

## Viewpoint

# Tackling biological invasions in Natura 2000 network in the light of the new EU Biodiversity Strategy for 2030

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## Abstract

The European Commission has recently adopted its EU Biodiversity Strategy for 2030, which sets out an ambitious plan for reversing biodiversity loss, and preserving and restoring protected ecosystems. A central binding target is focused on enlarging the EU network of legally protected areas (Natura 2000, the largest global network of the world), and on maintaining or improving the conservation status of all vulnerable habitats and species included in them. Biological invasions are currently a major threat to Natura 2000, so fulfilling the objectives of the EU Biodiversity Strategy calls for stepping up the implementation and enforcement of the relevant legislation on the matter, which has been thoroughly revised over the last decade. We discuss here the regulatory aspects of legislation on invasive alien species (IAS) that need to be optimised to address the challenge posed by biological invasions to the Natura 2000 network in the light of the new EU Biodiversity Strategy. We highlight that, while the EU has designed a solid regulatory framework to tackle the threat of biological invasions, its successful implementation will mainly rely upon appropriate national enforcement and allocation of economic and human resources. Despite previous warnings, the creation of dedicated EU funding mechanisms to support a comprehensive implementation of the legislation still remains a priority. Due to the yet small number of IAS regulated at the EU level, prevention and management of IAS will largely depend on national and local administration efforts, and on regional coordination and cooperation across neighbouring countries. Therefore, a well-integrated system responsible for biosecurity, pests and invasive alien organisms at the EU level would be better accomplished through a centralized, independent EU agency of new creation. Likewise, the establishment of a similar lead agency at the MS level, with special focus on IAS management in Natura 2000, is recommended to navigate the existing complex regulatory framework.

**Key words:** biosecurity, blacklists, environmental management, European legislation, funding, invasive alien species (IAS)

## Introduction

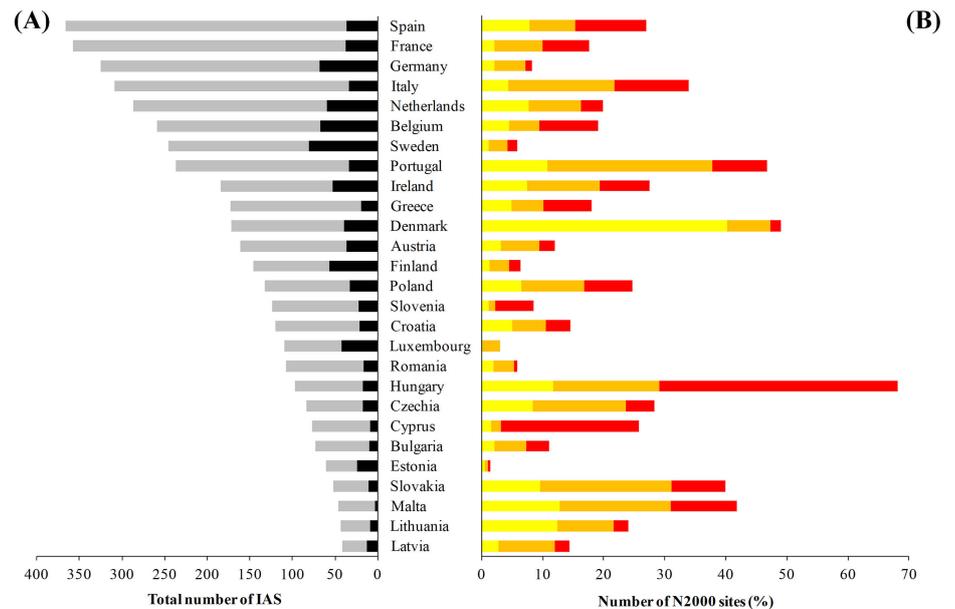
The European Commission (EC) has recently adopted the new EU Biodiversity Strategy for 2030 (hereinafter “EU Biodiversity Strategy”; EC 2020), a comprehensive, long-term plan for curtailing biodiversity loss, and preserving and restoring ecosystems. The EU Biodiversity Strategy contains

specific binding targets that, amongst others, include: (1) improving and enlarging (at least 30%) the European Union (EU) network of legally protected areas, building upon existing Natura 2000 sites (hereafter “N2000”); and (2) developing an ambitious EU Nature Restoration Plan, containing specific actions to restore degraded ecosystems and to ensure no worsening in the conservation status of all habitats and species protected by the EU Nature Directives (EC 2020).

