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Baseline distribution of species listed in the 1st update of Invasive Alien Species of Union concern

Tsiamis K, Gervasini E, Deriu I, D'Amico F, Katsanevakis S, Cardoso AC

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Contact information

Name: Ana Cristina Cardoso
Address: Via E. Fermi 2749
E-mail: ana-cristina.cardoso@ec.europa.eu
Tel.: +39 0332 785702

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Abstract

The current EU geographical distribution of the species listed in the 1st update (Commission Implementing Regulation 2017/1263) of the Invasive Alien Species (IAS) of Union concern (IAS Regulation 1143/2014) is set, based on the best available knowledge, resulting from an assessment of data aggregated through the European Alien Species Information Network (EASIN) in collaboration with the Competent Authorities of 21 EU Member States. The established spatial baseline is crucial when it comes to tracking new detections of IAS of Union concern in uninfested areas of EU territory in the frame of the IAS Regulation. Thus, the current baseline, together with the baseline distribution of the 37 IAS listed in the first Union list, constitutes an important tool supporting the implementation of the IAS Regulation, and also provides a factual basis for the review of its application.

Foreword

Invasive Alien Species (IAS) are animals and plants introduced accidentally or deliberately into a natural environment different from the one they originate, with serious negative consequences for their new environment. They represent a major threat to biodiversity worldwide. In Europe, IAS damages cost billions of euros to the economy every year.

The European Commission biodiversity strategy aims to halt biodiversity loss by 2020. In this frame, Regulation (EU) 1143/2014¹ on IAS (IAS Regulation) was adopted, and entered into force on 1 January 2015. This Regulation seeks to address the problem of IAS in a comprehensive manner and prevent, minimise and mitigate their negative impacts on biodiversity and ecosystem services, as well as on human health and the economy. Towards these goals, the IAS Regulation foresees three types of interventions: prevention, early detection and rapid eradication of new introductions, and management of established populations, with priority given to a subset of IAS considered as of Union concern. Species are included in the list of Union concern, *inter alia*, because they can cause such a significant damage in the EU Member States that the adoption of dedicated measures at Union level is justified.

In this context, the establishment of an EU geographical baseline distribution of IAS of Union concern is important to support the implementation of the IAS Regulation. For example, it can provide useful information with reference to Art. 16, that requires Member States to notify the European Commission and other Member States of early detections of listed species, and help Member States in the establishment of a surveillance system for the targeted species. In addition, the baseline information will provide a factual basis for the review of the application of the IAS Regulation.

The Joint Research Centre (JRC) published the baseline distribution of the first list of IAS of Union concern, based on the best available knowledge, in 2017². Following a similar approach, the current report publishes the baseline distribution of the IAS included in the first update of the list of Union concern³, as the result of an assessment of data aggregated through the European Alien Species Information Network (EASIN⁴), and drawing on collaboration between the JRC and the Member States Competent Authorities for implementing the IAS Regulation.

We trust that a commonly acknowledged baseline can foster the cooperation and coordination among Member States, across borders or within shared biogeographical regions. Ultimately, the information included in the current baseline can be used for monitoring the achievement of Target 5 of the EU Biodiversity Strategy to 2020 for combatting IAS.

Giovanni de Santi

Director for Sustainable Resources
Joint Research Centre
European Commission

Humberto Delgado Rosa

Director for Natural Capital
Directorate-General Environment
European Commission

¹ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014R1143>

² <https://easin.jrc.ec.europa.eu/easin/Documentation/Baseline>

³ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1263>

⁴ <https://easin.jrc.ec.europa.eu/>

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BE: The Belgian baseline distribution was also published and versioned in an online repository and can be used and cited: Adriaens Tim, Barbier Yvan, Branquart Etienne, Coupremagne Maxime, Desmet Peter, Devisscher Sander, Devisscher, Sander; Van Hoey, Stijn; Vanderhoeven, Sonia, Prevot Celine (2018). Belgian baseline distribution of invasive species of Union concern. (Regulation (EU) 1143/2014) [Data set]. Zenodo. <http://doi.org/10.5281/zenodo.1288628>.

The Belgian dataset was compiled from various datasets holding invasive species observations such as data from research institutes and research projects, citizen science observatories and a range of other sources such as governmental agencies, water management and invasive species control companies, angling and hunting organizations, etc. The providers of the IAS data for this exercise (individuals and their respective organizations) are listed in the "data providers" section of the metadata dataset, which also describes date range and validation criteria. Much of the primary occurrence data that formed the basis for this aggregated dataset will be published as open data on the Global Biodiversity Information Facility (GBIF) within the framework of the Tracking Invasive Alien Species project (TrIAS, <https://osf.io/7dpgr/>, 2017-2020). The contributing data managers, researchers or contact persons who have helped in gathering or providing the data are mentioned hereafter: Seynaeve, Adriaan - Agency for Nature and Forest (ANB), Vanderweeën, Marc - Flanders Environment Agency (VMM), Beck, Olivier - Brussels Environment (BIM), Devaere, Nathalie - Waterwegen en Zeekanaal NV afdeling Bovenschelde, Dochy, Olivier - Provincie West-Vlaanderen Dienst Milieu-, Natuur- en Waterbeleid, Van Roeyen, Koen - Provincie Oost-Vlaanderen dienst Integraal Waterbeleid, Mahieu, Filip - Provincie Oost-Vlaanderen, De Vlaeminck, Rembrandt - Provincie Antwerpen Natuur en Landschap, Veraert, Bianca - Provincie Antwerpen dienst Integraal Waterbeleid, Schelfhout, Tijn - Provincie Antwerpen dienst Integraal Waterbeleid, Gielen, Josse - Provincie Limburg dienst waterlopen, Vanreusel, Wouter - Natuurpunt Studie, Gielen, Karin - Natuurpunt Studie, Brackx, Nicolas - Vogelbescherming Vlaanderen, Pijcke, Jimmy - Vogelbescherming Vlaanderen, Standaert, Sofie - RATO vzw, Van Moer, Karel - RATO vzw, Coene, Peter - Sportvisserij Vlaanderen, Gouwy, Jan - INBO marternetwerk, Van Landuyt, Wouter - INBO florabank, Denys, Luc - INBO, Packet, Jo - INBO, Leyssen, An - INBO, Provoost, Sam - INBO, Van Gompel, Wouter, Vanderhaeghe, Floris, Paquet, Jean-Yves - Natagora, Cammaerts, Roger, Boets, Pieter - Provinciaal Centrum voor Milieuonderzoek, Smooth, Augustin - Contrats de rivière de Wallonie, Darchambeau, François - Aquabio.

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- The Global Invasive Species Information Network (GISIN)

- The Regional Euro-Asian Biological Invasions Centre (REABIC)
- The Hellenic Network on Aquatic Invasive Species (ELNAIS)
- The International Commission for Scientific Exploration of the Mediterranean Sea (CIESM)
- The European Environmental Agency (EEA) / Hellenic Centre for Marine Research (HCMR)
- The International Union for Conservation of Nature (IUCN) online information system for monitoring invasive non-native species in marine protected areas (IUCN-MedMIS)
- The Marine Mediterranean Invasive Alien Species (MAMIAS)
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- The Stop Vespa Asiatica LIFE project (STOPVESPA)
- The EEIKO multi-platform application for control of invasive alien flora species (EEIKO).

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Executive summary

Policy background

Invasive Alien Species (IAS) constitute one of the most important threats to biodiversity, causing severe ecological and socio-economic impacts. Recognizing the need for a coordinated set of actions to prevent, control and mitigate IAS, the European Parliament and the Council adopted the EU Regulation 1143/2014 (hereafter referred to as the IAS Regulation). The IAS Regulation gives priority to a list of species, named as IAS of Union concern. Species are included in this list *inter alia* because they can cause a significant damage in Member States (MS) justifying the adoption of dedicated measures at Union level. The first list of IAS of Union concern included 37 species. Following the dynamic character of the Union concern list, 12 species were added by means of the Commission Implementing Regulation (EU) 2017/1263 of 12.07.2017. All species entered into legal force on 02.08.2017, with the exception of *Nyctereutes procyonoides*, for which the Regulation shall apply as of 02.02.2019.

Under the IAS Regulation, MS must prevent the introduction and spread of IAS of Union concern, enforce effective early detection and rapid eradication mechanisms for new introductions, and adopt management measures for species already widely spread.

Detailed and up to date spatial information on the IAS of Union concern in the MS territories is needed for setting a geographic baseline of their current distribution, in particular to support the implementation of Art. 16 of the IAS Regulation, dictating the mandatory notification of early detections of listed species to the European Commission (EC) and to the other MS. The EU baseline of spatial distribution for the 37 IAS of the first list of Union concern was published in 2017 as a JRC science-for-policy report. The current report aims at defining an EU baseline of spatial distribution for 11 species (excluding *Nyctereutes procyonoides*) included in the 1st update of the list of IAS of Union concern.

Building the baseline

Spatial information on species included in the 1st update of IAS of Union concern list is generally scattered across various sources (scientific literature, online and offline databases, reports, etc.). Addressing this challenge, the European Alien Species Information Network (EASIN), developed by the Joint Research Centre, offers a single aggregation point of alien species (AS) spatial data, which are standardized, harmonized and integrated. Consequently, EASIN was chosen as the primary source of data for compiling the distribution baseline of the species listed in the 1st update of IAS of Union concern.

In a second phase, MS Competent Authorities responsible for implementing the IAS Regulation were invited to check the EASIN baseline data of the targeted species, at country and grid 10x10 km level, and to supplement the available information with national data. The final aim was to promote collaboration and coordination with MS and ensure data sharing and exchange, leading to a consolidated baseline of the species of the 1st update. The feedback received by the MS Competent Authorities was satisfactory, with 21 MS providing feedback and additional data. 7 MS did not provide feedback and the relevant baseline information provided in the current report, comes only from the EASIN geodatabase, and should be considered as the best available knowledge.

Main findings

For each of the species added to the list of IAS of Union concern spatial information is provided for each MS, both at country and grid 10x10 km level, based on the best available knowledge. The report also provides traits of the targeted species, which have a key role in biological invasions management. For each species, the year and country of first introduction in the EU, the main pathway of introduction, the taxonomic group, the habitat, the origin, and the impact are given.

The distribution baseline has revealed that most of the species have been introduced and spread across north-western EU countries (e.g. FR, DE, IT, ES, UK), while their presence is more limited in southern MS (e.g. MT, CY, EL). Several species are already quite widespread across the EU (e.g. *Impatiens glandulifera*, *Heracleum mantegazzianum*, *Ondatra zibethicus*), while other species have been rarely found (e.g. *Alternanthera philoxeroides*, *Gunnera tinctoria*) or are still completely absent from the EU (*Microstegium vimineum*). Most of the regulated species have been primarily introduced into the EU through escapes linked with ornamental purposes, horticulture and aquarium trade before the 1950's. Most of them originate from America (mainly North America).

Key conclusions

- The distribution baseline of the 11 IAS included in the 1st update of the list of Union concern, together with the baseline distribution of the 37 species included in the first list of Union concern, constitute an important tool supporting the implementation of the IAS Regulation, and also provide a factual basis for the review of its application.
- A commonly acknowledged baseline will help MS in the establishment of a surveillance system of the targeted species under Art. 14, and can foster MS cooperation and coordination across borders or within shared biogeographical regions, as recalled by Art. 22. The distribution of the targeted species will also help the discussion amongst MS about the appropriate management measures to be implemented (Art. 19).
- A shared baseline will also help MS and the EC in monitoring the evolution of the IAS distribution in Europe and the effectiveness of the actions undertaken by MS Competent Authorities implementing the IAS Regulation. The evaluation of those data can eventually lead to reconsider or modify implementation activities and give an input when updating the list of IAS of Union concern.
- EASIN proved to be a good information source of IAS distribution records within EU MS, attesting its role of official information system supporting MS in the implementation of the IAS Regulation (Art. 25).

1 Introduction

1.1 Background

Invasive Alien Species (IAS) are animals and plants introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. They constitute one of the most important threats to biodiversity, causing severe ecological and socio-economic impacts (Mack et al. 2000; Millennium Ecosystem Assessment 2005; Ricciardi et al. 2013; Jeschke et al. 2014). As a conservative estimate, IAS cost the European Union (EU) Member States €12 billion in damages on annual basis (Kettunen et al. 2009) but cumulated costs probably reach €20 billion per year (<http://www.ieep.eu/work-areas/biodiversity/invasive-alien-species/> accessed on 4 November 2016). In addition, there is an increasing trend towards introduction of new IAS, with the vast majority being introduced unintentionally (Hulme 2009; Essl et al. 2015; Roques et al. 2016). To this end, economic resources invested by the EU in research and management of IAS have grown steadily over the years (Scalera 2010; Silva et al. 2014).

Recognizing the need for a coordinated set of actions to prevent, control and mitigate the impact of IAS, the European Parliament and the Council adopted the EU Regulation no. 1143/2014 (EU 2014; hereinafter referred to as the IAS Regulation) on the prevention and management of the introduction and spread of IAS, which entered into force on 1 January 2015. The IAS Regulation gives priority at European level to a subset of IAS, named as IAS of Union concern (Art. 4 “the Union list”, hereinafter IAS of Union concern). Species are included in this list *inter alia* because they can cause such a significant damage in Member States (MS) justifying the adoption of dedicated measures at Union level. The list of IAS of Union concern has a dynamic character, focusing on species whose inclusion in the list would effectively prevent, minimize or mitigate their adverse impact in a cost efficient manner (EU 2014).

An evaluation process on priority species, based on specific criteria and requirements laid down in Art. 4.3 of the IAS Regulation, and on Risk Assessments meeting the requirements of Article 5.1, led to the adoption of a first list of IAS of Union concern, published with the Commission Implementing Regulation (EU) 2016/1141 of 13.07.2016 (which entered into force on 03.08.2016)⁵. The first list contained 37 taxa, including both animals and plants. Following the dynamic character of the Union concern list, 12 additional species were added to the Union concern list by the Commission Implementing Regulation (EU) 2017/1263 of 12.07.2017 (which entered into force on 02.08.2017)⁶. Under the IAS Regulation, MS must prevent the introduction and spread of the listed species, enforce effective early detection and rapid eradication mechanisms for new introductions, and adopt management measures for species already widely spread.

The European Alien Species Information Network (EASIN⁷) constitutes the core of the information system supporting MS in the implementation of the IAS Regulation (EU 2014, Art. 25). EASIN, developed by the European Commission’s Joint Research Centre (Katsanevakis et al. 2012), aims to facilitate easier access to data on alien species (AS) in Europe, and to provide a single repository for accessing all the information necessary to underpin AS related policy and management decisions (Katsanevakis et al. 2013). It facilitates the exploration of AS data from distributed sources through a network of publicly and freely available interoperable web services, following internationally

⁵<http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1468477158043&uri=CELEX:32016R1141>

⁶With the exception of the species *Nyctereutes procyonoides* for which its inclusion shall apply as from 02.02.2019.

⁷<https://easin.jrc.ec.europa.eu/>

recognized standards and protocols (Katsanevakis et al. 2015). Moreover, an Early Warning and Rapid Eradication Notification System (NOTSYS) has been developed within the EASIN platform, allowing MS to notify the European Commission (EC) and all MS about the new occurrences of IAS of Union concern detected on their territory, and for reporting on eradication measures applied, and on their effectiveness, as foreseen in Art. 16 and 17 of the IAS Regulation.

The effective implementation of the IAS Regulation, in particular with reference to Art. 16, dictating the mandatory notification of early detections of listed species to the EC and to the other MS, can benefit from a detailed and up to date spatial information of the IAS of Union concern in the MS territories. Therefore, it is crucial to set a geographic baseline of current distribution of the IAS of Union concern. To this end, an EU baseline of spatial distribution for the 37 IAS of the first Union list was published as a JRC science-for-policy report in 2017 (Tsiamis et al. 2017a). The first baseline report was based on the best available knowledge, resulting from an assessment of data aggregated through EASIN in collaboration with the Competent Authorities of 18 EU MS. A similar approach was followed for setting an EU baseline of spatial distribution for the IAS in the 1st update of the list of Union concern.

1.2 Purpose of the report

Despite the availability of several distribution maps at different scales, there are not yet accurate distribution maps at EU level concerning the IAS included in the 1st update of the list of Union concern. The current report includes a consolidated EU distribution map as a current baseline for the 11 species added to the Union list in 2017. The proposed baseline includes the best available knowledge of the regulated species within the EU territory based on EASIN spatial data, coming from various data sources (scientific literature, databases). These data are aggregated, harmonized and integrated for the first time through EASIN, at country and 10x10 km grid level. MS Competent Authorities had an active role in this process by substantially contributing with national data, validating and endorsing the updated information.

The report also provides information on the traits of the targeted species, which have a key role in biological invasions management. For each species the year and country of first introduction in the EU, the main pathway of introduction, the taxonomic group, the habitat, the origin, and the impact (environmental, economic, social) are given.

2 Methodology

2.1 Background

Spatial information on AS is scattered across various repositories, including scientific literature, online and offline databases, reports, institute collections, web sources, etc. In addition, the type and format of geographical data vary substantially. Addressing these challenges, EASIN offers a single aggregation point of AS spatial data, which are standardized, harmonized and integrated (Katsanevakis et al. 2012). EASIN, the official information system supporting the IAS Regulation, was chosen as the primary source of data for compiling the distribution baseline in EU countries for the IAS included in the 1st update of the list of Union concern.

In a second phase, MS Competent Authorities for implementing the IAS Regulation were invited to check and validate the EASIN distribution data of the targeted species, at country and grid level, and to supplement it with national data. By this way, any error and omission of spatial data could be addressed for each country. The final aim was to promote collaboration and coordination with MS and ensure data sharing and exchange of information, leading to a consolidated distribution baseline of the 11 IAS added to the list of Union concern (*Nyctereutes procyonoides* was not included in the baseline since its inclusion in the Union list shall apply as from 02.02.2019).

2.2 The use of EASIN as a data source

EASIN aggregates scientific information and spatial data on AS from several sources, and offers flexible web services for searching and mapping AS in Europe.

A key component of the EASIN system is the "**EASIN Catalogue**": a comprehensive list of AS occurring in Europe, currently including information on about 14,000 taxa in all the environments. For each taxon, information is available on the year and country of the first observation in Europe, alien status (alien, cryptogenic, questionable), native range, taxonomy, synonyms, common names, environment, pathways, vectors and impact. Links to factsheets are also provided for selected taxa (Katsanevakis et al. 2015). The initial EASIN Catalogue was compiled collating information from 43 databases (Katsanevakis et al. 2012). All data collected were harmonised, standardized and integrated. Since the initial compilation, the EASIN Catalogue has been continuously updated, revised and validated through a process which includes several steps to pursue high quality standards, with the engagement of external experts. All taxonomic groups have been updated and validated by the end of 2018 including virus taxa.

