsibility could be delegated to the Scientific Forum or to a dedicated panel of independent experts.
- (2) Engaging the public using well-designed citizen science initiatives utilizing state-of-the art technologies to capture information on new introductions (e.g., mobile phones app to record ragweed distribution, e.g., <http://ragweed.eu/app/>) can provide up-to-date valuable information (cf. Roy *et al.* 2012) and raise public awareness.
- (3) Biological invasions have been often compared to natural disasters (Ricciardi *et al.* 2011). This suggests that relevant funding opportunities should be considered to deal with IAS. For example the European solidarity fund (EU tool for responding rapidly to natural catastrophes such as earthquakes and floods) could also include funding options for rapid response actions to new incursions of IAS. In the likely event that the list of IAS of Union concern does not cover all relevant threats at the national and regional level, a similar scheme should be considered for “IAS of MS concern.” These funds should be directed to MS which are disproportionately affected by the economic

impacts of IAS of regional concern to ensure a consistent response against IAS across the EU.

Creating strong social norms

Biological invasions are a consequence of human activities, so the solutions to this problem lie in what people do and how they behave. The challenge therefore is to increase public awareness of the full consequences of their actions. Strong legislation and enforcement (e.g., Australia and New Zealand) reflects the severity of the issue and sets a strong social norm (Koger & Winter 2011). The establishment of a social norm both within industry and the general public is perhaps the most crucial component of a successful policy to combat IAS. Similar to a broad acceptance not to drop litter or illegally dump unwanted items, a social norm should be encouraged to promote responsible action to return unwanted pets instead of “dumping” them into the wild, and to dispose of garden waste in biowaste containers and not into nearby woodland. Although European public awareness of IAS has expanded in recent years, capacity-building and awareness initiatives are not equally well developed across all MS (BIO-IS 2011). Since IAS management and control can evoke emotional debates, it is important to raise awareness, invest in research and base decisions on sound scientific evidence that is then communicated effectively.

Conclusions and synopsis of key recommendations

The legislation sets up a solid framework to tackle IAS in the EU, but provides little means and guidance about how to apply it. Its success will thus largely depend on the abilities and desire of MS to implement it, which we hope will be informed by our policy recommendations (Table 1). Once the Union list is established and pathway and risk assessments have been conducted for those species, specific management recommendations will need to be developed. Some countries have already started compiling best practices within their territory. We highlight key areas where research efforts will be needed to support the establishment of this new legislation (Table 2). Dedicated governance tools may also be needed, given the range of responsibilities concerning technical and information support, financing, decision-making and improved communication foreseen by the regulation. Currently, much of these needs are to be overseen by the EU, which may be supported in this role by the Scientific Forum. Whilst this solution may be sufficient in the short-term, an independent, overseeing body responsible for directing the monitoring, surveillance and management of IAS across MS would represent

a more sustainable long-term alternative (Hulme *et al.* 2009, Beninde *et al.* 2015). In New Zealand, having a lead agency for biosecurity matters (under the Ministry of Agriculture and Fisheries) has enabled the development of an effective, well-integrated and comprehensive biosecurity system, albeit biased toward commercially significant species (BIO-IS 2011). In the EU, a central agency could ensure cost-effective centralization and coordination among MS, act as the EU IAS exchange platform with the rest of the world, and could eventually assume some MS responsibilities and costs.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Appendix S1. Methods used for producing Figure 1 497.

Table S1. Criteria used to assess the development of IAS legislations for prevention, early-warning, 498 and management.

References

- Bellard, C., Thuiller, W., Leroy, B., Genovesi, P., Bakkenes, M. & Courchamp, F. (2013) Will climate change promote future invasions? *Glob. Change Biol.*, **19**, 3740–3748.
- Beninde, J., Fischer, M.L., Hochkirch, A. & Zink, A. (2015) Ambitious advances of the European Union in the legislation of invasive alien species. *Conserv. Lett.*, **8**, 199–205.
- BIO Intelligence Service, (2011) A comparative Assessment of existing policies on invasive species in the EU Member States and in selected OECD countries. Final report for the European Commission. DG ENV.
- Blackburn, T.M., Essl, F., Evans, T., *et al.* (2014). A unified classification of alien species based on the magnitude of their environmental impacts. *PLoS Biol.*, **12** (5), e1001850.
- Bonesi, L. & Palazon, S. (2007). The American mink in Europe: status, impacts, and control. *Biol. Conserv.*, **134**(4), 470–483.
- Bullock, J., Chapman, D., Schafer, S., *et al.* (2010) Assessing and controlling the spread and the effects of common ragweed in Europe. European Commission. Final report: ENV.