Reaching these commitments calls for tackling the key drivers of biodiversity loss, including invasive alien species (IAS), whose number has continued to rise over time in Europe, not showing any sign of stopping or slowing down (Seebens et al. 2017). A central question to foresee how effectively the EU Biodiversity Strategy can be implemented is whether enlarging the existing coordinated network of protected areas in the EU will be enough to safeguard vulnerable native species, habitats and ecosystems from biological invasions under accelerating global change. While protected areas have overall provided a refuge from biological invasions, IAS are becoming an increasingly central problem therein (Liu et al. 2020). Despite growing awareness of IAS threats to biodiversity in protected areas, integrated, science-based, global initiatives that are sufficiently resourced to inform management and policy are lacking (Hulme et al. 2014; Foxcroft et al. 2017).

In Europe, nationally designated protected areas, such as national parks or nature reserves, have generally proved effective in resisting biological invasions, especially those created longer ago, characterized by low human accessibility and strong restrictions to human activities, and subject to intensive and sustained conservation management (Gallardo et al. 2017). By contrast, the scarce available literature provides evidence that to date the legal status of N2000 sites has been ineffective to prevent introduction and establishment of IAS therein (Gallardo et al. 2017; Guerra et al. 2018; Mazaris and Katsanevakis 2018; Scalera et al. 2020). In fact, IAS accumulation rate has accelerated, since the proportion of N2000 sites where IAS were recorded as a pressure and threat has increased from 11 to 18% between consecutive evaluation periods – 2007–2012 (Rabitsch et al. 2019, cited in Scalera et al. 2020) vs. 2013–2018 (Baquero et al. 2021, based on data from EEA 2020a). Further, almost half of Member States (MS) reported IAS pressure and threats in over 25% of their N2000 sites (Figure 1).

Increased rate and magnitude of biological invasions in the last decades in the EU was partially facilitated by a highly fragmented and incoherent legislative setup at both EU and national levels, leading to substantial gaps in species covered, lack of cooperation between neighbouring MS, different restrictions in IAS trade between MS, and legal uncertainty in the context of the internal market (EC 2013). While the EU policy framework included a variety of regulatory initiatives on IAS, they addressed only partial aspects of the challenge and provided a fragmented response. To address



**Figure 1.** (A) Total number of IAS in each Member State (MS) (high-impact alien species in EASIN 2020). The number of IAS partly native to Europe is indicated in black. (B) Proportion of N2000 sites presenting IAS pressure and threats to their protected species and habitats by MS and broken down by the intensity of the impact: low (yellow), medium (orange) and high (red) (calculated from data compiled in the European database of Natura 2000 sites, EEA 2020a; last accessed on 20/04/2021).

this policy problem, the EU has performed over the last decade a major revision of its legislative framework on biological invasions. The central step-up was the adoption of innovative legislation on the prevention and management of the introduction and spread of IAS, the Regulation (EU) 1143/2014 (hereinafter “IAS Regulation”) (Genovesi et al. 2015). Likewise, the EU modernised and integrated additional biodiversity concerns into its biosecurity, and plant and animal health regimes, resulting in the adoption of Regulation 2016/2031 on protective measures against pests of plants (hereinafter “Plant Health Law”) and Regulation 2016/429 on transmissible animal diseases (“Animal Health Law”).

Given that IAS can significantly undermine EU economic efforts to revert biodiversity loss, fulfilling the commitment of conserving and restoring the status of protected ecosystems laid out in the EU Biodiversity Strategy will require stepping up the implementation and enforcement of provisions on the IAS Regulation, other relevant EU legislation and international agreements. In the next sections, we discuss the regulatory aspects of legislation on IAS that need to be optimised to address the challenge posed by biological invasions to the N2000 network under the new EU Biodiversity Strategy.