EASIN also offers flexible and efficient online mapping tools for the retrieval of spatial data through the **EASIN Geodatabase** (Deriu et al. 2017). All species occurrence records mapped in the EASIN Geodatabase result from the crawling of data from a network of **Data Partners**, on the basis of the species contained in the EASIN Catalogue. The process of retrieving the data from the Data Partners is done through the EASIN Data Broker system, which is able to retrieve the species occurrences and related information (date, source) from different data sources and store them in a normalized database. Data are transformed by converting the harvested data to the EASIN Data Model through the following steps: Validation, Cleansing and Standardization, Geocoding, Mapping, Application of Quality rules. Data are finally uploaded on the Geodatabase (Data warehouse). Collected data are shown in occurrences maps at country, grid 10x10 km, river basin district and marine ecoregion level.

The EASIN Data Partners are global, regional and national databases that provide EASIN with spatial information on AS in Europe. Ownership of the data remains with its source, which is properly cited and linked in the EASIN Geodatabase. The EASIN Data Partners

gain increased visibility and networking possibilities through EASIN, and can also benefit from mutual data exchange. EASIN follows international standards and protocols for distribution spatial data (INSPIRE Framework Directive 2007/2/EC – EU 2007; INSPIRE 2013). Given the vast amount of information recorded in EASIN and the need for constant updates and revision, an **Editorial Board** has been established to ensure the quality of the data in the EASIN system (Tsiamis et al. 2016).

The EASIN network is composed of 12 Data Partners, both global and European (reference date 5 November 2017), and includes:

- The Global Biodiversity Information Facility (GBIF)
- The Global Invasive Species Information Network (GISIN)
- The Regional Euro-Asian Biological Invasions Centre (REABIC)
- The Hellenic Network on Aquatic Invasive Species (ELNAIS)
- The International Commission for Scientific Exploration of the Mediterranean Sea (CIESM)
- The European Environmental Agency (EEA) / Hellenic Centre for Marine Research (HCMR)
- The International Union for Conservation of Nature (IUCN) online information system for monitoring invasive non-native species in marine protected areas (IUCN-MedMIS)
- The Marine Mediterranean Invasive Alien Species (MAMIAS)
- The Norwegian Biodiversity Information Centre (NBIC) Norway
- The European and Mediterranean Plant Protection Organization (EPPO)
- The Stop Vespa Asiatica LIFE project (STOPVESPA)
- The EEIKO multi-platform application for control of invasive alien flora species (EEIKO)

Additional and updated spatial data have been gathered through EASIN-Lit, an internal EASIN activity (Trombetti et al. 2013), that contributes to enriching the Geodatabase through screening the scientific literature and retrieving geo-referenced data. In the context of EASIN-Lit, part of the literature review for the species considered in this report was outsourced to a fee paid expert, and supplemented by in-house work carried out by the EASIN team. Finally, a data quality check took place on all spatial data of IAS of Union concern of the EASIN Geodatabase, especially at grid 10x10 km level data, thus ensuring the accuracy of the related information.

2.3 Methodology for Member States contributions

At the IAS Committee Meeting of 05.12.2017, organism established under Art. 27 of the IAS Regulation, DG Environment (DG ENV) invited MS Competent Authorities to review and supplement the baseline distribution provided by EASIN of the 11 IAS included in the 1st update of the list of Union concern. In addition, MS were invited to comment if the species present in their country were “established” (reproducing in the wild and forming self-sustaining populations) or “casual” (few sporadic records and/or not reproducing in the wild).

A two-steps process was followed:

1. Country-level check

MS were invited to check EASIN occurrences of each species on their territory, and to provide revisions and/or updates of spatial data by using the protocol in Annex I.

2. Grid-level check (GIS data 10x10 km)

Shapefiles including all EASIN data concerning the occurrences of the 11 species per MS and per species were delivered by the EASIN team to the MS Competent Authorities. The grid 10x10 km level corresponds to the 10 km resolution level of the EEA reference grid, which is recognised by the INSPIRE Framework Directive 2007/2/EC – EU 2007 (INSPIRE 2013). The coordinate reference system and projection of the spatial information were

the European Terrestrial Reference System 1989 and Lambert azimuthal equal-area projection (ETRS89/ETRS-LAEA, EPSG: 3035, <http://spatialreference.org/ref/epsg/etrs89-etrs-laea>). Shapefiles could be opened and managed with GIS software such as ArcGIS, QGIS, GRASS. MS were invited to compare the EASIN shapefile data with their national data at grid level 10x10 km. The shapefiles provided to each MS by EASIN contained the following information (GIS Attribute Table):

- Identifier of the record (FID: a code for each EASIN record).
- Spatial information (Shape: polygon, line or dot).
- Scientific name of the species (Species_NA).
- Name of the entity providing the original observation (EASIN Data Partner: <http://easin.jrc.ec.europa.eu/Partners/Partners>).
- Identifier of the reference (e.g. scientific publication) (code of reference). Full citation references were provided in a separate excel file by EASIN.
- The column "Accepted"; to be filled-in by the MS (Y/N).
- The column "Notes"; to be filled-in by the MS in case "N" has been indicated; appropriate reference(s) when applicable were provided.

In addition, EASIN provided an Excel file containing the full references mentioned in the shapefiles (reference code and associated citation). References were the sources (e.g. scientific publications, datasets) from which the information about the species occurrences had been extracted and processed.

New spatial data entries were provided by MS using the same shapefile received from EASIN (adding new features in the Attribute Table in the GIS environment) or by creating a new shapefile following the same structure. New spatial data entries contained all the relevant information included in the Attribute Table:

- Record identifier (FID).
- Spatial information (polygon, line or dot).
- Scientific name (Species_NA).
- Name of the entity providing the record (the official name of the MS national authority organization).
- Reference identifier (providing a code of reference). The national code and the full citation reference were added by the MS in the excel file provided by EASIN.

More technical details on the process can be found in the baseline protocol (Annex I).

2.4 Member States feedback

By the 25th June 2018, 21 MS submitted feedback concerning the distribution at country level of the IAS included in the 1st update of the list of Union concern, and 19 MS provided spatial data at grid level. All details concerning the MS feedback on the EASIN data are illustrated in Table 1.

Table 1. MS feedback on EASIN occurrences data concerning the 11 species listed in the 1 st update of IAS of Union concern, at country and grid level.		
Member States	Feedback at country level provided	Feedback at grid level provided
AUSTRIA (AT)	YES	Only for <i>Alopochen aegyptiacus</i>
BELGIUM (BE)	YES	YES
BULGARIA (BG)		
CROATIA (HR)	YES	YES
CYPRUS (CY)	YES	
CZECH REPUBLIC (CZ)	YES	YES (except for <i>Alopochen aegyptiacus</i> and <i>Ondatra zibethicus</i>)
DENMARK (DK)	YES	YES

ESTONIA (EE)	YES	YES
FINLAND (FI)	YES	YES
FRANCE (FR)	YES	YES
GERMANY (DE)		
GREECE (EL)		
HUNGARY (HU)	YES	YES (except for <i>Asclepias syriaca</i> and <i>Myriophyllum heterophyllum</i>)
IRELAND (IE)	YES	YES
ITALY (IT)	YES	YES
LATVIA (LV)	YES	YES
LITHUANIA (LT)	YES	YES
LUXEMBOURG (LU)	YES	YES
MALTA (MT)		
NETHERLANDS (NL)	YES	
POLAND (PL)	YES	YES
PORTUGAL (PT)		
ROMANIA (RO)		
SLOVAKIA (SK)	YES	YES
SLOVENIA (SI)	YES	YES
SPAIN (ES)	YES	YES
SWEDEN (SE)	YES	YES (except for <i>Ondatra zibethicus</i>)
UNITED KINGDOM (UK)		
TOTAL	21	19

2.5. Scientific and technical issues

The check of spatial data by MS frequently required close collaboration with the EASIN team, through the exchange of e-mails. During this process, several technical problems regarding the data format and other specifications were addressed. At the same time, a number of issues were highlighted by MS, summarized as follows:

Time limitation: AT pointed the need for additional time to verify the grid data (with the exception of *Alopochen aegyptiacus*), having them ready not before June 2019. DE was currently not able to check and endorse the EASIN data since this process would require the cross-check with all relevant databases at federal state (Länder) level, requiring consultation with all 16 Federal states.

Lack of national data: CY raised the need for more time to provide grid level data, in the absence of national updated digitalized data.

Casual records: occasional, rare records were included in the MS distribution data, but with an indication of "casual status" (e.g. *Alopochen aegyptiacus* in EE and HU).

Taxonomic difficulties: FI pointed the difficulty to distinguish *Heracleum mantegazzianum* from *H. persicum*. As a result, several occurrence records are reported for FI as *Heracleum persicum/mantegazzianum* and may contain one of the species or both. CY marked the difficulty to distinguish *Pennisetum setaceum* from *Cenchrus purpureus*, and the Cypriot records of the former should be treated with reservations.

Exclusion of specific EASIN records: Several MS proposed to exclude specific EASIN records (e.g. *Elodea nuttalli* in FI, *Gunnera tinctoria* and *Pennisetum setaceum* from SE). These species were proven to belong to either museum preserved specimens or live specimens in botanical gardens, and were thus excluded from the current baseline.

2.6. Building the distribution baseline

The final distribution baseline, at country and grid level, of the IAS included in the 1st update of the list of Union concern was built on:

- EASIN data endorsed by MS Competent Authorities
- additions/exclusions/revisions proposed by MS Competent Authorities

Important Note: At the time of finalisation of this report (November 2018) 7 MS have not provided feedback on EASIN distribution data at country level concerning the IAS included in the 1st update of the list of Union concern, while 9 MS have not provided feedback concerning the grid level (Table 1). As a result, the baseline data presented in the current report for these MS are those corresponding to the original EASIN dataset (see chapter 2.2). It has also to be mentioned that the feedback received from AT at grid level concerned only *Alopochen aegyptiacus*, thus the rest of the AT species grid distribution is based exclusively on EASIN. Finally, concerning the grid level, CZ did not provide feedback on *Alopochen aegyptiacus* and *Ondatra zibethicus*, HU did not provide feedback on *Asclepias syriaca* and *Myriophyllum heterophyllum*, and SE did not provide feedback on *Ondatra zibethicus*. For these species and countries the grid distribution is also based exclusively on EASIN.

2.7. Traits of IAS of Union concern

A detailed search was performed for each species in the EASIN Catalogue, Risk Assessments of the IAS Regulation, and web sources (CABI, NOBANIS, GISD, DAISIE, WORMS, ITIS), concerning:

- Common name: in English.
- Taxonomic position: Kingdom, Phylum/Division, Class; following the ITIS (<https://www.itis.gov/>) and WORMS (<http://www.marinespecies.org/>).
- Habitat: terrestrial / freshwater / oligohaline / marine.
- Origin: the native distribution range of each species, provided at sub-continent level.
- Pathways of introduction in Europe: the CBD categorization of pathways (CBD 2014) was adopted for the current study (Table 2). One or more CBD pathways were attributed for each IAS of Union concern, based on updated literature.
- Year of first observation in EU: year of the first detection or report of the species within EU.
- Country of first observation in EU: the country of first detection or report of the species within EU.
- Impact: environmental / economic / social; referring to impacts reported globally, but focusing on European studies.

1	RELEASE IN NATURE: Biological control
2	RELEASE IN NATURE: Erosion control/ dune stabilization (windbreaks, hedges, ...)
3	RELEASE IN NATURE: Landscape/flora/fauna "improvement" in the wild
4	RELEASE IN NATURE: Fishery in the wild (including game fishing)
5	RELEASE IN NATURE: Hunting

6	RELEASE IN NATURE: Introduction for conservation purposes or wildlife management
7	RELEASE IN NATURE: Release in nature for use (other than above, e.g., fur, transport, medical use)
8	RELEASE IN NATURE: Other intentional release
9	ESCAPE FROM CONFINEMENT: Agriculture (including Biofuel feedstocks)
10	ESCAPE FROM CONFINEMENT: Farmed animals (including animals left under limited control)
11	ESCAPE FROM CONFINEMENT: Forestry (including afforestation or reforestation)
12	ESCAPE FROM CONFINEMENT: Fur farms
13	ESCAPE FROM CONFINEMENT: Aquaculture / mariculture
14	ESCAPE FROM CONFINEMENT: Botanical garden/zoo/aquaria (excluding domestic aquaria)
15	ESCAPE FROM CONFINEMENT: Pet/aquarium/terrarium species (including live food for such species)
16	ESCAPE FROM CONFINEMENT: Horticulture
17	ESCAPE FROM CONFINEMENT: Ornamental purpose other than horticulture
18	ESCAPE FROM CONFINEMENT: Research and ex-situ breeding (in facilities)
19	ESCAPE FROM CONFINEMENT: Live food and live bait
20	ESCAPE FROM CONFINEMENT: Other escape from confinement
21	TRANSPORT – CONTAMINANT: Contaminant nursery material
22	TRANSPORT – CONTAMINANT: Contaminated bait
23	TRANSPORT – CONTAMINANT: Food contaminant (including of live food)
24	TRANSPORT – CONTAMINANT: Contaminant on animals (except parasites, species transported by host/vector)
25	TRANSPORT – CONTAMINANT: Parasites on animals (including species transported by host and vector)
26	TRANSPORT – CONTAMINANT: Contaminant on plants (except parasites, species transported by host/vector)
27	TRANSPORT – CONTAMINANT: Parasites on plants (including species transported by host and vector)
28	TRANSPORT – CONTAMINANT: Seed contaminant
29	TRANSPORT – CONTAMINANT: Timber trade
30	TRANSPORT – CONTAMINANT: Transportation of habitat material (soil, vegetation,...)
31	TRANSPORT - STOWAWAY: Angling/fishing equipment
32	TRANSPORT - STOWAWAY: Container/bulk
33	TRANSPORT - STOWAWAY: Hitchhikers in or on airplane
34	TRANSPORT - STOWAWAY: Hitchhikers on ship/boat (excluding ballast water and hull fouling)
35	TRANSPORT - STOWAWAY: Ship/boat ballast water
36	TRANSPORT - STOWAWAY: Ship/boat hull fouling
37	TRANSPORT - STOWAWAY: Hitchhikers on ship/boat (excluding ballast water and hull fouling)
38	TRANSPORT - STOWAWAY: Machinery/equipment
39	TRANSPORT - STOWAWAY: People and their luggage/equipment (in particular tourism)
40	TRANSPORT - STOWAWAY: Organic packing material, in particular wood packaging
41	TRANSPORT - STOWAWAY: Vehicles (car, train, ...)
42	TRANSPORT - STOWAWAY: Other means of transport
43	CORRIDOR: Interconnected waterways/basins/seas
44	CORRIDOR: Tunnels and land bridges
45	UNAIDED: Natural dispersal across borders of invasive alien species that have been introduced through pathways 1 to 5
46	UNKNOWN

3 Results

3.1. Baseline distribution at country level

The overall country-level baseline of IAS included in the 1st update of the list of Union concern is presented in Table 3. The higher numbers have been found in FR (10 species), DE (8 species), IT (8 species), ES (8 species), and UK (8 species), while CY (1 species) and MT (1 species) have the lowest number (Figure 1). The mammal *Ondatra zibethicus* is the most common species within EU, since it has been found in 25 MS (Figure 2). The land plants *Impatiens glandulifera* and *Heracleum mantegazzianum* are also very common, and reported in 24 and 21 MS respectively (Figure 2). Other species have been rarely found across EU (e.g. *Alternanthera philoxeroides*, *Gunnera tinctoria*) or are not present (*Microstegium vimineum*) (Figure 2).

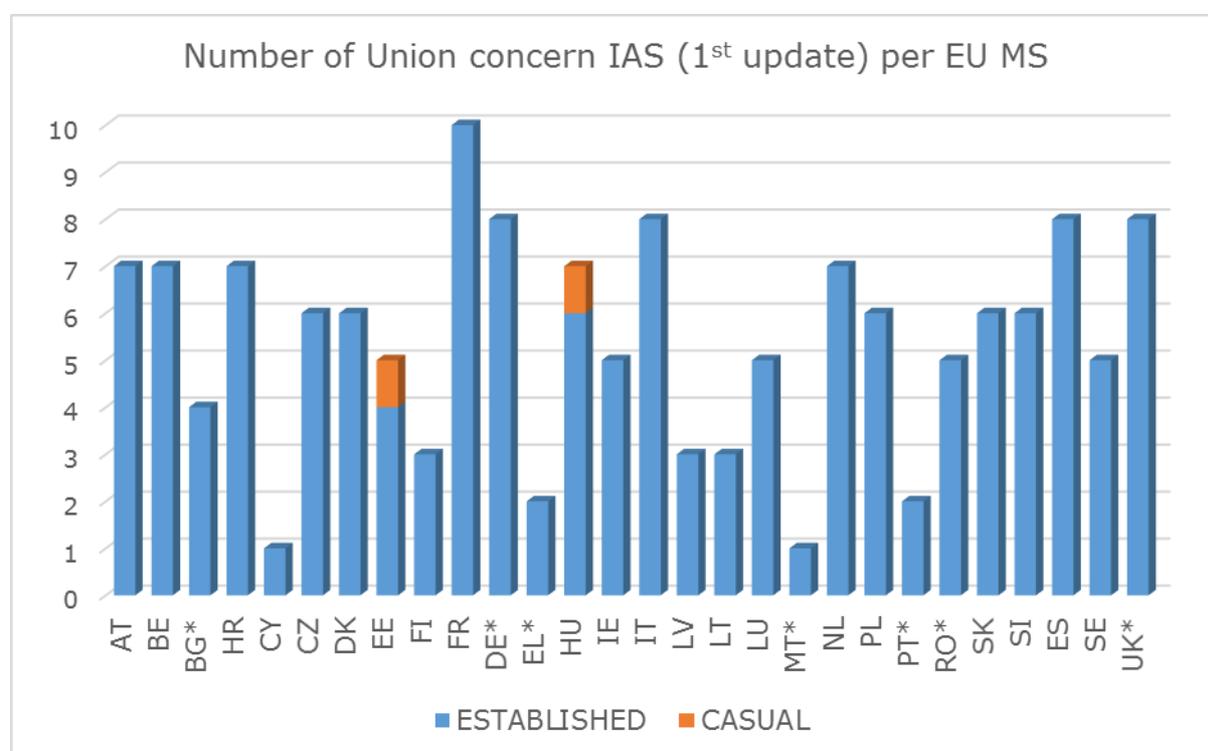


Figure 1. Number of IAS of Union concern (listed in the 1st update) per EU MS. Both established and casual country-level records are depicted. Information corresponding to MS marked with * comes only from EASIN datasets. In these cases there is no distinction between established and casual records.