- CBD. (2014) Global Biodiversity Outlook 4. Montréal.
- DAFF. (2012) Reform of Australia's biosecurity system: New biosecurity legislation. Department of Agriculture, Fisheries and Forestry, Australian Government.
- Essl, F., Dullinger, S., Rabitsch, W., *et al.* (2011) Socioeconomic legacy yields an Invasion debt. *Proc. Natl. Acad. Sci.*, **108**, 203-207.
- European Union. (2014a) 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. Brussels.
- European Union. (2014b) Statement No 13266/14. Proposal for a Regulation of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species. Brussels.
- Genovesi, P., Carboneras, C., Vilà, M. & Walton, P. (2015) EU adopts innovative legislation on invasive species: a step towards a global response to biological invasions? *Biol. Invasions*, **17**(5), 1307-1311.
- GIA Secretariat (2014) Engagement in the end-to-end biosecurity system. New Zealand Government Industry Agreement. Secretariat guidance.
- Hulme, P.E. (2011) Addressing the threat to biodiversity from botanic gardens. *Trends Ecol. Evol.*, **26**, 168-174.
- Hulme, P.E., Pyšek, P., Nentwig, W. & Vilà, M. (2009) Will threat of biological invasions unite the European Union. *Science*, **324**, 40-41.
- Katsanevakis S, Deriu I, D'Amico F, *et al.* (2015) European Alien Species Information Network (EASIN): supporting European policies and scientific research. *Management of Biological Invasions*, **6**, 147-157.
- Kettunen, M., Genovesi, P., Gollasch, S., *et al.* (2009) Technical support to EU strategy on invasive species (IAS): assessment of the impacts of IAS in Europe and the EU (final module report for the European Commission). Institute for European Environmental Policy (IEEP), Brussels, Belgium, 43.
- Koger, S.M. & Winter, D.D. (2011) *The psychology of environmental problems: Psychology for sustainability*. Psychology Press. Hove, East Sussex, UK.
- Kopenhagen Fur, (2012) Annual Report. www.kopenhagenfur.com
- Lockwood, J.L., Hoopes, M.F., & Marchetti, M.P. (2013). *Invasion ecology*. John Wiley & Sons. Malden, MA, USA.
- Molnar, J.L., Gamboa, R.L., Revenga, C., & Spalding, M.D. (2008). Assessing the global threat of invasive species to marine biodiversity. *Front. Ecol. Environ.*, **6**(9), 485-492.
- Nordström, M., Högmänder, J., Laine, J., Nummelin, J., Laanetu, N. & Korpimäki, E. (2003) Effects of feral mink removal on seabirds, waders and passerines on small islands in the Baltic Sea. *Biol. Conserv.*, **109**, 359-368.
- Olenin, S., Narščius, A., Minchin, D., *et al.* (2014). Making non-indigenous species information systems practical for management and useful for research: an aquatic perspective. *Biol. Conserv.*, **173**, 98-107.
- Orlova-Bienkowskaja, M.J. (2013) Ashes in Europe are in danger: the invasive range of *Agrilus planipennis* in European Russia is expanding. *Biol. Invasions*, **16**(7), 1345-1349.
- Plant Health Australia (2010) Government and Plant Industry Cost Sharing Deed in Respect of Emergency Plant Pest Responses. Plant Health Australia, Canberra.
- Rabitsch, W., Essl, F., Genovesi, P. & Scalera, R. (2012) Invasive alien species indicator in Europe: a review of Streamlining European Biodiversity (SEBI) Indicator 10. EEA Technical report no.15/2012.
- Ricciardi, A., Palmer, M.E. and Yan, N.D. (2011) Should biological invasions be managed as natural disasters? *Bioscience* **61**, 312-317
- Richter, R., Berger, U.E., Dullinger, S., *et al.* (2013) Spread of invasive ragweed: climate change, management and how to reduce allergy costs. *J. Appl. Ecol.*, **50**, 1422-1430.
- Roy, H., Pocock, M., Preston, C., *et al.* (2012) Understanding citizen science & environmental monitoring. Final Report on behalf of UK-EOF. NERC Centre for Ecology & Hydrology and Natural History Museum.
- Roy, H.E., Schonrogge, K, Dean, H, *et al.* (2014a). Invasive alien species – framework for the identification of invasive alien species of EU concern ENV.B.2/ETU/2013/0026. Brussels, European Commission.
- Roy, H.E., Peyton, J., Aldridge, D.C., *et al.* (2014b) Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. *Glob. Change Biol.* **20**(12), 3859-3871.
- Scalera, R. (2010) How much is Europe spending on invasive alien species? *Biol. Invasions*, **12**, 173-177.
- Vilà, M., Basnou, C., Pyšek, P., *et al.* (2009). How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment. *Front. Ecol. Environ.*, **8**(3), 135-144.