### Complex and fragmented regulatory landscape

The IAS Regulation was developed to provide a comprehensive, dedicated legal instrument for tackling IAS impacting EU biodiversity and related ecosystem services, fulfilling in this way Target 5 of the EU Biodiversity

Strategy to 2020, while operating in line with the Convention of Biological Diversity's Guiding Principles. To ensure a coherent integration of the IAS Regulation into the existing EU legal framework, organisms targeted by existing legislative acts were excluded from its scope of application, namely: pathogens causing animal diseases, organisms that are harmful to plants and plant products (invasive pests and pathogens; IPPs), species used in aquaculture, genetically modified organisms, and micro-organisms used in plant protection and biocidal products. While the IAS Regulation is on the whole fit for its purpose (Davies 2016), an intersectoral law addressing all IAS that affect not only biodiversity and ecosystem services, but also human health and livelihood does not exist in the EU (García-de-Lomas and Vilà 2015).

The lack of such a general comprehensive regulation is mirrored in the legislations of MS and at the local legislative level, wherein IAS management is conducted. This is particularly problematic within the N2000 network, which supports the principle of sustainable development, and thus its aim is not to ban human activities but to ensure that they are developed in a way that conservation objectives of N2000 sites can still be achieved. Consequently, national and local strategies towards IAS in N2000 sites must integrate measures to comply with requirements scattered across several sectoral regulations that are in turn enforced by different authorities. For example, IPPs and parasitic plants are regulated under the Plant Health Law but plants that are themselves IAS (and thus are harmful to native plants) are regulated under the IAS Regulation. Conversely, some IAS are also vectors of diseases or pests that are in turn addressed by the EU animal and plant health regimes – see the case of the invasive American bullfrog *Lithobates catesbeianus*, which transmits the *Batrachochytrium dendrobatidis* pathogen that threatens EU protected amphibians (Miaud et al. 2016). However, existing legislation does not focus on wildlife pathogens other than those affecting livestock, plant crops or human health (Roy et al. 2017). This problem could be exacerbated in the near future by species that shift their range without direct human intervention in response to changing ecological conditions and climate change (Gervais et al. 2020). Such species could be carriers of IPPs or animal pathogens as contaminants (Dunn and Hatcher 2015) and would fall outside of the scope of the IAS Regulation, even when invasive. Another grey area lies in relation to kept alien terrestrial or aquatic species regulated under the Animal Health Law or the Aquaculture Regulation that become invasive in natural ecosystems but cannot be managed through the IAS Regulation, such as the Pacific oyster *Crassostrea gigas* which is causing strong ecological impacts in several N2000 sites (Herbert et al. 2016).

The management of N2000 sites is a complex process because of the great number of stakeholders involved. In many instances, the effective implementation of management plans have been hampered by a lack of

horizontal and vertical consistency (in cooperation, coordination and communication) within and across governance levels, and by poor cross-sectoral policy integration (ECNC 2010). The management of invasive organisms in N2000 is handicapped in both dimensions. The legislative sectorization existing at the national scale, which is common to all MS, requires a great coordination among institutions and agencies responsible for biodiversity conservation, human health, and economic sectors such as agriculture, forestry or fisheries (García-de-Lomas and Vilà 2015). In this respect, more integrative regulations are needed (Hulme 2021), and a single lead authority, with a clear legal responsibility for biosecurity, pests and invasive alien organisms, should be established in each MS (Caffrey et al. 2014; Piria et al. 2017). Likewise, the establishment of an independent EU Centre to oversee and coordinate EU-level actions of IAS monitoring, control and management has long been proposed (Caffrey et al. 2014; Beninde et al. 2015; Tollington et al. 2017). In this line, the EC has developed the European Alien Species Information Network (EASIN), an information exchange mechanism to facilitate the implementation of the EU policy on IAS, which includes the notification system through which MS must inform on new observations of IAS of Union concern and the rapid eradication actions taken.