Table 3. IAS included in the 1st update of the list of Union concern per EU MS. E=established populations, C=casual occurrences, Q=questionable occurrences. Information corresponding to MS marked with * comes only from EASIN datasets. In these cases there is no distinction between established, casual or questionable records (all marked as Present = "P"). Information corresponding to grey-shaded indicates grid level data coming only from EASIN datasets.

SPECIES NAME	AT	BE	BG*	HR	CY	CZ	DK	EE	FI	FR	DE*	EL*	HU	IE	IT	LV	LT	LU	MT*	NL	PL	PT*	RO*	SK	SI	ES	SE	UK*
<i>Alopochen aegyptiacus</i>	E	E		E		E	E	C		E	P	P	C		E			E		E	E	P	P	E	E	E		P
<i>Alternanthera philoxeroides</i>										E					E											E		
<i>Asclepias syriaca</i>	E	E	P	E		E	E			E	P		E		E		E			E	E		P	E	E	E	E	P
<i>Elodea nuttalli</i>	E	E	P	E		E	E	E		E	P		E	E	E			E		E	E		P	E	E		E	P
<i>Gunnera tinctoria</i>										E	P			E														P
<i>Heracleum mantegazzianum</i>	E	E		E		E	E	E	E	E	P		E	E	E	E		E		E	E			E	E	E	E	P
<i>Impatiens glandulifera</i>	E	E	P	E		E	E	E	E	E	P		E	E	E	E	E	E		E	E		P	E	E	E	E	P
<i>Microstegium vimineum</i>																												
<i>Myriophyllum heterophyllum</i>	E	E		E						E	P		E							E						E		P
<i>Ondatra zibethicus</i>	E	E	P	E		E	E	E	E	E	P	P	E	E	E	E	E	E		E	E		P	E	E	E	E	P
<i>Pennisetum setaceum</i>					Q					E					E				P			P				E		

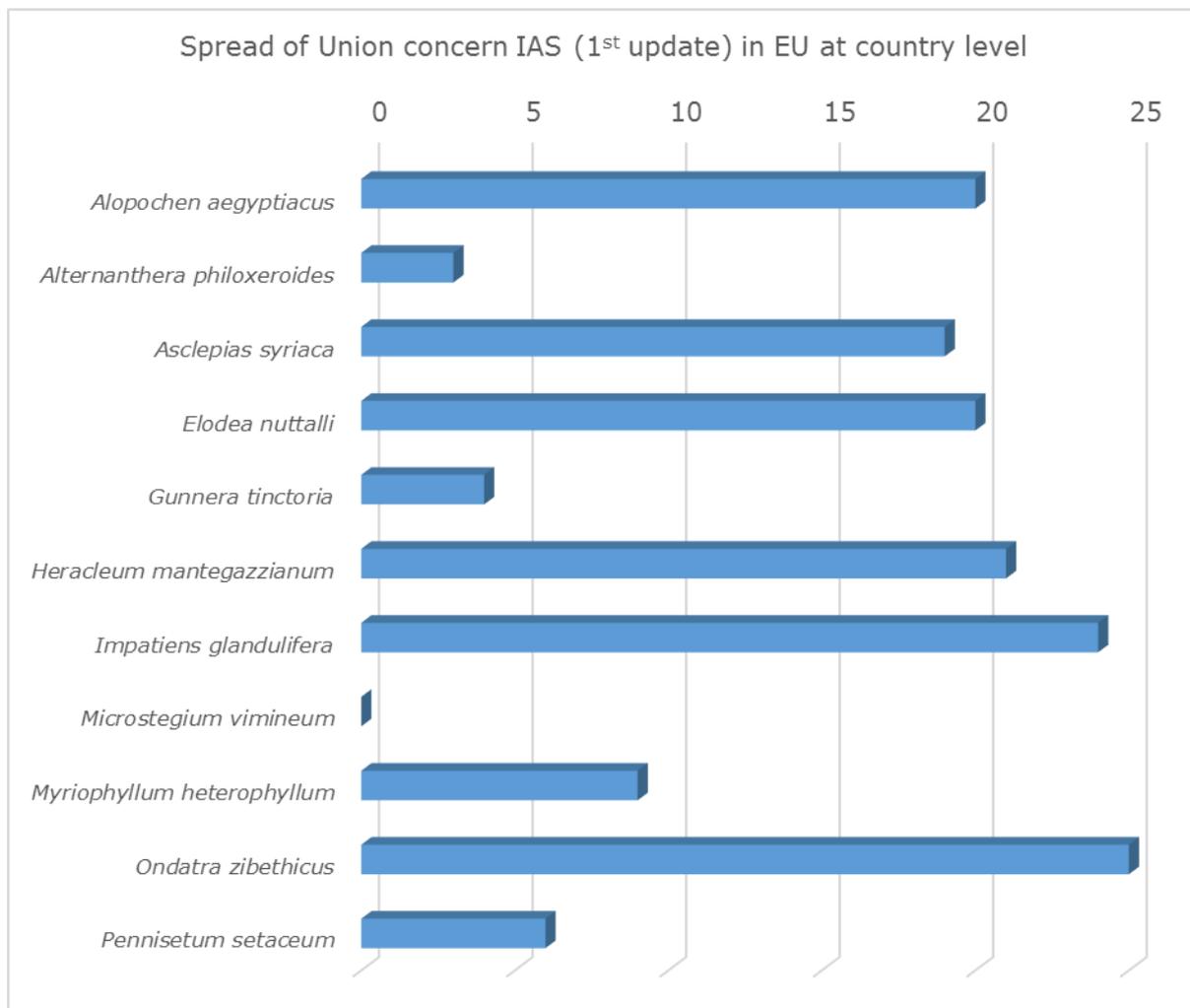


Figure 2. Number of MS where each species listed in the 1st update of IAS of Union concern has been reported. Both established and casual country-level records per country are included in the analysis.

3.2. Baseline distribution at grid level

The grid-level baseline (10x10 km) of the IAS included in the 1st update of the list of Union concern is presented in Figure 3. Dense grid level occurrences have been reported mostly from BE, NL, FR, DE and UK. The species *Impatiens glandulifera*, *Heracleum mantegazzianum* and *Ondatra zibethicus* show the highest spread in Europe (Figure 4). On the other hand, limited spread characterises the species *Gunnera tinctoria*, *Alternanthera philoxeroides* and *Myriophyllum heterophyllum* (Figure 4). The overall grid-level baseline distributions across EU for each of the IAS added to the list of Union concern are depicted in Figures 5-14, with the exception of *Microstegium vimineum* which has not been found in the EU by 2018.

Important Note: Detailed spatial information and original sources are provided for each species and for each EU MS in Annex II.

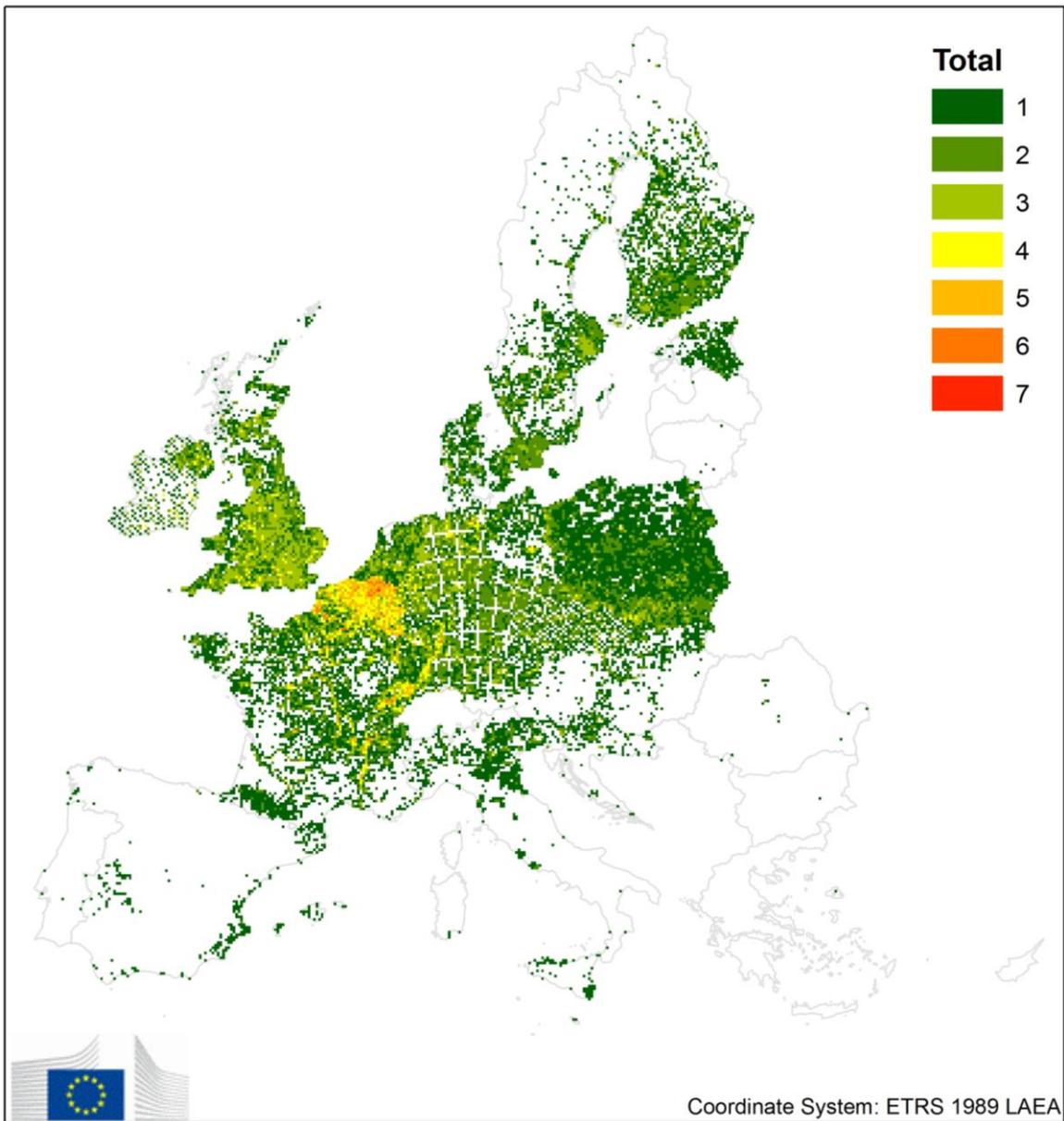


Figure 3. Cumulative number of IAS added to the list of Union concern at grid level (10x10 km pixel grid) in the EU MS, based on the available georeferenced information for each MS.

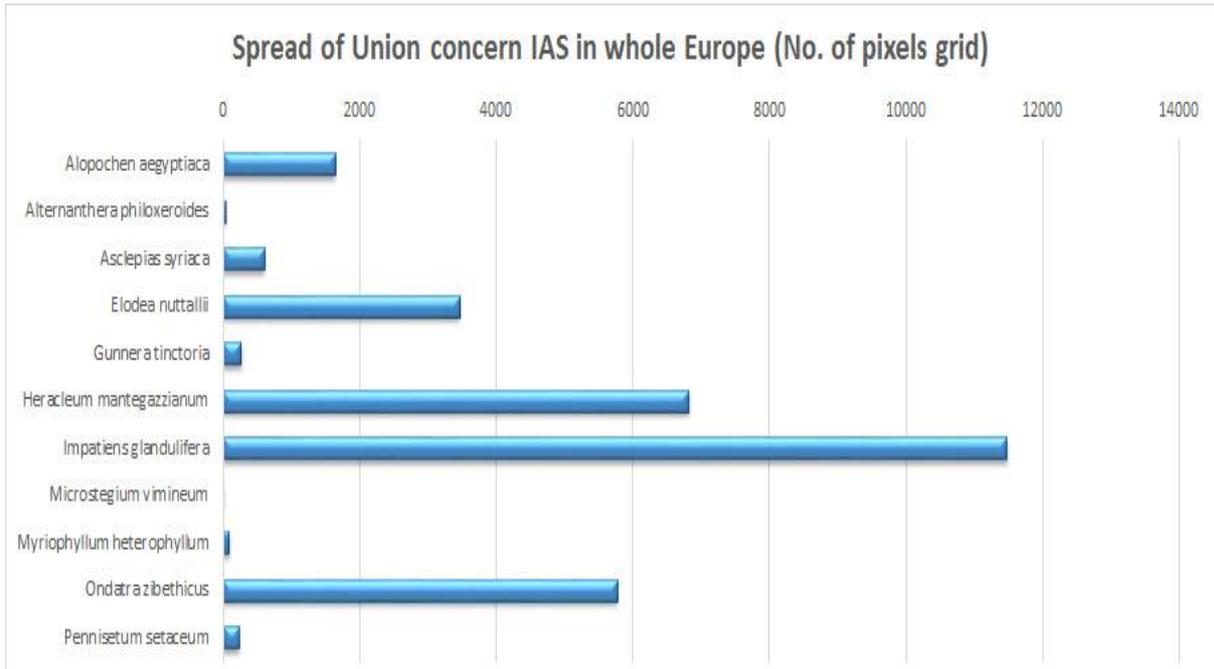


Figure 4. Number of grid cells (10x10 km) where each of the 11 IAS added to the list of Union concern has been reported in the EU MS, based on the available georeferenced information.

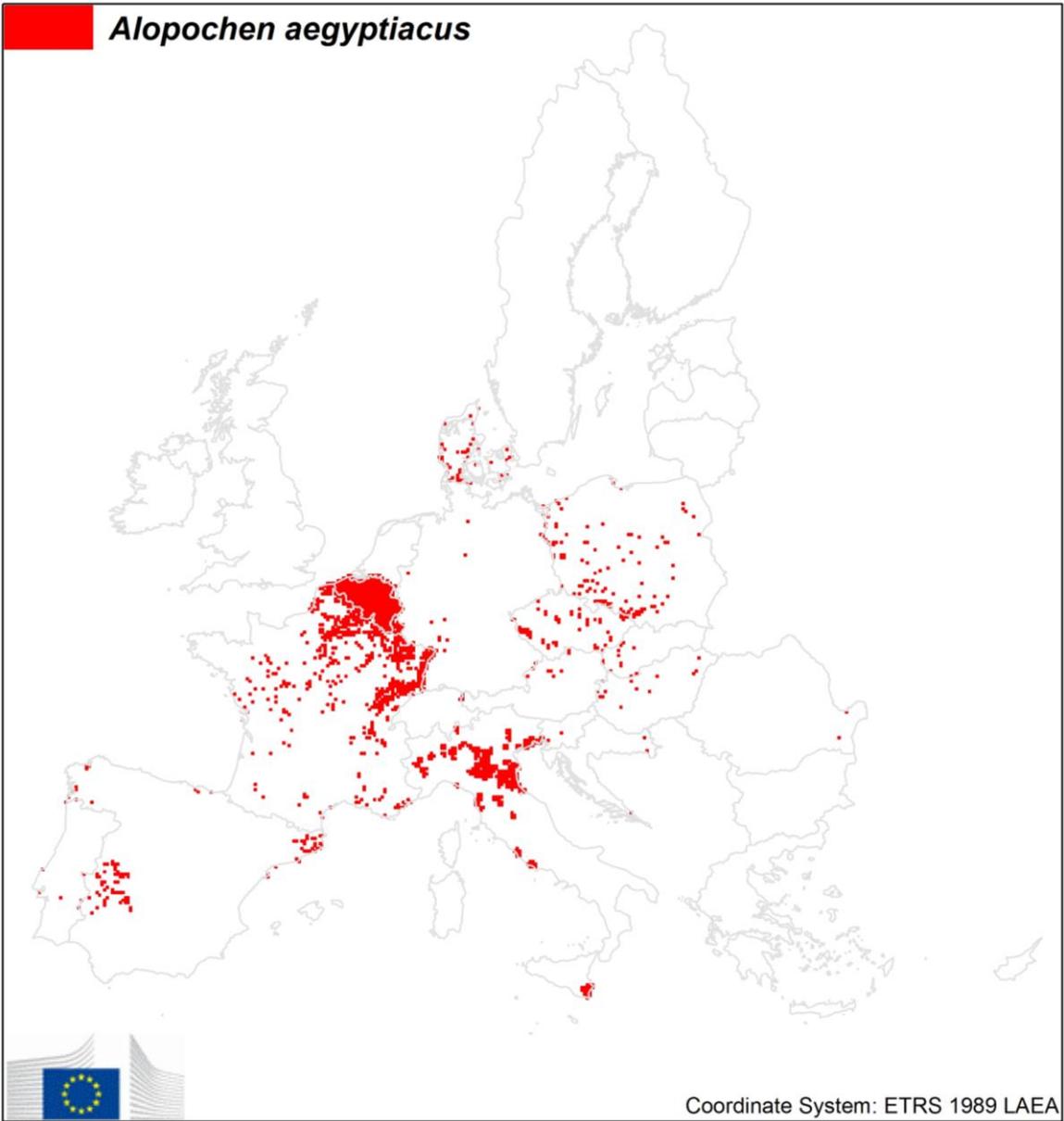


Figure 5. Grid-level (10x10 km) baseline distribution of *Alopochen aegyptiacus* in EU MS. The species is also present in EE (casual), EL, NL and UK but no georeferenced data are available.

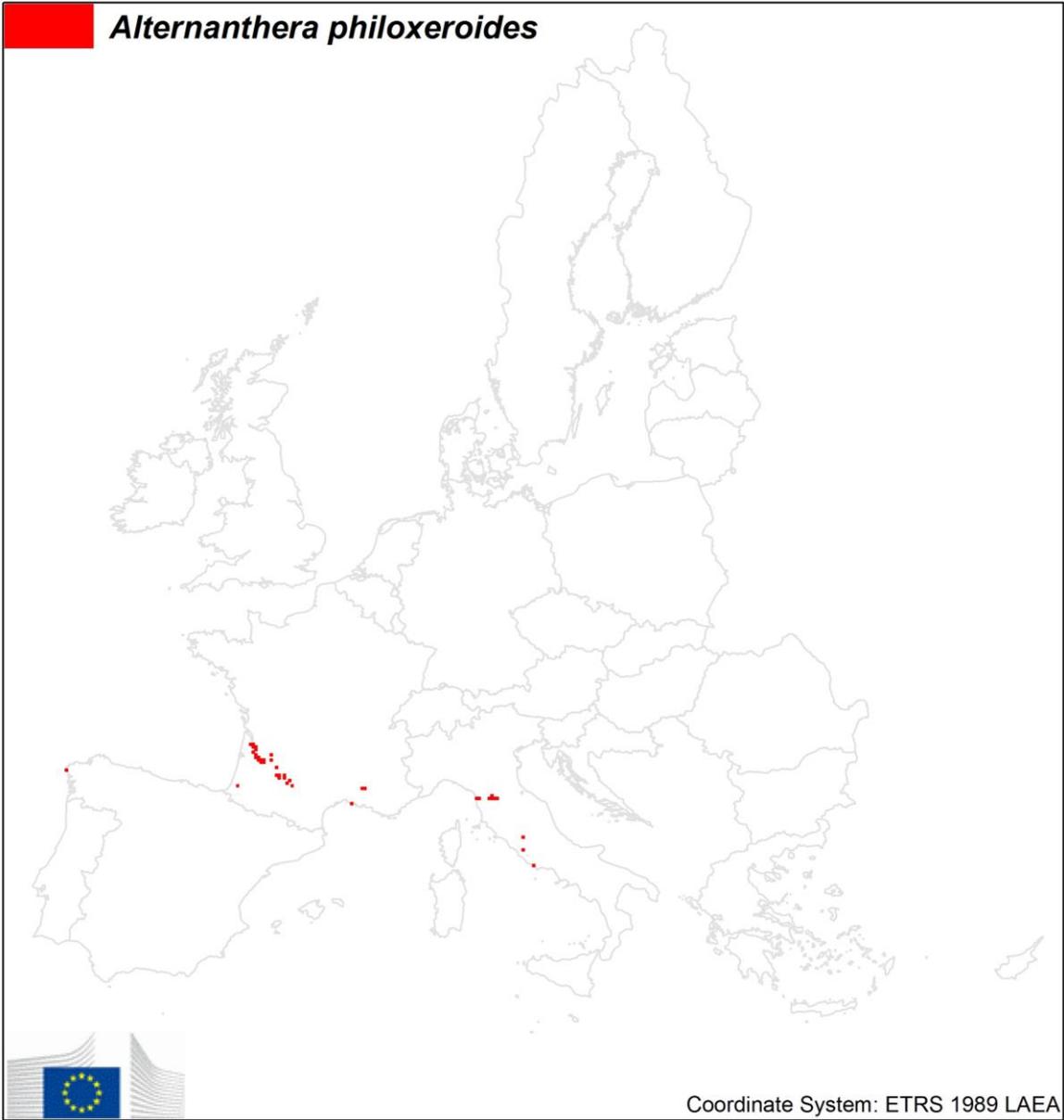


Figure 6. Grid-level (10x10 km) baseline distribution of *Alternanthera philoxeroides* in the EU MS.

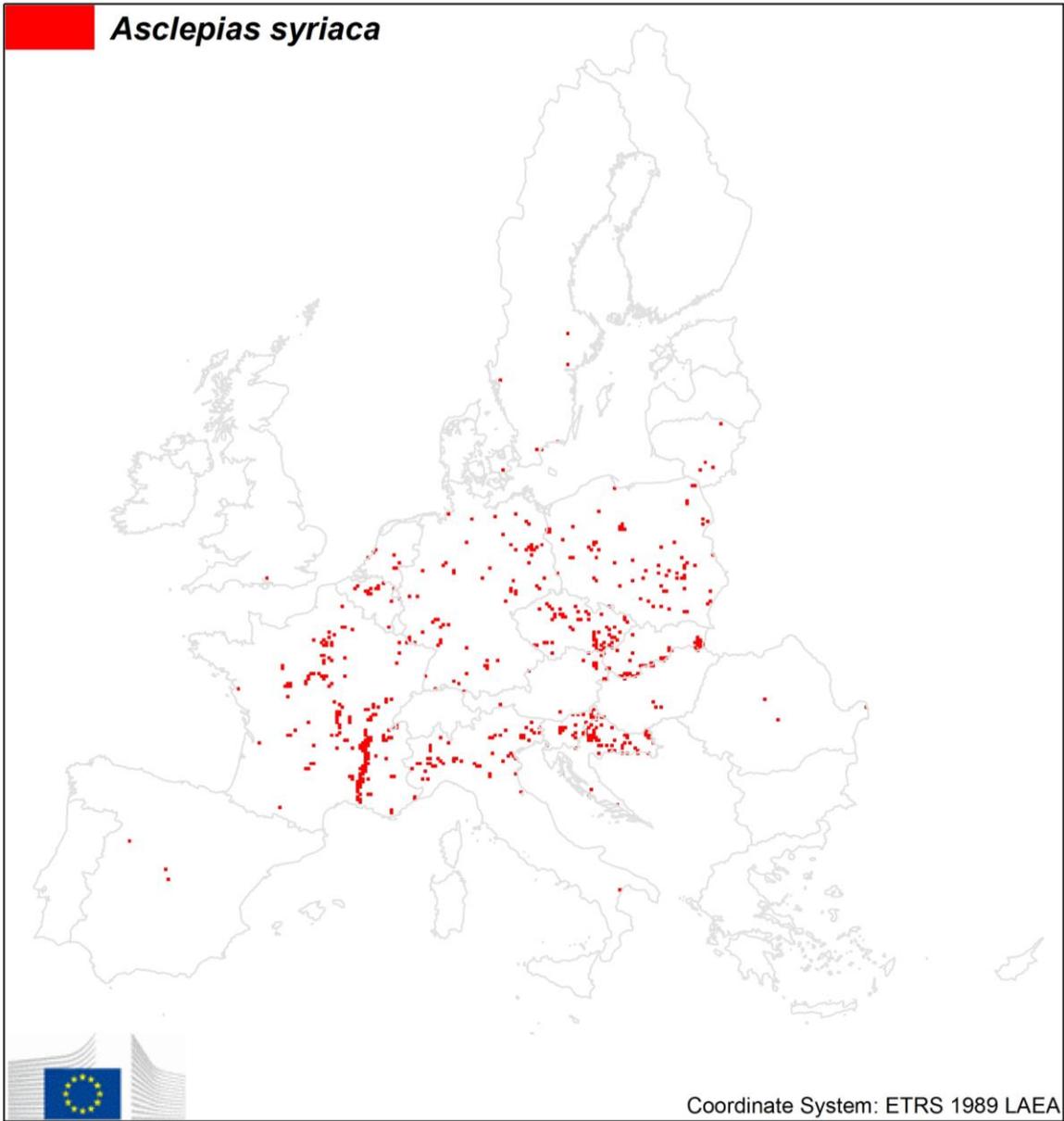


Figure 7. Grid-level (10x10 km) baseline distribution of *Asclepias syriaca* in the EU MS. The species is also present in BG but no georeferenced data are available.

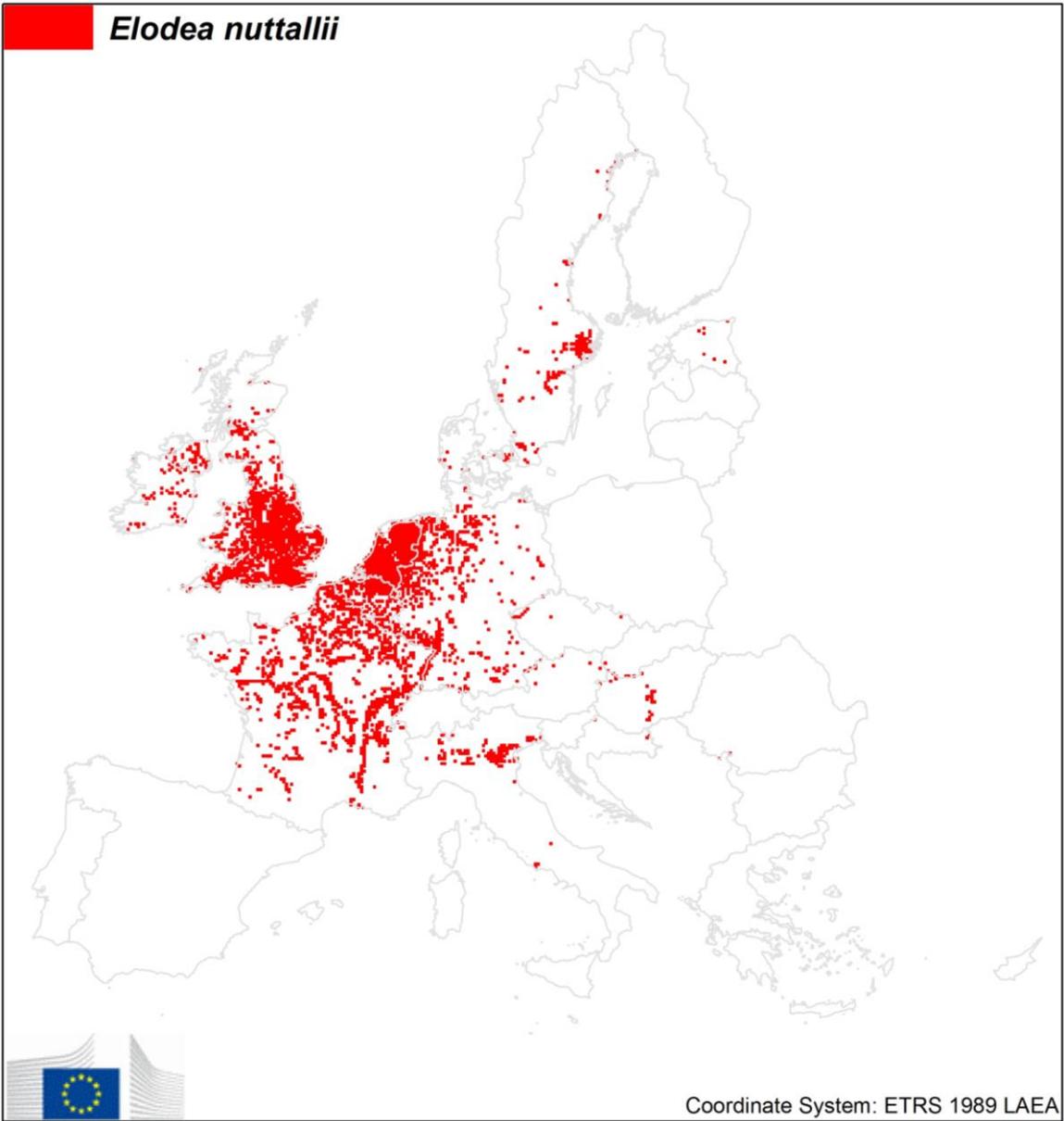


Figure 8. Grid-level (10x10 km) baseline distribution of *Elodea nuttallii* in the EU MS. The species is also present in BG, PL and SI but no georeferenced data are available.

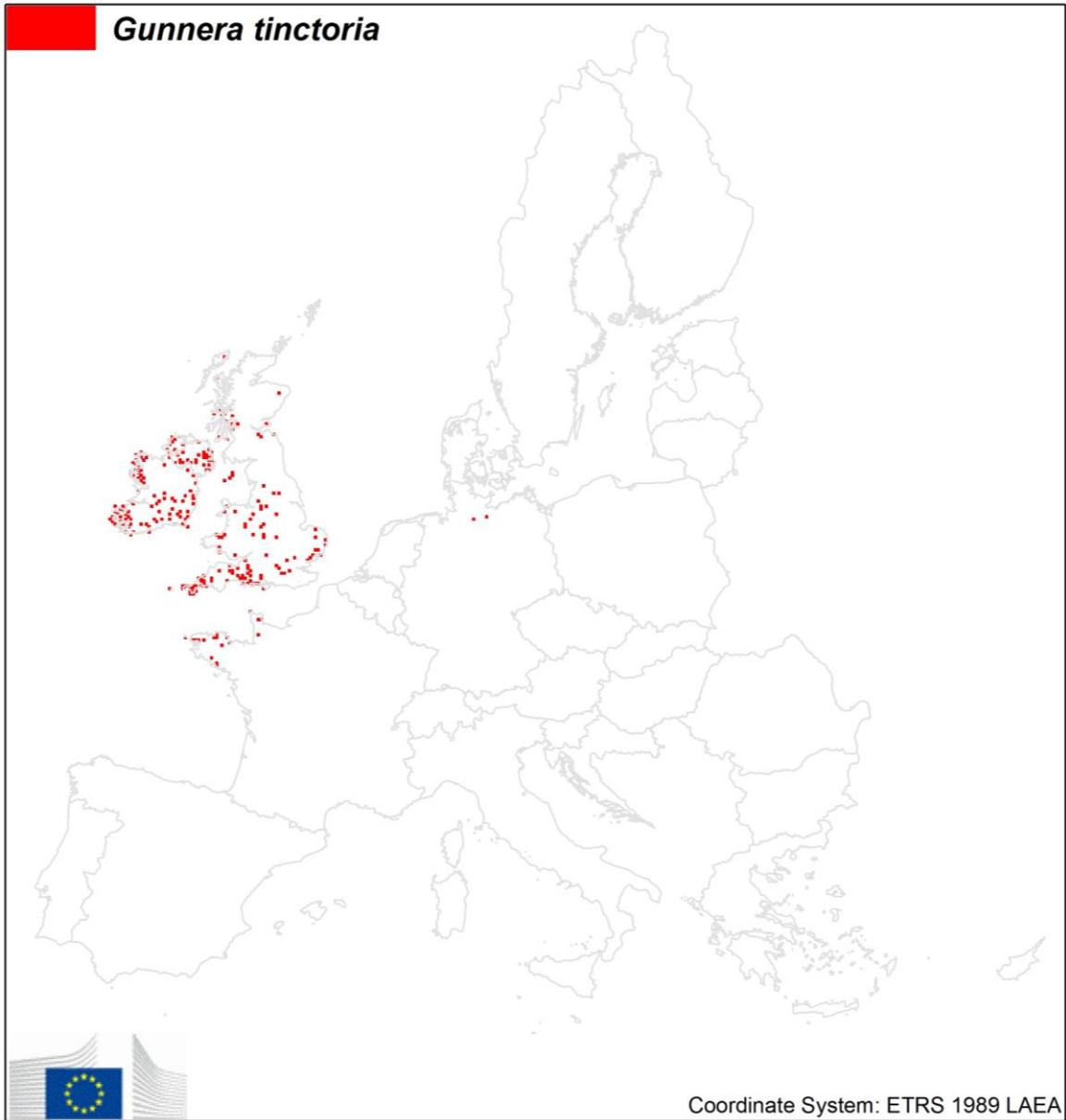


Figure 9. Grid-level (10x10 km) baseline distribution of *Gunnera tinctoria* in the EU MS.

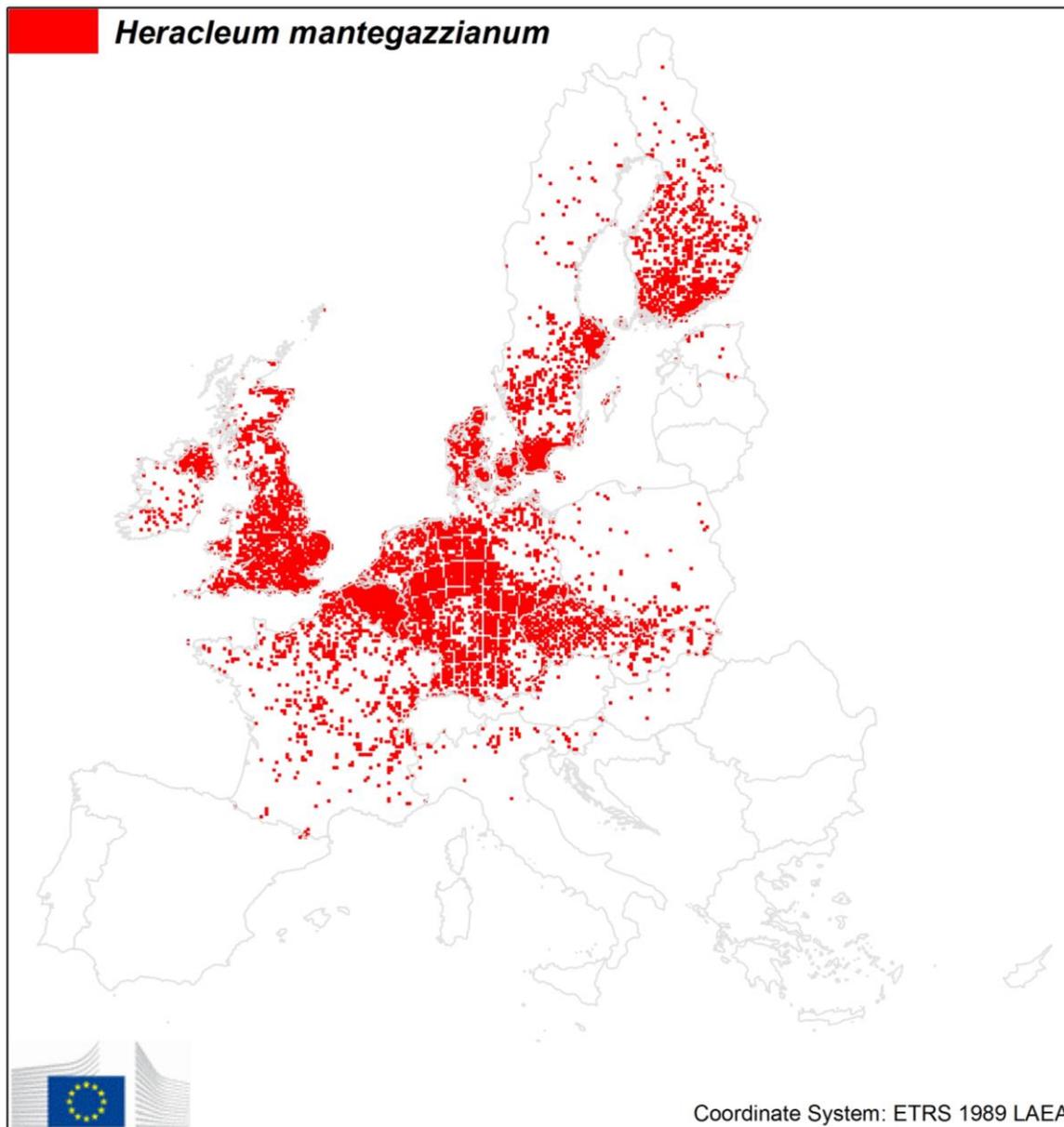


Figure 10. Grid-level (10x10 km) baseline distribution of *Heracleum mantegazzianum* in the EU MS. Several occurrence records from FI may refer to *H. persicum*.