### **Interaction with EU Nature Directives**

The N2000 is composed of protected sites designated under the Nature Directives – the Habitats Directive 1992/43/EEC, and the Birds Directive 2009/147/EC. The EU Fitness Check of the Nature Directives concluded that the status and trends of protected species and habitats in N2000 sites would be much worse in the absence of the Nature Directives. However, it also indicated that a substantial proportion of species and habitats are still in an unfavourable conservation status, some of which continue to decline or remain endangered (EC 2016). This trend has been maintained during the 2013–2018 reporting period (EEA 2020b). Insufficient progress in delivering the specific objectives of N2000 sites can be attributed to problems related to the level of availability and targeting of funding, full policy integration, knowledge and communication gaps, effective management and monitoring, varying levels of reliable data availability, lack of full stakeholder engagement, and human resource constraints (EC 2016; EEA 2020b).

In addition, many of the pressures and threats that have led to downgrade in conservation status continue to persist nowadays (EEA 2020b). Regarding IAS, the EC impact assessment concluded that, in practice, provisions on the Nature Directives had not proved effective in preventing the continuous introduction and spread of IAS in the EU territory (EC 2013). Further, it indicated that certain measures under the Nature Directives may have had indeed unintended consequences for IAS (EC 2013, pp. 28 in

Annex V): “Some alien species are currently listed for protection and as priority species for co-financing; certain species are protected in their whole current range although they are native only in part of the European range; some bird species alien to the whole of Europe are listed in the birds Directive and subject to the same protection/management and derogation provisions as naturally occurring species; for some habitat types, alien species are included in the EU Habitats Interpretation manual as characteristic species”. While amending the Annexes of Nature Directives is possible, it is complex and not only requires further development of a technical, robust and transparent assessment methodology, but also regarding relevant legal commitments under pertinent international nature conventions and agreements (EC 2016). This is major drawback of the current implementation of the Habitats Directive, and hence many authors have advocated for regularly updated, adaptive annexes rather than fixed species lists (e.g., Hochkirch et al. 2013).

Notwithstanding that provisions on the IAS Regulation are complementary to those on the Nature Directives, the pressure exerted by IAS on protected habitats and species in N2000 has kept increasing since its adoption (EEA 2020b), even though there is likely underreporting of such pressures and threats in the official documentation provided by MS (Mazaris and Katsanevakis 2018; Scalera et al. 2020). In general, limited information is available on the extent of implementation of management measures regarding IAS under the Nature Directives (EC 2016), making it hard to assess the magnitude of the risk posed by IAS in N2000.

### **Funding mechanisms to support implementation**

One of the weak links in the new EU legislation on invasive organisms is funding availability. The effective implementation of the IAS Regulation is questioned due to the lack of a dedicated funding mechanism (Genovesi et al. 2015; Tollington et al. 2017). Since the financial burden of implemented actions falls on MS, those with budget constraints might derogate from their responsibilities. For instance, MS could abstain from taking eradication or management action against IAS or restore damaged ecosystems if a cost-benefit analysis demonstrates with reasonable certainty that costs will be disproportionate to the long-term benefits. The IAS Regulation incorporated the concept of ecosystem services (first introduced into EU policy with the Biodiversity Strategy to 2020), allowing both the quantification and valuation of these services and the impacts of IAS on them, and their incorporation into economic analysis (Frommelt 2020). However, comprehensive cost-benefit analyses including future (unknown) market and non-market damage and social and cultural values still need to be fully developed (Essl et al. 2017; Tollington et al. 2017; Vilà and Hulme 2017). Some research projects are underway to tackle this challenge (e.g., Essl et al. 2019; Gallardo et al. 2019) and, indeed, first applications of recently

developed frameworks to account for IAS impacts on ecosystem services have already been carried out (e.g., Fedele et al. 2019 and La Notte et al. 2020).