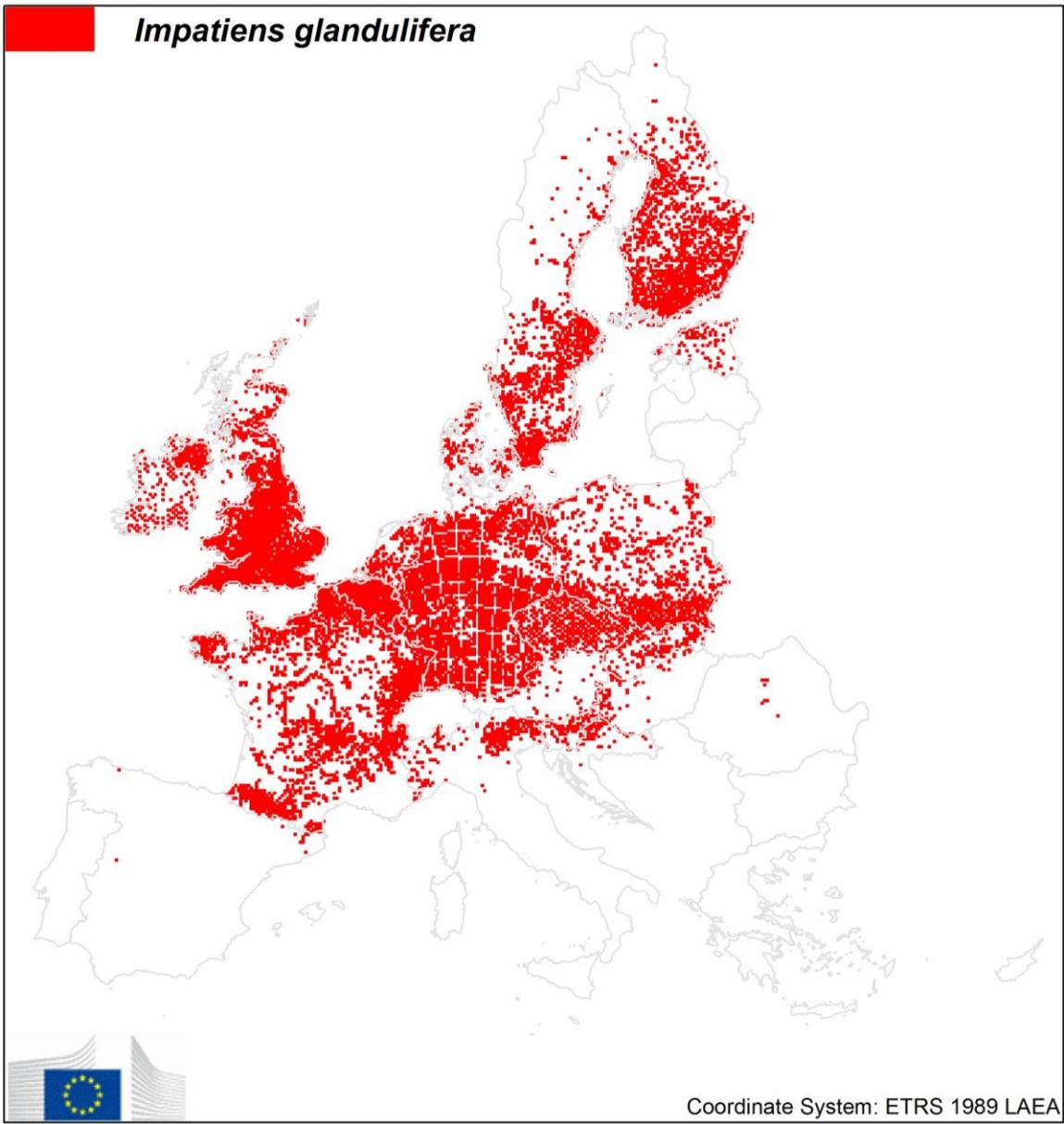


Figure 11. Grid-level (10x10 km) baseline distribution of *Impatiens glandulifera* in the EU MS. The species is also present in BG, LV, LT but no georeferenced data are available.

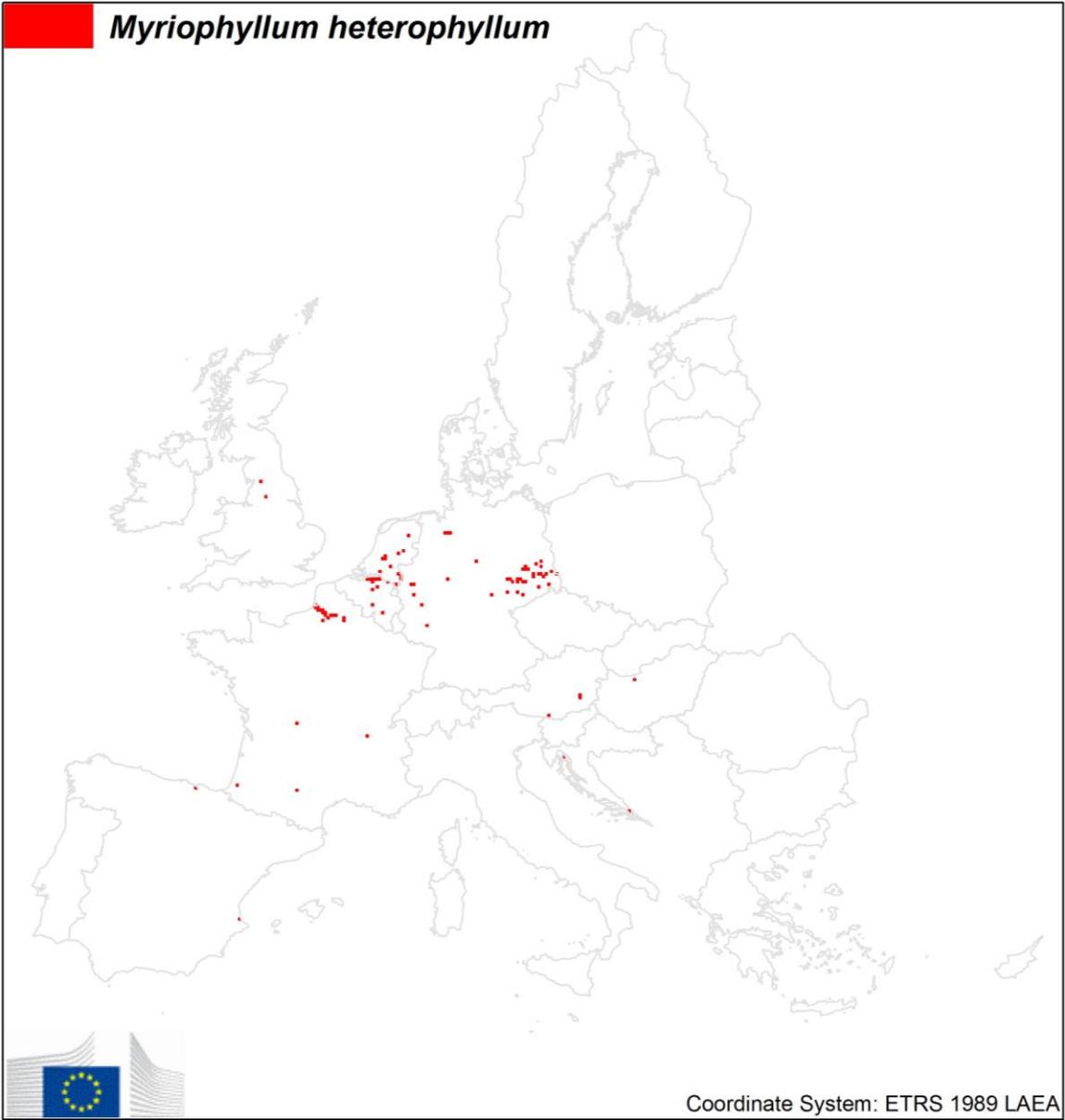


Figure 12. Grid-level (10x10 km) baseline distribution of *Myriophyllum heterophyllum* in the EU MS.

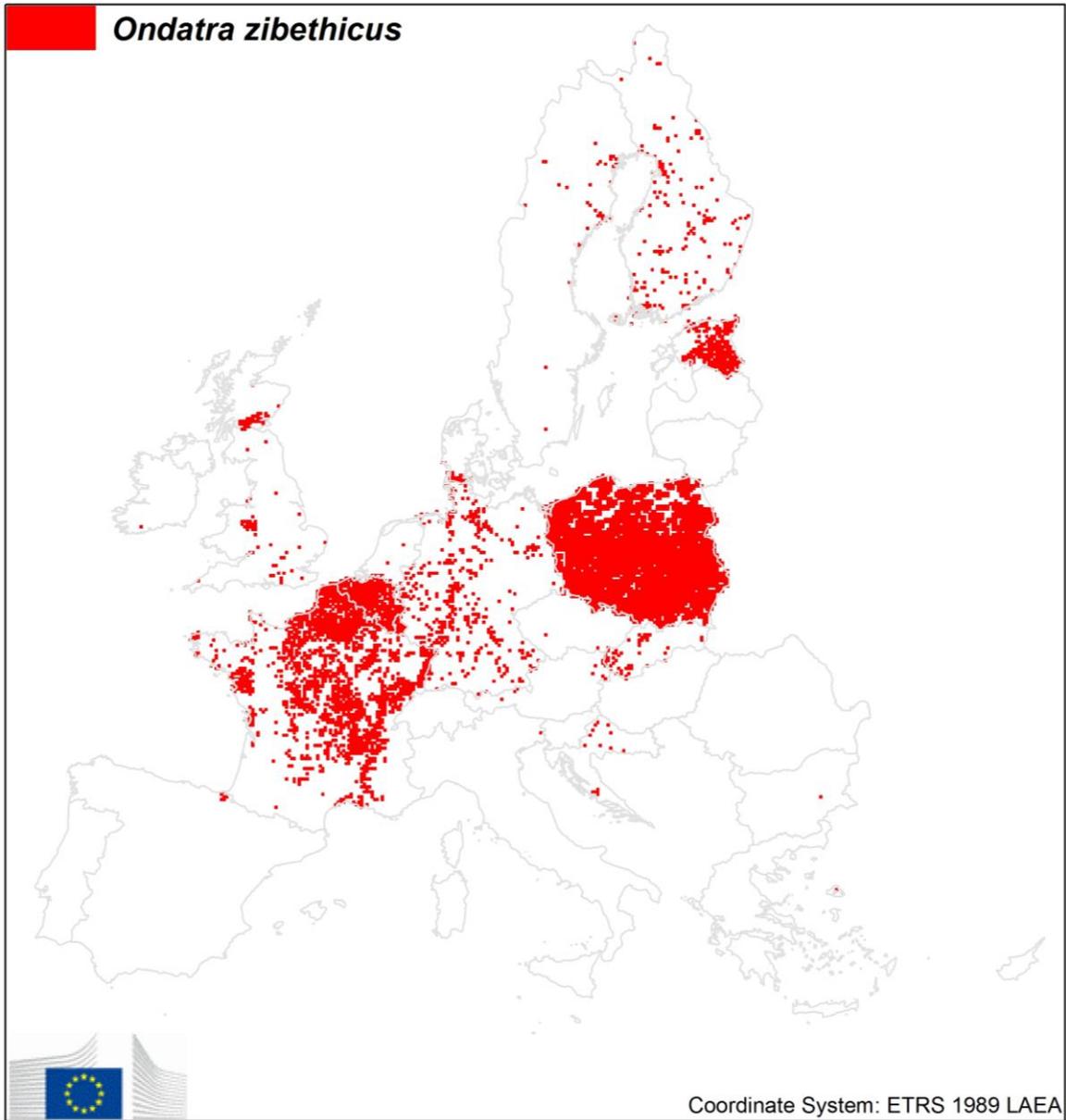


Figure 13. Grid-level (10x10 km) baseline distribution of *Ondatra zibethicus* in the EU MS. The species is also present in HU, LV, LT, RO and SI but no georeferenced data are available.

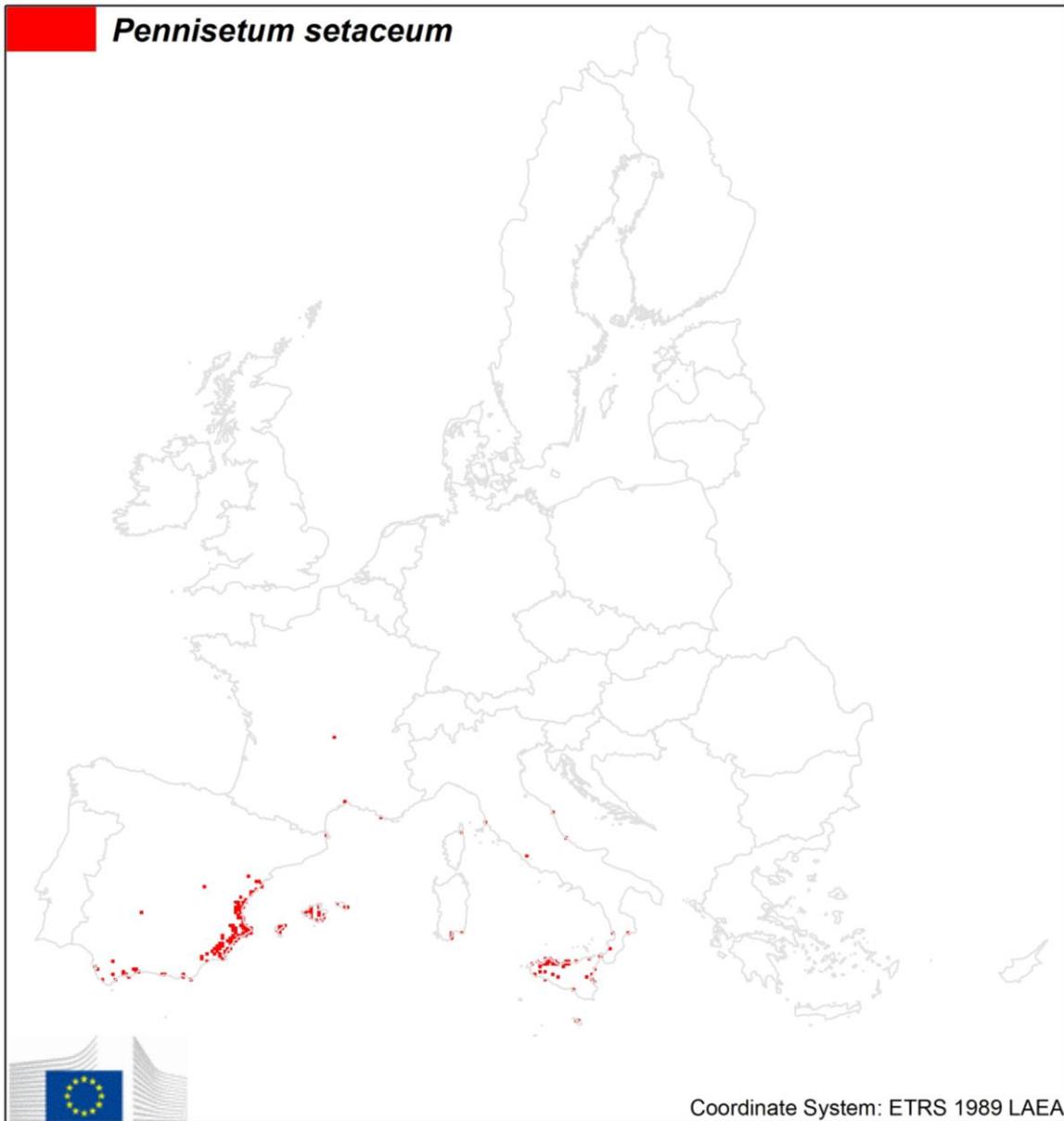


Figure 14. Grid-level (10x10 km) baseline distribution of *Pennisetum setaceum* in the EU MS. The species is also present in PT and CY but no georeferenced data are available. In CY the presence of the species needs confirmation.

3.3. Traits of IAS of Union concern

In Table 4, all traits of the IAS added to the list of Union concern are summarized, including information regarding their reported impact. Related information has been extracted from EASIN, Risk Assessments of the IAS Regulation and web sources (CABI, GISID, NOBANIS, DAISIE, ITIS, WORMS). For more details see sub-chapter 2.7.

Table 4. Traits of species listed in the 1st update of IAS of Union concern. Related information has been extracted from EASIN, Risk Assessments of the IAS Regulation and web sources (CABI, GISID, NOBANIS, DAISIE, ITIS, WORMS). For more details see sub-chapter 2.7.

Species name	Common name	Taxonomic group	Habitat	Origin	Pathway (CBD)	Year of first introduction in EU	Country of first introduction in EU	Environmental impact	Economic impact	Social impact
<i>Alopochen aegyptiacus</i>	Egyptian goose	Aves	Terrestrial, Freshwater	Africa	Escape from confinement: botanical garden/zoo/aquaria (excluding domestic aquaria); pet/aquarium/terrarium species (including live food for such species)	1676	UK	(-) hybridization with other goose and duck species (-) competes with native birds for food and nesting sites	(-) may cause agricultural damages (-) introduction of diseases (eg. avian influenza)	(-) may be a nuisance due to defecating in recreational areas near water reservoirs
<i>Alternanthera philoxeroides</i>	Alligator weed	Plant	Terrestrial, Freshwater	South America	Transport-contaminant: contaminant on plants (except parasites, species transported by host/vector); seed contaminant Escape from confinement: ornamental purpose other than horticulture	1500	IT	(-) blankets the water surface, impedes light penetration, promotes sedimentation and flooding (-) in terrestrial habitats it degrades riverbanks, producing massive underground root systems	(-) affects agriculture, irrigation and fisheries	(-) provides habitat for mosquitoes and degrades natural aesthetics
<i>Asclepias syriaca</i>	Common milkweed	Plant	Terrestrial	North America	Release in nature: release in nature for use (other than above, e.g., fur, transport, medical use) Escape from confinement: agriculture (including Biofuel feedstocks); ornamental purpose other than horticulture Transport stowaway: vehicles (car, train, ...)	1825	FR	(-) threatens native species and natural habitats (-) can change the vegetation structure	(-) negative impacts in agriculture (-) poisonous to sheep, cattle, poultry (-) potential vector of fungal and virus plant diseases (-) can detract bees from pollinating sunflower, therefore it causes crop loss (+) cultivated in Europe as a melliferous and fibre plant, as well as an ornamental	(-) allergic and allelopathic effects; direct contact with the plant can cause skin irritation (-) milk poisonous
<i>Elodea nuttalli</i>	Nuttall's pondweed	Plant	Freshwater	North America	Escape from confinement: pet/aquarium/terrarium species (including live food for such species)	1939	BE	(-) outcompetes native plants (-) can reduce water movement, cut off	(-) blocks pipes and drainage systems (-) impedes boating,	

								light, produce anoxic conditions and trap sediments in a system (-) impacts spawning success among certain indigenous fish species (+) efficient up-take of heavy metals and nutrients	fishing, tourism (+) aquarium trade	
<i>Gunnera tinctoria</i>	Giant rhubarb	Plant	Terrestrial	South America	Escape from confinement: ornamental purpose other than horticulture; horticulture	1849	UK	(-) shades out native flora (-) erosion to river banks (-) can alter natural successional processes and change vegetation structure	(-) can block drain and streams, enhancing flooding	
<i>Heracleum mantegazzianum</i>	Giant hogweed	Plant	Terrestrial	Caucasus	Escape from confinement: ornamental purpose other than horticulture Transport stowaway: other means of transport	1814	EE	(-) competes and replaces most native plants (-) soil erosion (-) changes seedbank composition	(-) may limit tourism and leisure activities due to the areas made inaccessible	(-) serious dermatological effects on skin
<i>Impatiens glandulifera</i>	Himalayan balsam	Plant	Terrestrial	Asia	Escape from confinement: ornamental purpose other than horticulture; horticulture Release in nature: release in nature for use (other than above, e.g., fur, transport, medical use)	1839	UK	(-) reduces native species diversity (-) can exclude native plants from pollination (-) facilitates river bank erosion	(-) limits angling area of river and lakesides (+) used as a nectariferous plant	
<i>Microstegium vimineum</i>	Japanese stiltgrass	Plant	Terrestrial	Asia	Transport stowaway: machinery/equipment Transport-contaminant: seed	1997	TR	(-) outcompetes native plants (-) can alter soil	(-) reduces natural tree regeneration (-) invades gardens	

					contaminant			properties (-) may decrease arthropod abundance and diversity		
<i>Myriophyllum heterophyllum</i>	Broadleaf watermilfoil	Plant	Freshwater	North America	Escape from confinement: pet/aquarium/terrarium species (including live food for such species)	1800	AT	(-) outcompetes native aquatic plants and other organisms (fish, invertebrates) (-) prevents water flow, reduces sunlight and oxygen availability	(-) impedes swimming, boating and fishing (-) negatively impacts drainage and irrigation systems, hydropower and drinking water resources (+) aquarium trade	
<i>Ondatra zibethicus</i>	Muskrat	Mammal	Terrestrial, Freshwater	North America	Escape from confinement: fur farms Release in nature: release in nature for use other than above (e.g., fur, transport??, medical use)	1905	CZ	(-) damages vegetation through grazing (-) may threaten invertebrate communities (-) burrowing can weaken riverbanks causing them to collapse	(-) damage to agriculture, railways, dams, dikes, fish farms (+) used in fur farms, but not anymore	(-) can host parasites affecting humans and domestic animals
<i>Pennisetum setaceum</i>	Fountain grass	Plant	Terrestrial	North Africa	Escape from confinement: ornamental purpose other than horticulture; horticulture Release in nature: erosion control/ dune stabilization (windbreaks, hedges, ...)	1989	ES	(-) reduces native species diversity by reducing available space, water and nutrients (-) extremely inflammable, increasing the intensity and spread of fire	(-) unpalatable to cattle; reduction of natural pastures (+) horticulture trade	

Taxonomy

The first list of IAS of Union concern included more animal (62%) than plant species (38%) (Tsiamis et al. 2017a). IAS included in the 1st update of the list of Union concern record 2 animals and 9 plants. The overall taxonomic proportion of all 48 IAS of Union concern is depicted in Figure 15.

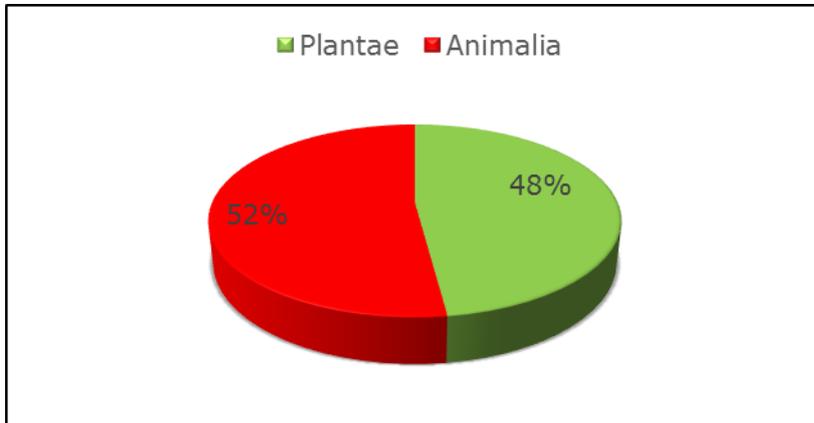


Figure 15. Proportion of animal and plant species of all 48 IAS of Union concern.

Habitat

The first list of IAS of Union concern included about half terrestrial and half freshwater species, while one species is oligohaline (*Eriocheir sinensis*) (Tsiamis et al. 2017a). Species listed in the 1st update include additional terrestrial and freshwater species (mostly terrestrials), while no marine species has been included in the Union list so far. The overall environment proportion of all 48 IAS of Union concern is depicted in Figure 16.

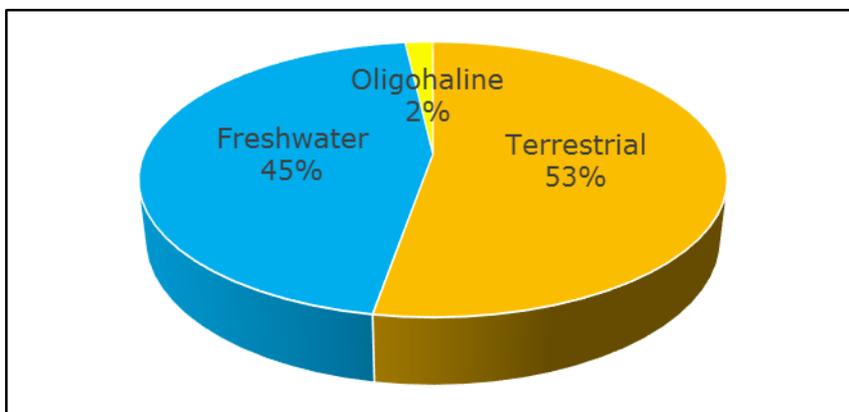


Figure 16. Environment of all 48 IAS of Union concern.

Origin

Similarly to the first list, most of the species of the 1st update of IAS of Union concern originate from America (mainly North America) (Figure 17). Again, species with African origin are low represented, while no species come from Oceania.

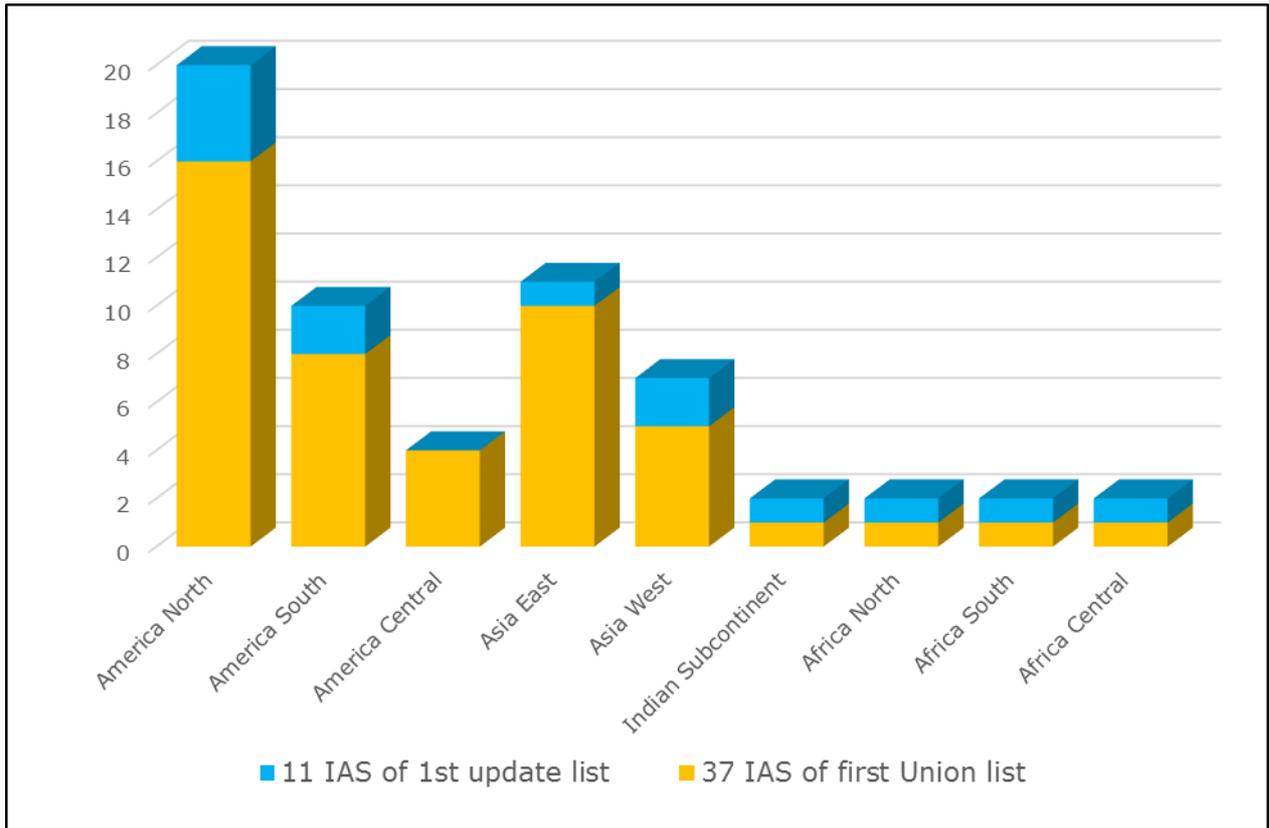


Figure 17. Origin of all 48 IAS of Union concern.

Pathways of introduction

Species belonging to the 1st update of IAS of Union concern were introduced in Europe mainly through the pathway “Escape from confinement”. This pathway is mostly related to the sub-categories “Ornamental purpose other than horticulture”, “Horticulture” and “Pet/aquarium/terrarium species (including live food for such species)”, following the same traits of the species listed in the first Union list (Tsiamis et al. 2017a). The overall pathways patterns of all the 48 IAS of Union concern are depicted in Figures 18 and 19.

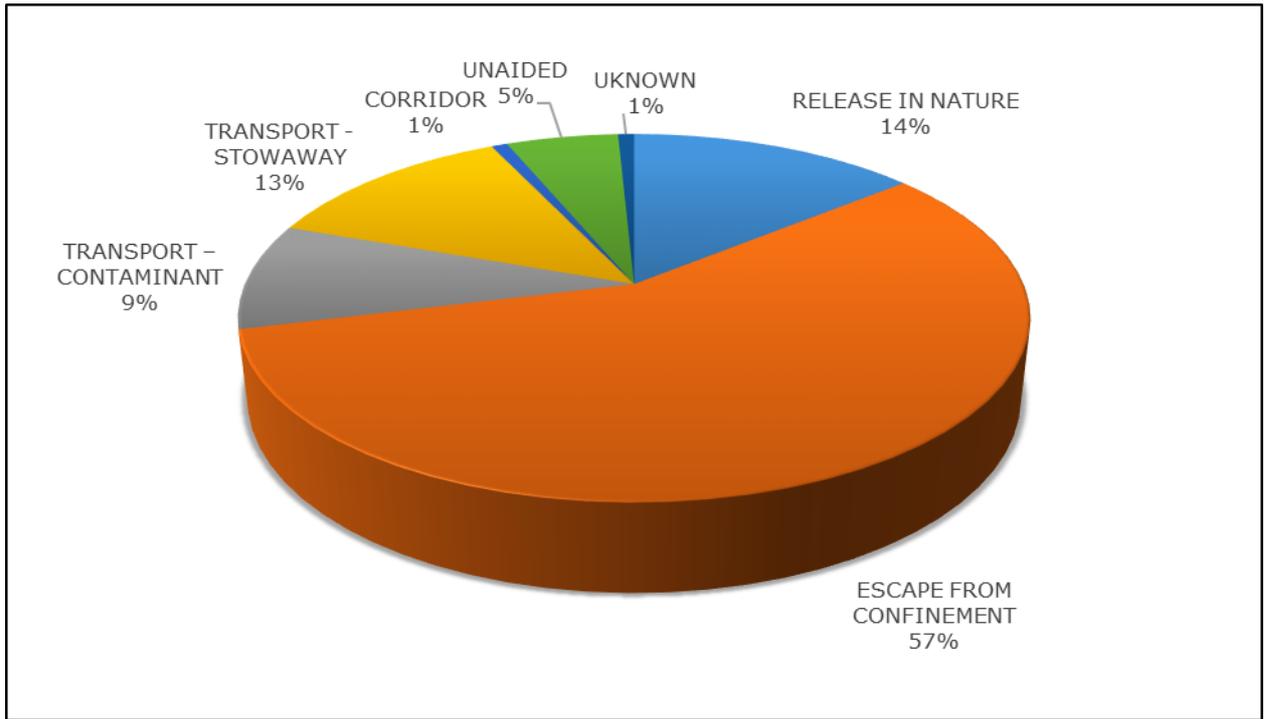


Figure 18. Main pathways of introduction of all 48 IAS of Union concern, based on CBD pathways categorization.

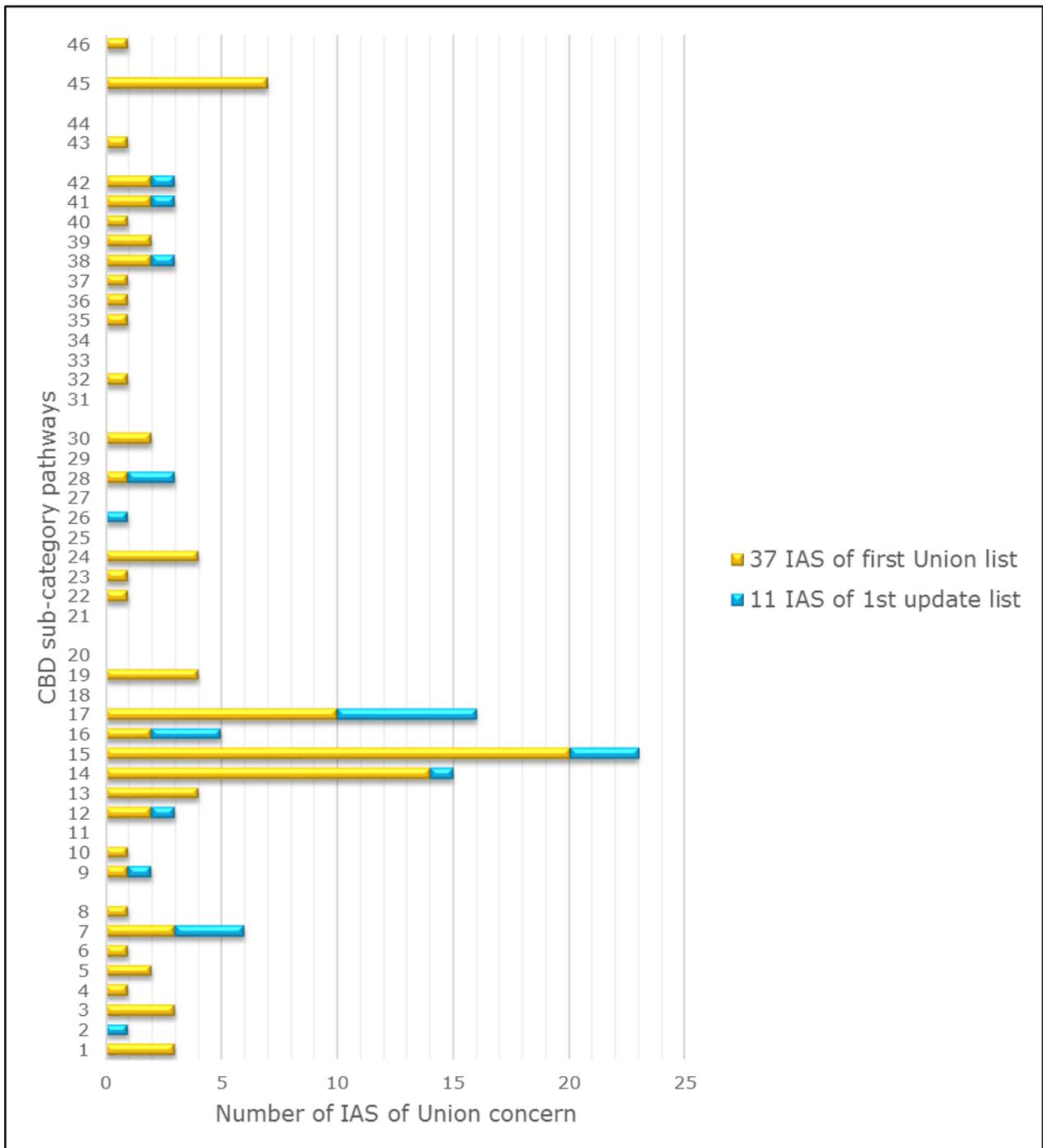


Figure 19. Sub-category pathways of introduction of all 48 IAS of Union concern in Europe, based on CBD categorization. Multiple pathways for each species have been taken into consideration. CBD pathways' codes are based on Table 2 (see sub-chapter 2.7).

Year of first introduction in the EU

Similarly to the species of the first Union list, the majority of the species listed in the 1st update correspond to rather old introductions in EU, dating before the 1950's (Figure 20). Only one species was introduced in EU after the 1950's (*Pennisetum setaceum*), while the plant *Microstegium vimineum* has not been found in EU yet (but reported from Turkey).