The LIFE Environment programme is the most frequently used EU financial instrument for implementing IAS action plans in N2000, as it identifies management, prevention and communication measures related to IAS as priority topics (Silva et al. 2015), but MS still play a key financial role since they must cofund 40% of the costs (Tollington et al. 2017). Yet LIFE programme mainly finance projects to control/eradicate already established IAS, and only recently started funding early detection and rapid eradication actions, as well as communication initiatives to raise public awareness and increase public engagement and contribution to IAS monitoring and management (Piria et al. 2017). While the LIFE programme plays a strategic role in supporting the implementation of the Nature Directives, it represents less than 1% of the EU budget (EC 2016) and appears to be inefficiently distributed, as the regions with the greatest biodiversity or number of threatened species are not the most funded (Hermoso et al. 2017). Other N2000 funding opportunities exist under each of the relevant key EU funds, but N2000 has to compete with a range of different national policy goals, such as alternative economic activities and infrastructure. Hence, there are difficulties at local level in accessing some of these funding opportunities when competing against other national priorities (EC 2016). A substantial funding gap (80–90%) between the estimated total needs and available EU allocations is thus a major constraint on the effective implementation of N2000 conservation strategies (EC 2016). Adoption of the European Commission's recent proposal to significantly increase the LIFE programme's budget will help implement actions on IAS in the N2000, but the creation of long-term core funding schemes, rather than short-term projects, will be crucial for the effective implementation of the IAS Regulation (Piria et al. 2017; Tollington et al. 2017).

By contrast, the EU provides several financial instruments to implement official controls, survey programmes, and measures for prevention, containment and eradication of IPPs and animal diseases (regulated under the Regulation 652/2014 for the 2014–2020 period). While Regulation 652/2014 covers funding for the implementation of emergency measures to control IPP outbreaks, such instruments for IAS are lacking. The creation of an EU funding mechanism for IAS emergencies thus remains a priority (Caffrey et al. 2014; Piria et al. 2017).

### **Blacklisting approach of invasive organisms**

Under the current EU legislative framework on biosecurity, pests and invasive alien organisms, MS are obliged to take action to prevent the introduction, establishment and spread of only listed IPPs regulated under the Plant Health Law and IAS included into the Union list (those concerning species whose adverse impact has been deemed such as to

require concerted action at Union level). Therefore, the EU follows a “blacklist” approach, i.e. their legally binding lists identify those species subject to restrictions. However, the number of blacklisted organisms (66 species in the Union list, 174 in the list of Union quarantine pests, and just over 100 protected-zone or non-quarantine regulated pests) seem insufficient given that there are roughly 900 high-impact alien species already recorded in Europe (EASIN 2020) (Figure 1). In fact, while IAS of Union concern and regulated IPPs and animal pathogens account for 20 and 8%, respectively, of reported pressure and threats of invasive organisms in N2000 sites, much greater impact is reported from IAS not regulated at the EU level (54%; EEA 2020b).

The prioritization of invasive organisms for inclusion into legally binding blacklists must be technically justified through risk assessments. EU blacklists of pests regulated under the Plant Health Law are based on already-known IPPs, but past evidence has shown that many bioinvaders were unknown to be harmful, and thus were unregulated, before they had already been introduced and established (Eschen et al. 2015). Thus, risk assessments prior to possible introductions are needed to streamline and prioritize prevention efforts and early response towards bioinvaders, e.g., horizon scanning (Roy et al. 2014; Tsiamis et al. 2020). An additional problem with risk assessments is that socioeconomic impacts can be underestimated, because they are often evaluated under existing management activities, which probably masks the full range of impacts that would occur without such management (Essl et al. 2017).

Given that the costs of implemented actions will be covered by MS, there is a potential risk that EU legally binding blacklists will be short, non-representative and insufficiently dynamic (Tollington et al. 2017). All unlisted organisms of unknown risk thus remain unregulated at the Union level, so they might be imported as an alternative to blacklisted species, increasing the risk of introduction of novel invaders (Eschen et al. 2015; García-de-Lomas and Vilà 2015). Since a blacklist of prohibited species can never be comprehensive enough to prevent novel invasions, some authors have advocated for the inclusion in regulations of whitelists of permitted species instead, as they represent a more manageable, proportionate, effective and less bureaucratic regulatory process (e.g., Simberloff 2006), or grey lists including IAS of lower impact, but for which some level of regulation is desirable (e.g., Pergl et al. 2016). Moving in this line, and as a case example, Spain has recently strengthened its regulation on IAS by complementing its list of IAS of MS concern with a pioneering new list (Royal Decree 570/2020, of 16 June 2020), which identifies 1698 potentially invasive taxa whose introduction from outside the EU will require official authorization, subject to risk assessment by the importer.

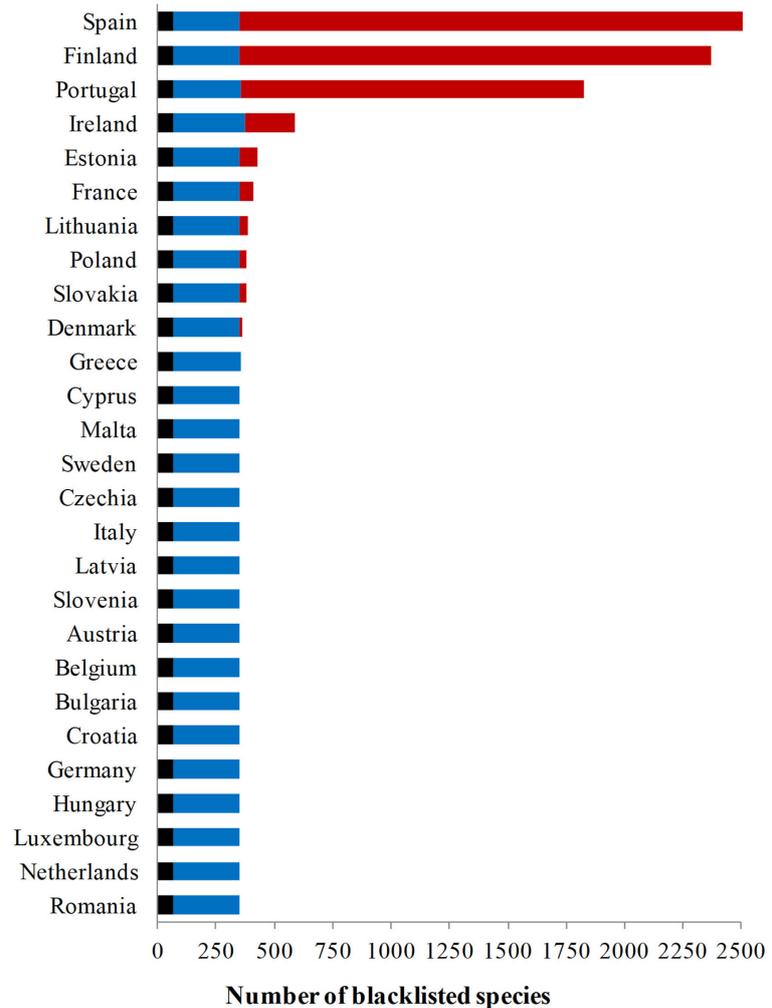
Protected areas like N2000 sites are not typically main locations for the introduction of IAS because they are subject to intense conservation

management (Liu et al. 2020); however, they remain highly vulnerable to invasions once IAS have successfully colonized nearby disturbed habitats. In fact, IAS richness in the surrounding belts is the main determinant of IAS richness within protected areas, highlighting that bioinvaders must be managed beyond their boundaries (Genovesi and Monaco 2013). This means that MS will often need to manage a much larger number of invasive alien organisms than that required by the IAS Regulation or the Plant Health Law to prevent or minimize colonization events into N2000 from adjacent areas. However, while the Nature Directives require MS to address any IAS that negatively affect protected habitats or species within N2000, irrespective of whether the species is regulated or not, beyond their boundaries only the management of listed species is enforced by law (Baquero et al. 2021).