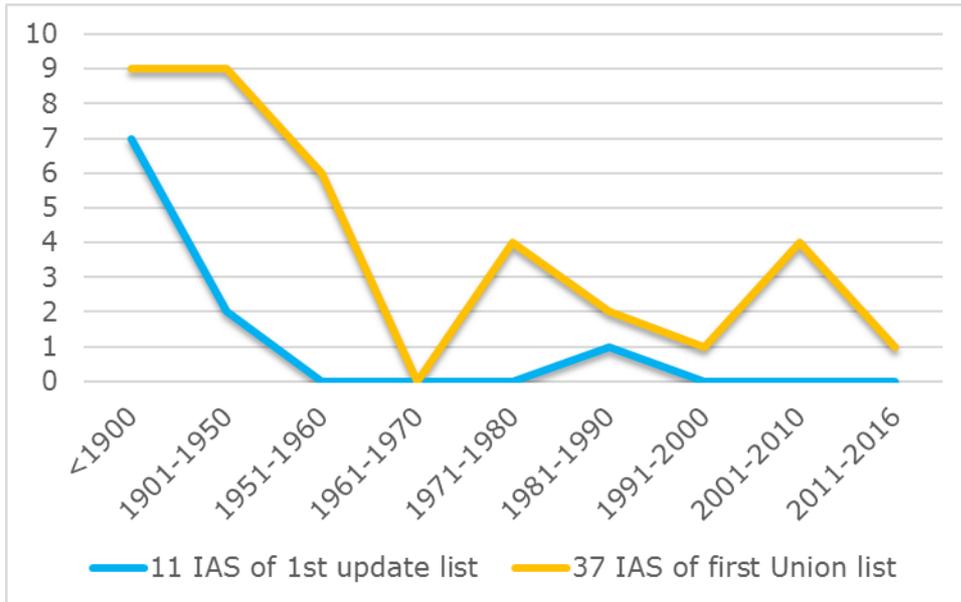


Figure 20. Timeline of first introduction events of IAS of Union concern in EU.

Country of first introduction in the EU

Most of the first introduction events of species listed in the 1st update occurred in UK (Figure 21). No first introduction events have been observed for 11 EU MS. The overall pattern of countries of first introduction for all IAS of Union concern is depicted in Figure 21.

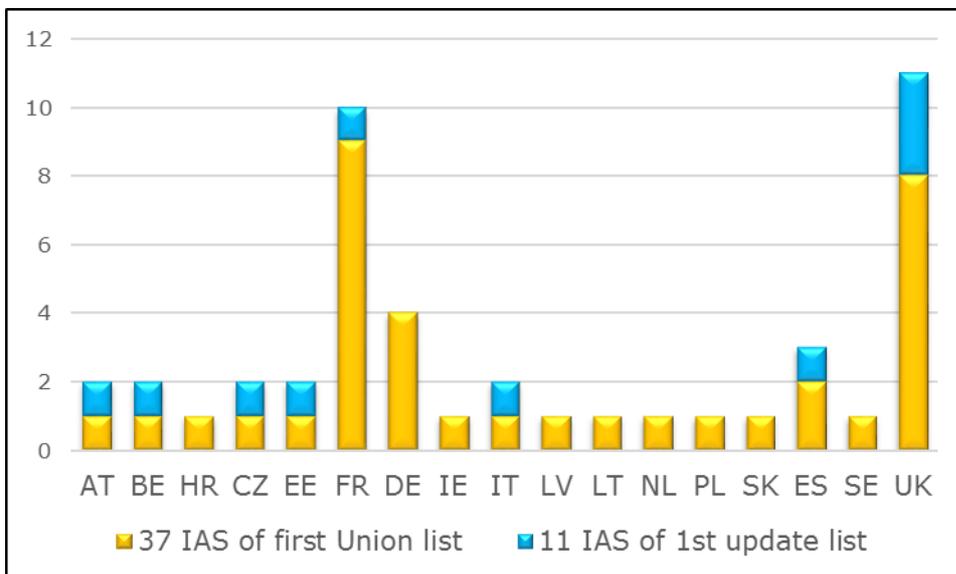


Figure 21. Countries of first introduction of all 48 IAS of Union concern at EU scale. No first introduction events have been observed for 11 EU MS (not depicted).

4. Discussion & Conclusions

The distribution baseline of the 11 IAS included in the 1st update of the list of Union concern, together with the baseline distribution of the 37 species of the first Union list (Tsiamis et al. 2017a), constitute an important tool supporting the implementation of the IAS Regulation. These baseline data are crucial to track new detections of IAS of Union concern in unaffected areas of the EU territory, in relation with Art. 16 which dictates the mandatory notification of early detections of listed species to the European Commission (EC) and to the other MS. In addition, the baseline data will be made available in the EASIN platform, which obeys to the format required by the Commission Implementing Regulation (EU) 2017/145⁸, and can be reused by MS to comply with reporting obligations under Art. 24 of IAS Regulation. However, it should be noted that the present baseline has not been fully checked by all MS (7 countries did not provide any feedback). For these countries the baseline information provided in the current report, coming from EASIN geodatabase, should be considered as the best available knowledge, in the absence of information and checking by the relevant MS Competent Authorities.

The current baseline can help MS in the establishment of a surveillance system for the targeted species under Art. 14 of the IAS Regulation, and can foster MS cooperation and coordination across borders or within shared biogeographical regions, as recalled by Art. 22. The distribution of the targeted species will also help the discussion amongst MS about the appropriate management measures to be implemented (Art. 19). In addition, the data provided can assist MS and the EC in monitoring the evolution of the IAS distribution across Europe and evaluating the effectiveness of the actions undertaken by MS Competent Authorities while implementing the IAS Regulation. The evaluation of those data can eventually lead to reconsider or modify implementation activities and give an input when updating the list of IAS of Union concern.

Nine of the IAS included in the 1st update of the list of Union concern are plants, while only 2 are animals (*Alopochen aegyptiacus* and *Ondatra zibethicus*). They are all terrestrial or freshwater species, and already present in EU, with the exception of *Microstegium vimineum*, which however has been found in Turkey. Several species are already widespread across EU (e.g. *Ondatra zibethicus*, *Impatiens glandulifera*, *Heracleum mantegazzianum*), while few others are still rare (e.g. *Alternanthera philoxeroides*, *Gunnera tinctoria*, *Pennisetum setaceum*).

Distribution data have revealed that most of the species were introduced and have spread across north-western EU countries (e.g. BE, NL, FR, DE, UL), while their presence is more limited in southern EU MS (e.g. MT, CY, EL). The same pattern was observed for the first 37 IAS of Union concern (Tsiamis et al. 2017a), and it should be attributed to historical reasons, since most of the first introduction events across EU took place in FR and UK. In addition, lack of data and limited monitoring results could explain the fact that for some MS only a limited reported presence and spread of the listed species has been recorded up to now. The cumulative numbers of all 48 IAS of Union concern per EU MS at country and grid 10x10 km level are presented in Figures 22 and 23 respectively.

⁸ COMMISSION IMPLEMENTING REGULATION (EU) 2017/1454 of 10 August 2017 specifying the technical formats for reporting by the Member States pursuant to Regulation (EU) No 1143/2014

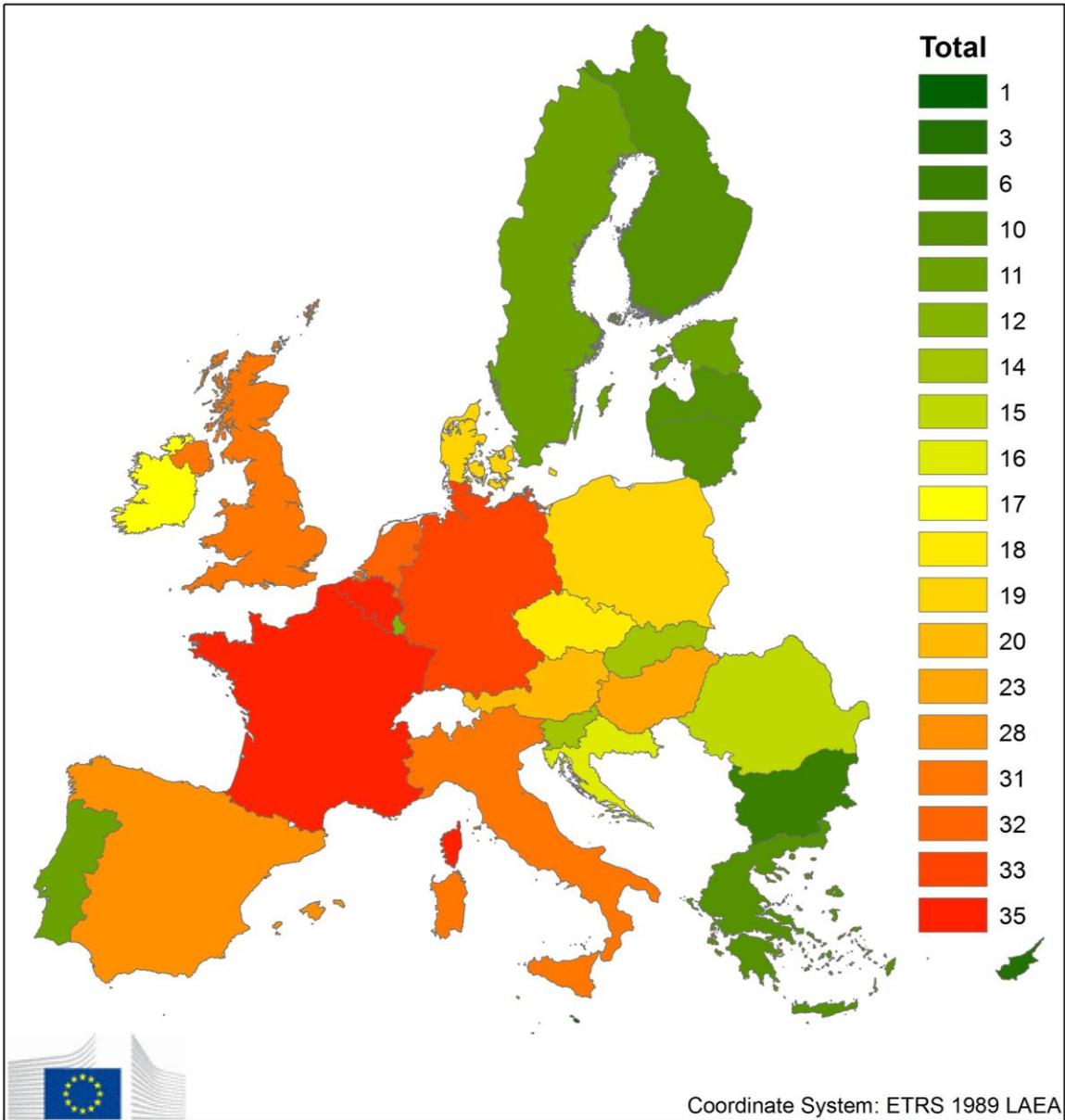


Figure 22. Cumulative number of all 48 IAS of Union concern per EU MS. Both established and casual country-level records per country are included in the analysis. *Nyctereutes procyonoides* has not been considered since its inclusion in the Union list took place on 02.02.2019.

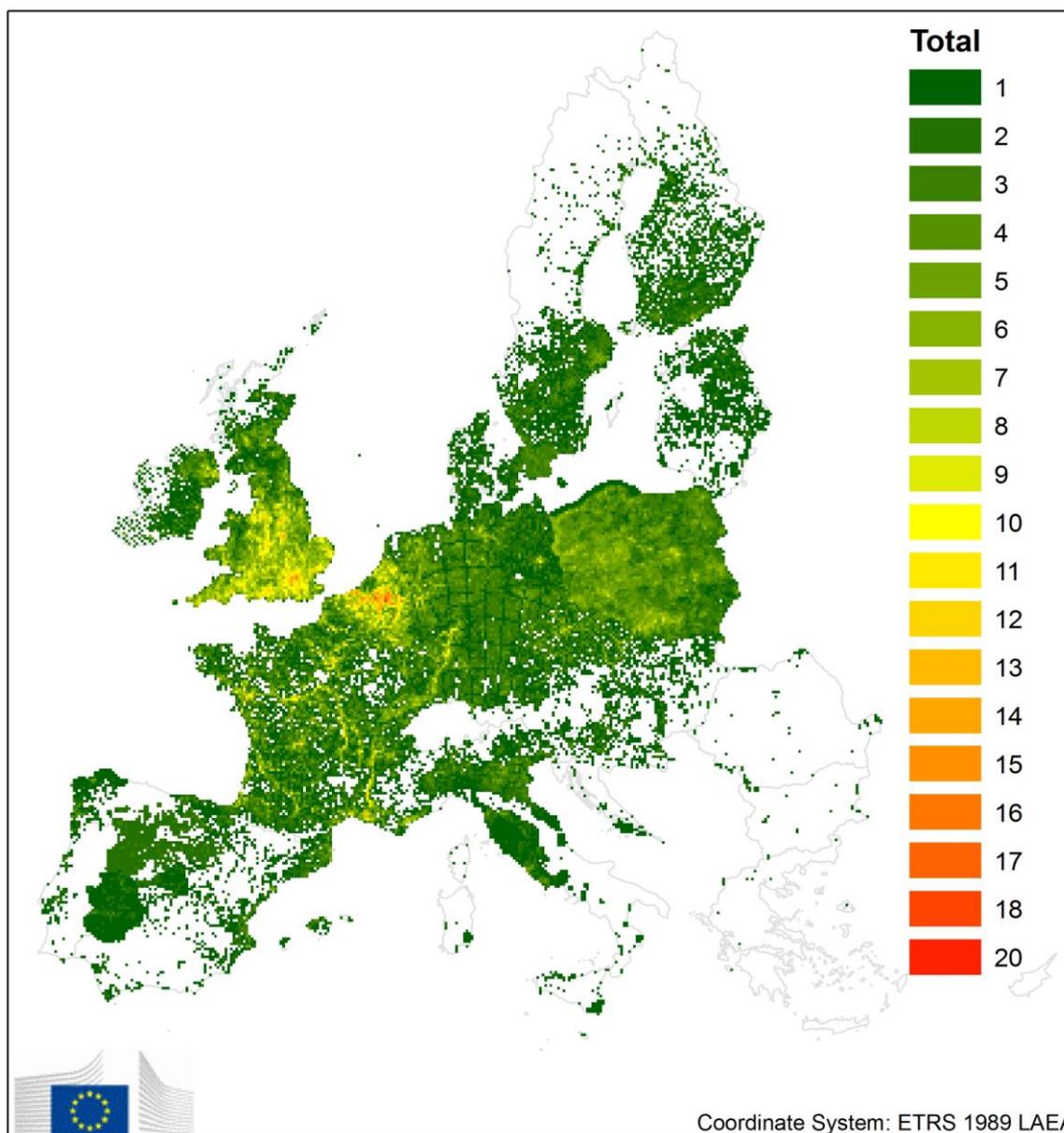


Figure 23. Cumulative number of all 48 IAS of Union concern per EU MS at grid 10x10 km level in EU, based on the available georeferenced information for each MS. *Nyctereutes procyonoides* has not been considered, since its inclusion in the Union list took place on 02.02.2019.

When it comes to primary introduction pathways, most of the 11 species considered in this report have been introduced into EU through escapes linked with ornamental purposes, horticulture and aquarium trade. It should be noted that most primary introductions events took place during the 19th century, a few events during the first half of the 20th century, while only one species was introduced during the last decades (*Pennisetum setaceum*, in 1989). Similarly with the first 37 IAS of Union concern, species listed in the 1st update originate mostly from North America.

As in the case of the distribution baseline of the first Union list (Tsiamis et al. 2017a), EASIN proved to be an excellent source of information on AS spatial data for compiling the distribution baseline of the species listed in the 1st update, coming from the scientific literature, online and offline databases, reports, institute collections, web sources, etc. The 10x10 km grid level scale was the most appropriate choice for depicting spatial data due to limitations of data coming from the EASIN Data Partners network.

MS Competent Authorities in charge of implementing the IAS Regulation were invited to check and validate the EASIN baseline data of the targeted species, at country and grid level, supplementing it with national data. The feedback received was satisfactory, since 21 MS provided relevant data. Still, 7 MS were unable to provide feedback, some of them highlighting problems such as time limitations, organizational issues and the absence of relevant digitalized data within their national repositories.

The overall matching between the EASIN records and the data provided by the MS Competent Authorities was very high (90%), revealing that EASIN is a good source of information for IAS distribution records, attesting its role as official information system supporting MS in the implementation of the IAS Regulation (Art. 25). The mismatches observed between EASIN and MS Competent Authorities data concerned mostly species records corresponding to specimens from museums and botanical gardens, which were excluded from the baseline.

The 11 IAS included in the 1st update of the list of Union concern have been already included in the dedicated smartphone application (app) on IAS of Union concern, called "Invasive Alien Species Europe", developed by JRC (Tsiamis et al. 2017b). This application can act as a supplementary tool for monitoring IAS of Union concern and a way to increase public awareness and citizens' engagement. Preliminary results of the app's use are encouraging, including dozens of citizens' records across EU, of which 41 correspond to IAS of Union concern, validated and confirmed by the EASIN team and EASIN Editorial Board (Tsiamis et al. 2016). Finally, in the context of a 'Proof of Concept Project', the Joint Research Centre has engaged in promoting the uptake of the "Invasive Alien Species Europe" app as a tool for the purpose of national official surveillance activities in Europe, guaranteeing at the same time the link to the EC official information system on IAS (EASIN) and the reuse of the data at European level.