To manage national needs, the IAS Regulation allows MS to place restrictions on species of their concern (which require a national action), similar to those on IAS of Union concern, or even more strict as long as they are compatible with the Treaty on the Functioning of the EU. Likewise, MS can list IAS of regional concern that require enhanced cooperation among involved countries. However, there is no overall ban for IAS of MS or regional concern at the EU level. Therefore, preventing the introduction of IAS into the EU will highly depend on individual MS efforts (i.e., on the strictness of national or local legislative frameworks), while preventing their spread will require strong regional coordination and cooperation. To date, however, only 10 MS have developed unifying national lists of IAS of MS concern (Figure 2). The rest of MS rely on EU-level lists plus a variable number of national blacklists scattered across different sectorial regulations, targeting at a more limited number of species. Nevertheless, lists of IAS of MS concern are being developed and some countries, e.g., Germany and Austria (Essl et al. 2011), Belgium (Vanderhoeven et al. 2015), or Czech Republic (Pergl et al. 2016), have already elaborated blacklists of IAS threatening their native biodiversity, which are taken into account for the development of national biodiversity strategies and management plans but are not legally binding. Lists of MS or regional concern are also useful to tackle IAS native to the Union, that is, species native to one MS that are introduced, intentionally released or unintentionally translocated, outside their natural range within the EU. These species are out of the scope of the IAS Regulation and thus cannot be managed at the EU level. This is a relevant issue as 26% of recorded IAS in Europe are partly native, and on average the  $21.3 \pm 9.1\%$  of recorded IAS in MS are native to other MS (Figure 1).

### **Assessment and control of introduction and spread pathways**

The IAS regulation mandates MS to carry out a comprehensive analysis of the pathways of unintentional introduction and spread of IAS of Union concern, and to identify priority pathways that require priority action. This



**Figure 2.** Number of IAS regulated under the IAS Regulation (Union list; black) and the Plant Health law (quarantine, protected-zone, and regulated non-quarantine pests; blue) and IAS of Member State concern that are not included in Union-level lists and are legally binding (red). Species blacklisted under national sectorial regulations are not included. Member States (MS) are ordered by total number of blacklisted species. MS with the same number of blacklisted species are displayed by alphabetical order.

represents the minimum level of effort, but a fully comprehensive assessment that may include all possible IAS, including those present and horizon scanning species, also addressing intentional pathways, is recommended (Working Group on Invasive Alien Species 2018). Prioritizing pathways based only on the IAS of Union concern might result in setting up pathway action plans that do not fully cover the management needs of MS at the national level. While some MS are conducting fully comprehensive assessments (e.g., Germany, Rabitsch et al. 2018), the amount of time and effort in conducting pathway analyses and prioritization, and the lack of dedicated EU funding schemes to do it (see previous sections) will likely lead MS only to stick to minimum requirements. The Plant Health Law also requires MS to control the key pathways for IPP unintentional introductions, namely import and movement of plants for planting, timber, wood products, wooden packaging materials, and soil (Eschen et al. 2015). Member States with national blacklists regulating a

higher number of organisms will require more economic and human resources and increased training of inspectors to recognize listed organisms in border controls (García-de-Lomas and Vilà 2015).

Controlling intentional and unintentional pathways of IAS introduction and spread will require key sectors in the EU economic network to adopt more responsible behaviour with respect to the introduction and use of IAS (Genovesi et al. 2015). Certain sectors, with the support of the LIFE programme in some cases, have already developed or have started work on the preparation of European codes of good conduct to address risks from IAS (Silva et al. 2015). However, the implementation of voluntary countermeasures may not suffice to prevent introductions and spread of IAS, therefore competent authorities should enforce liability for infringing those pathways (Tollington et al. 2017). This is a key aspect for the N2000 network within which human activities such as farming, forestry, hunting and fishing, tourism and other recreational uses are permitted; thus, the establishment (and enforcement) of social norms, best practices and codes of conduct within involved stakeholders and local communities is a key component of a successful policy to tackle IAS and improve conservation status of N2000.

### **Need for cooperation and coordinated responses**

Invasive alien species are a widespread concern, have multiple vectors and know no physical, geographical or jurisdictional boundaries. Once established, IAS are more difficult to eradicate and manage, thereby prevention, both in terms of cost and effectiveness, is preferable and desirable (Simberloff et al. 2013). Preventing the entry of IAS requires joining forces among countries or MS, government agencies and organizations, and involves multiple stakeholders. Likewise, preventing their spread across MS once introduced calls for strong regional cooperation and coordination; otherwise, efforts in preventing introduction or eradicating harmful IAS in one MS can be undermined if no action is taken in a neighbouring MS where the species is also present (Tollington et al. 2017). For example, MS reported 104 events of IAS entering their territory through natural dispersal from a neighbouring country in the last reporting period 2015–2018 (EEA 2020c). The management of IAS is therefore a complex, inter-jurisdictional challenge that requires a series of collective actions involving diverse actors at different scales (Graham et al. 2019). Consequently, the IAS Regulation mandates close and effective coordination and cooperation among MS, especially regarding exchange of information, rapid notification after new IAS detection and actions on IAS of regional concern (Baquero et al. 2021).

Many of the N2000 sites are located within a sole MS, which could facilitate their management at the legislative level. On the contrary, a large number of N2000 sites crosses the borders of European countries and are managed differently from one country to another (see Opermanis et al.

2012). However, IAS know no borders, so cooperation and coordination between MS is essential for proper and successful management, not only between N2000 sites that are part of neighbouring MS, but also those that belong to the same biogeographic region. In fact, conservation planning is usually highly efficient when it is coordinated at large scales (Jantke and Schneider 2010). Including collaborative approaches can have limitations, but as long as the benefits outweigh the costs, promoting cooperation (e.g., information sharing, biosecurity planning) can help prevent the spread of IAS (Kark et al. 2015).

Finally, N2000 sites provide a multitude of ecosystem services, closely related to humans and their activities (see above), which can also negatively impact conservation goals. For this reason, effective management of IAS in these protected areas requires cooperation between the different stakeholders involved (Shackleton et al. 2019). Collaboration and multidisciplinary partnerships are recommended and beneficial to minimize conflicts in conservation. Therefore, to achieve the conservation goals and to succeed in the ambitious commitments proposed by the EU Biodiversity Strategy, both theoretical and practical (i.e., regarding their implementation) frameworks of cooperation as well as coordinated responses to environmental problems (e.g., IAS) are strongly recommended.

### **Concluding remarks**

The recently adopted EU Biodiversity Strategy for 2030 sets out an ambitious plan for reversing biodiversity loss, and preserving and restoring protected ecosystems. The EU Nature Restoration Plan commits to cut down the number of Red List species threatened by IAS to half\_IAS currently pose a severe risk to 20% of the 1,872 species now considered threatened in Europe (EC 2020). Although N2000 cover Europe's most valuable and threatened species and habitats, no commitment to reduce the pressure and threat exerted by IAS in N2000 sites is explicitly laid out in the EU Biodiversity Strategy. Tackling the IAS problem in N2000 will call for stepping up the implementation and enforcement of the new EU framework on biosecurity, pests and invasive organisms. However, its successful implementation will mainly rely upon appropriate national enforcement and allocation of both economic and human resources. The creation of EU funding mechanisms to support a comprehensive implementation of the legislation thus remains a priority. Due to the small number of IAS regulated at the EU level, prevention and management of IAS will largely depend on national and local efforts, and especially on regional coordination and cooperation across MS. Therefore, a well-integrated system responsible for biosecurity, pests and invasive alien organisms at the EU level would be better accomplished through a centralized, independent EU agency of new creation. Likewise, the establishment of a similar lead agency at the MS level, with special focus on IAS management in Natura 2000, is recommended to navigate the existing complex regulatory framework.

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## Authors' Contribution

R.A.B. and G.G.N. contributed to funding provision and research conceptualization. D.A. contributed to investigation, and data collection, analysis and interpretation. R.A.B. and D.A. wrote the original draft. F.J.O. contributed to data interpretation and edited the final draft. G.G.N. reviewed the original draft.

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