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List of abbreviations and definitions

AS	Alien species as defined in Art. 3 of EU Regulation 1143/2014
CABI	Centre for Agriculture and Biosciences International (http://www.cabi.org/)
CBD	Convention on Biological Diversity (https://www.cbd.int/)
CIESM	International Commission for Scientific Exploration of the Mediterranean Sea (http://www.ciesm.org/)
DAISIE	Delivering Alien Invasive Species Inventories for Europe (http://www.europe-aliens.org/)
DG ENV	European Commission Directorate General for Environment
EASIN	European Alien System Information Network (http://easin.jrc.ec.europa.eu/)
EC	European Commission
EEA	European Environmental Agency (http://www.eea.europa.eu/)
ELNAIS	Hellenic Network on Aquatic Invasive Species (http://elnais.hcmr.gr/)
EPPO	European and Mediterranean Plant Protection Organization (https://www.eppo.int/)
EU	European Union
GBIF	Global Biodiversity Information Facility (http://www.gbif.org/)
GISID	Global Invasive Species Database (http://www.iucngisd.org/gisd/about.php)
GISIN	Global Invasive Species Information Network (http://ibis-live1.nrel.colostate.edu/DH.php?WC=/WS/GISIN/GISINDirectory/home_new.html&WebSiteID=4)
HCMR	Hellenic Centre for Marine Research (http://www.hcmr.gr/en/)
IAS	Invasive Alien Species as defined in Art. 3 of EU Regulation 1143/2014
IAS of Union concern	Species identified according to Art. 4 of the EU Regulation 1143/2014, requiring EU concerted action, published in the EU Commission Implementing Regulations 1141/2016 of 13 July 2016 and 1263/2017 of 12 July 2017
IAS Regulation	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
ITIS	Integrated Taxonomic Information System (https://www.itis.gov/)
IUCN	International Union for Conservation of Nature (https://www.iucn.org/)
JRC	Joint Research Centre Directorate of the European Commission

MAMIAS	Marine Mediterranean Invasive Alien Species (http://www.mamias.org/)
MS	Member States
NBIC	Norwegian Biodiversity Information Centre (http://www.biodiversity.no/)
NOBANIS	European Network on Invasive Alien Species (https://www.nobanis.org/)
NOTSYS	Official notification system for detection of IAS of Union concern (https://easin-notsys.jrc.ec.europa.eu/)
REABIC	Regional Euro-Asian Biological Invasions Centre (http://www.reabic.net/)
WoRMS	World Register of Marine Species (http://www.marinespecies.org/)

List of figures

Figure 1. Number of IAS of Union concern (listed in the 1st update) per EU MS. Both established and casual country-level records are depicted. Information corresponding to MS marked with * comes only from EASIN datasets. In these cases there is no distinction between established and casual records.

Figure 2. Number of MS where each species listed in the 1st update of IAS of Union concern has been reported. Both established and casual country-level records per country are included in the analysis.

Figure 3. Cumulative number of IAS added to the list of Union concern at grid level (10x10 km pixel grid) in the EU MS, based on the available georeferenced information for each MS.

Figure 4. Number of grid cells (10x10 km) where each of the 11 IAS added to the list of Union concern has been reported in the EU MS, based on the available georeferenced information.

Figure 5. Grid-level (10x10 km) baseline distribution of *Alopochen aegyptiacus* in EU MS. The species is also present in EE (casual), EL, NL and UK but no georeferenced data are available.

Figure 6. Grid-level (10x10 km) baseline distribution of *Alternanthera philoxeroides* in the EU MS.

Figure 7. Grid-level (10x10 km) baseline distribution of *Asclepias syriaca* in the EU MS. The species is also present in BG but no georeferenced data are available.

Figure 8. Grid-level (10x10 km) baseline distribution of *Elodea nuttalli* in the EU MS. The species is also present in BG, PL and SI but no georeferenced data are available.

Figure 9. Grid-level (10x10 km) baseline distribution of *Gunnera tinctoria* in the EU MS.

Figure 10. Grid-level (10x10 km) baseline distribution of *Heracleum mantegazzianum* in the EU MS. Several occurrence records from FI may refer to *H. persicum*.

Figure 11. Grid-level (10x10 km) baseline distribution of *Impatiens glandulifera* in the EU MS. The species is also present in BG, LV, LT but no georeferenced data are available.

Figure 12. Grid-level (10x10 km) baseline distribution of *Myriophyllum heterophyllum* in the EU MS.

Figure 13. Grid-level (10x10 km) baseline distribution of *Ondatra zibethicus* in the EU MS. The species is also present in HU, LV, LT, RO and SI but no georeferenced data are available.

Figure 14. Grid-level (10x10 km) baseline distribution of *Pennisetum setaceum* in the EU MS. The species is also present in PT and CY but no georeferenced data are available. In CY the presence of the species needs confirmation.

Figure 15. Proportion of animal and plant species of all 48 IAS of Union concern.

Figure 16. Environment of all 48 IAS of Union concern.

Figure 17. Origin of all 48 IAS of Union concern.

Figure 18. Main pathways of introduction of all 48 IAS of Union concern, based on CBD pathways categorization.

Figure 19. Sub-category pathways of introduction of all 48 IAS of Union concern in Europe, based on CBD categorization. Multiple pathways for each species have been taken into consideration. CBD pathways' codes are based on Table 2 (see sub-chapter 2.7).

Figure 20. Timeline of first introduction events of IAS of Union concern in EU.

Figure 21. Countries of first introduction of all 48 IAS of Union concern at EU scale. No first introduction events have been observed for 11 EU MS (not depicted).

Figure 22. Cumulative number of all 48 IAS of Union concern per EU MS. Both established and casual country-level records per country are included in the analysis. *Nyctereutes procyonoides* has not been considered since its inclusion in the Union list took place on 02.02.2019.

Figure 23. Cumulative number of all 48 IAS of Union concern per EU MS at grid 10x10 km level in EU, based on the available georeferenced information for each MS. *Nyctereutes procyonoides* has not been considered, since its inclusion in the Union list took place on 02.02.2019.

List of tables

Table 1. MS feedback on EASIN occurrences data concerning the 11 species listed in the 1st update of IAS of Union concern, at country and grid level.

Table 2. CBD main (in capital letters) and sub-category pathways (CBD 2014).

Table 3. IAS included in the 1st update of the list of Union concern per EU MS. E=established populations, C=casual occurrences, Q=questionable occurrences. Information corresponding to MS marked with * comes only from EASIN datasets. In these cases there is no distinction between established, casual or questionable records (all marked as Present = "P"). Information corresponding to grey-shaded indicates grid level data coming only from EASIN datasets.

Table 4. Traits of species listed in the 1st update of IAS of Union concern. Related information has been extracted from EASIN, Risk Assessments of the IAS Regulation and web sources (CABI, GISID, NOBANIS, DAISIE, ITIS, WORMS). For more details see sub-chapter 2.7.

List of Annexes

Annex I. Protocol for checking the EU baseline distribution of IAS of Union concern through EASIN (Regulation (EU) 1143/2014 - EU Impl. Reg. 1263/2017)

Introduction

A detailed and updated spatial baseline distribution information in relation to the Invasive Alien Species (IAS) of Union concern in the Member States (MS) territories is fundamental for the implementation of the IAS Regulation (1143/2014). The first list of IAS of Union concern contained 37 species and an EU baseline of spatial information for these species was published as a JRC science-for-policy report in 2017, with the relevant contributions by the MS (<http://publications.jrc.ec.europa.eu/repository/bitstream/JRC104969/kj-na-28596-en-n.pdf>).

Following the dynamic character of the Union concern list, 12 additional species were added by the Commission Implementing Regulation (EU) 2017/1263 of 12.07.2017 (which entered into force on 02.08.2017). Consequently, there is a need to establish a baseline distribution for these species within EU.

This protocol provides guidance to MS on how to check the EASIN (European Alien Species Information Network - <https://easin.jrc.ec.europa.eu>) records on occurrences and spatial data of each species listed in the 1st update of IAS of Union concern in their territory, aiming to set a valid geographic baseline. The current exercise does not concern *Nyctereutes procyonoides*, whose listing takes effect on 02.02.2019.

EASIN has conducted a thorough review of the existing scientific literature on the 11 species considered in this exercise, gathering spatial data and recently updating the geodatabase crawling data from the EASIN network of data partners. The set of data submitted to each MS represents therefore the best of knowledge available.

MS have been invited by DG ENV to actively get involved in the compilation of the baseline distribution of the species included in the 1st update of IAS of Union concern through EASIN, by evaluating and amending the data received from EASIN.

Baseline check

MS are invited to check the EASIN records of each species listed in the 1st update of the list of IAS of Union concern in their territory, and to provide revisions and/or updates. For each MS the EASIN team has prepared an Excel file (including the distribution of each IAS at Country level and at Grid 10x10 km level) and a shapefile (including the distribution of each IAS at Grid 10x10 km level). MS can decide to check and revise the data at Grid 10x10 km level using either Excel tables or GIS files.

EASIN records refer to occurrences, which means that a species is either:

- a) established (reproducing in the wild and forming self-sustaining populations) or
- b) casual (few sporadic records and/or not reproducing in the wild and/or not overwintering).

Scientific and technical issues

For the purpose of the current exercise the following criteria apply:

- Casual records (occasional, rare records, species not reproducing in the wild and/or not overwintering), should be included in the baseline distribution (country level check), but with an indication of "casual status" (using the "*").
- Historical records should be excluded from the baseline. The baseline should reflect the current distribution of the species in each MS. Therefore, excluding "historical records", i.e. species that are not currently present within their territory.
- Eradicated species, i.e. species which have been recently eradicated from a country territory should be excluded from the current baseline.

The baseline check should take place under 2 distinct phases:

- Country level check
- Grid 10x10 km level check.

a) Country level check

MS are invited to check the "EASIN Country level" sheet in the Excel file (Figure 1) which contains the information regarding the presence of each IAS of Union concern in the MS territory at Country level. MS are invited to provide revisions and/or updates of the data accepting or not the information provided by EASIN, and in the latter case providing further explanations supported by appropriate references.

NB. Species considered as "casual" at Country level should be marked with an *.

A	B	C	D	E	F
Union Concern IAS	Present in the EASIN Country-level map	EASIN reference(s)	EASIN reference(s) URL	Accept EASIN country-level map for your Country. Choose YES/NO	Remarks. In case you choose "NO" please explain, citing appropriate reference(s).
<i>Alouatta palliata</i>	YES	Gymesi & Lencik, 2010	http://www.buwa.nl/fileadmin/buwa_upload/Bureau_Waardenburg_rapporten/09-817_Egyptian_Goose_final_draft_30-09-2010_web.pdf		
<i>Albizia julibrissin</i>	NO				
<i>Asclepias syriaca</i>	YES	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a9d0-f176599318b		
<i>Elodea nuttallii</i>	YES	BioFresh Naturalis Biodiversity Center Thébaud and Di Nino, 2009 Dutch Foundation for Applied Water Research BeBIF Provider Allerra, Wageningen UR Research Institute for Nature and Forest (INBO) Segers and Branquart, 2010	http://www.gbif.org/publisher/8b726075-9ab5-4e27-b6c6-5ad486890279 http://www.gbif.org/publisher/396d5f30-dea9-11db-8a4-b6a03c50a8e2 http://www.aquaticinvasions.net/2009/AI_2009_4_2_Thebaud_DiNino.pdf http://www.gbif.org/publisher/88a216ee-f721-40cd-932c-84133af99451 http://www.gbif.org/publisher/37e62b90-1e21-11de-ab90-f72009d2669b http://www.gbif.org/publisher/2498d55c-dcd2-4caf-ab77-14f2ffe05c32 http://www.gbif.org/publisher/1cd669d0-80ea-11de-a9d0-f176599318b https://doi.org/10.1016/j.ecolman.2010.06.001		
<i>Castanea tectoria</i>	NO				
<i>Heracleum mantegazzianum</i>	YES	BeBIF Provider Research Institute for Nature and Forest (INBO) Halford et al., 2011 Musée national d'histoire naturelle Luxembourg	http://www.gbif.org/publisher/37e62b90-1e21-11de-ab90-f72009d2669b http://www.gbif.org/publisher/1cd669d0-80ea-11de-a9d0-f176599318b https://doi.org/10.1016/j.ppees.2011.06.001 http://www.gbif.org/publisher/7942979b-8855-11de-8235-b8a03c50a8e2		
<i>Impatiens glandulifera</i>	YES	Dutch Foundation for Applied Water Research Hagenblad et al., 2015 Council of Heads of Australasian Herbaria (CHAH) Research Institute for Nature and Forest (INBO) Allerra, Wageningen UR Cawoy et al., 2012 Naturalis.nl.nz	http://www.gbif.org/publisher/88a216ee-f721-40cd-932c-84133af99451 http://bmceconet.biomedcentral.com/articles/10.1186/s12863-015-0242-8 http://www.gbif.org/publisher/d76e0928-5a2f-44e8-8509-139a88938b4d http://www.gbif.org/publisher/1cd669d0-80ea-11de-a9d0-f176599318b http://www.gbif.org/publisher/2498d55c-dcd2-4caf-ab77-14f2ffe05c32 http://www.pollinationecology.org/index.php?journal=ipe&page=article&openview&path%5B%5D=203 https://www.naturalis.nl/nz		

Figure 1. Example of an Excel sheet for the Country level check. MS are invited to check the information and fill-in the columns "E" and "F".

b) Grid 10x10 km level check

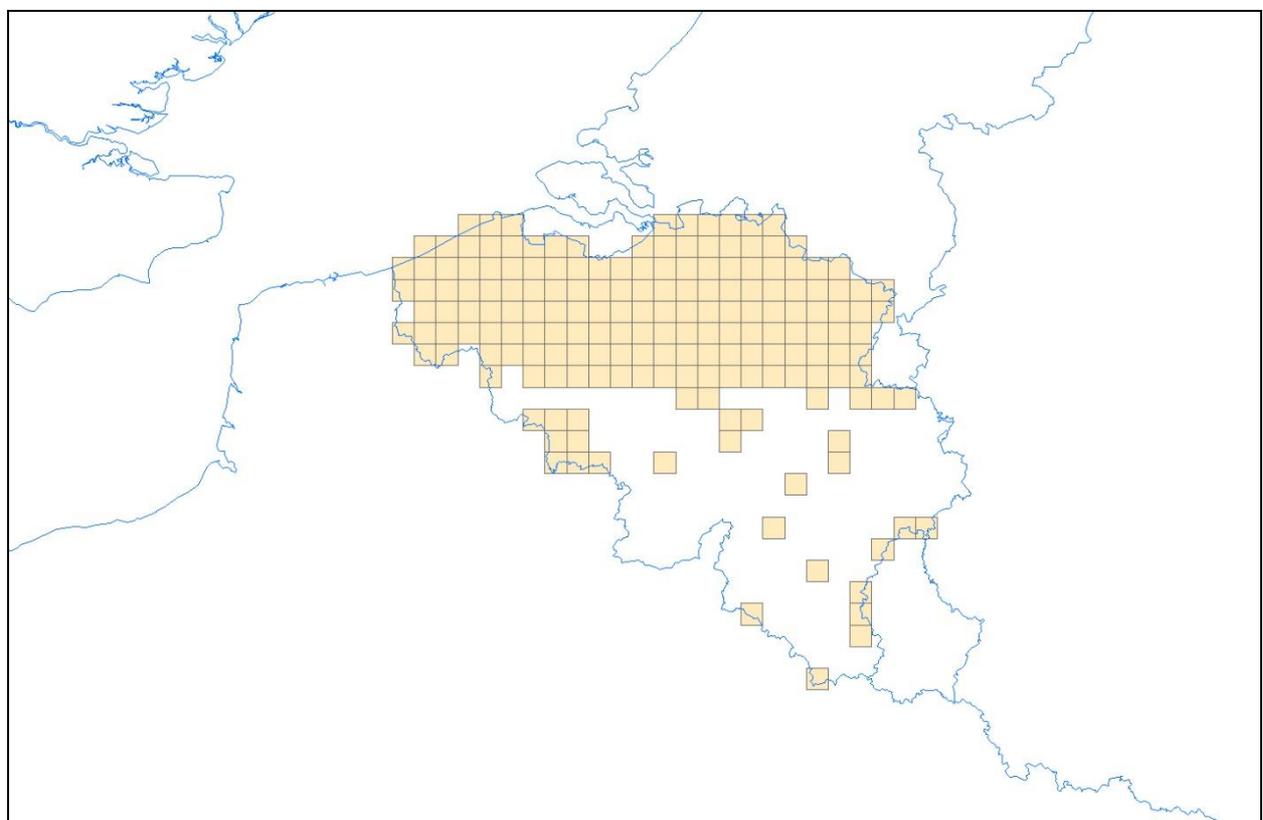
MS are invited to check the "EASIN Grid 10Km level" sheet of the Excel file (Figure 2) or the shapefile (Figure 3). The Excel file and the shapefile contain the information regarding the presence of each IAS of Union concern in the MS territory at Grid 10x10 km level. The Grid 10x10 km level corresponds to the 10 km resolution level of the EEA reference grid. Each cell of the EEA reference grid has a unique identifier, which is referred in the column as "Cell Code" of the Excel sheet. MS can alternatively use the

Excel file or the shapefile for checking and providing revisions and/or updates of the EASIN data, including the addition of new occurrences.

MS are invited to provide revisions and/or updates of the data accepting or not the information provided by EASIN and in the latter case providing further explanations supported by appropriate references.

A	B	C	D	E	F	G
Union Concern IAS	Cell Code (EEA Reference Grid 10Km)	EASIN Data Partner	EASIN Reference Name	EASIN Reference Url	Accept EASIN record for your Country, choose YES/NO	Remarks. In case you choose "NO" please explain, citing appropriate reference(s).
Alopochen aegyptiaca	10kmE403N301	EASIN-Lit	Konter and Lorgé, 2009	http://goo.gl/DX4ia0		
Asclepias syriaca	10kmE380N312	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Asclepias syriaca	10kmE393N314	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Asclepias syriaca	10kmE395N311	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Asclepias syriaca	10kmE396N313	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE380N313	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE381N309	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE381N311	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE381N312	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE382N310	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE382N312	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE382N314	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE383N313	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE383N314	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE383N315	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE384N308	GBIF	SPN - Service du Patrimoine naturel, Muséum national d'Histoire naturelle, Paris	http://www.gbif.org/publisher/1928bd0f-f5d2-11d4-8c12-b8a03c50a862		
Elodea nuttallii	10kmE384N310	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE384N311	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE384N314	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		
Elodea nuttallii	10kmE384N315	GBIF	Research Institute for Nature and Forest (INBO)	http://www.gbif.org/publisher/1cd669d0-80ea-11de-a900-1f765f9f18b		

Figure 2. Example of an Excel information for the grid 10x10 km level check. MS are invited to check the information and fill-in the columns "F" and "G".



Annex II. Detailed spatial information at grid level 10x10 km as well as original sources are provided for each species listed in the 1st update of IAS of Union concern and for each EU country through ARC GIS digital files.

Important Note: Due to the huge number of ARC GIS files, the information is directly provided through a web-link in the EASIN website (<https://easin.jrc.ec.europa.eu/>).

The related information is also available on request by the EASIN team (jrc-easin@ec.europa.eu).

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