NeoBiota 52: 47–86 (2019)
doi: 10.3897/neobiota.52.38113
http://neobiota.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

Horizon scanning to identify invasion risk of ornamental plants marketed in Spain

Álvaro Bayón[1], Montserrat Vilà[1]

1 *Estación Biológica de Doñana (EBD-CSIC), Avda. Américo Vespucio 26, Isla de la Cartuja, 41092 Sevilla, Spain*

Corresponding author: *Álvaro Bayón* (alvarobayon@gmail.com)

Academic editor: *Philip Hulme* | Received 9 July 2019 | Accepted 8 October 2019 | Published 11 November 2019

Citation: Bayón Á, Vilà M (2019) Horizon scanning to identify invasion risk of ornamental plants marketed in Spain. NeoBiota 52: 47–86. https://doi.org/10.3897/neobiota.52.38113

Abstract

Horticulture is one of the main pathways of deliberate introduction of non-native plants, some of which might become invasive. Of the 914 commercial ornamental outdoor plant species sold in Spain, 700 (77%) are non-native (archaeophytes excluded) marketed species. We classified these into six different lists based on their invasion status in Spain and elsewhere, their climatic suitability in Spain and their potential environmental and socioeconomic impacts. We found sufficient information for 270 species. We provide a Priority List of eight regulated invasive species that were still available on the market. We also established an Attention List with 68 non-regulated invasive and potentially invasive species that might cause various impacts. To prioritise the species within the Attention List, we further assessed the risk of invasion of these species by using an adaptation of the Australian WRA protocol and the level of societal interest estimated from values of the Google Trends tool. We also propose a Green List of seven species with probably no potential to become invasive, a Watch List with 27 potentially invasive species with few potential impacts and an Uncertainty List with 161 species of known status but with insufficient information to include them in any of the previous lists. We did not find sufficient information for 430 (61%) of the marketed non-native plant species, which were compiled into a Data Deficient List. Our findings of prohibited species for sale highlight the need for stronger enforcement of the regulations on invasive plant species in Spain. In addition, our results highlight the need for additional information on potential impacts and climate suitability of horticultural plants being sold in Spain, as insufficient information could be found to assess the invasion risk for most species.

Keywords

e-commerce, Google trends, horizon-scanning, impact assessment, non-native plants, nursery, priority list, risk assessment

Introduction

The introduction of invasive non-native species by humans may be accidental – for example seed crops as contaminants amongst cargo – or deliberate (Mack et al. 2000), such as the introduction of species used in forestry, aquaculture and horticulture. In particular, the sale of ornamental plants, including sale by nurseries, is the main deliberate pathway for plant invasions (Van Kleunen et al. 2018) which includes some of the most harmful invasive plant species in the wild (Hulme 2007).

There is a close relationship between domestic market-based propagule pressure and invasion success (Dehnen-Schmutz et al. 2007a; Johnston et al. 2009; Blackburn et al. 2013; García-Díaz et al. 2015). Horticulture activities reduce biotic and abiotic stresses on plants, bring species of different geographic origin together and increase the likelihood that plants escape into the wild (Niinemets and Peñuelas 2008). Moreover, introduction biases, or preferences for non-native species that perform better than natives (Chrobock et al. 2011), include plants that have increased germination rates, faster and larger growth and higher fecundity than native plants (Chrobock et al. 2011; Parker et al. 2013; Maurel et al. 2016). Therefore, the commercial use of non-native ornamental plant species is not only important as the main pathway of introduction (Hulme 2007), but it also favours the invasion potential of these plants and their impacts. In fact, in less than 20 years on the market, some non-native species can become invasive (Pemberton and Liu 2009).

The most effective way to manage the impacts of non-native species is through prevention (Convention on Biological Diversity 2010). In the last two decades, there has been great progress in developing risk assessment protocols as an essential management component to identify potentially invasive species (Pheloung et al. 1999; Leung et al. 2012; Roy et al. 2014, 2015). Most of these risk assessments are used to rank non-native species according to their probability of becoming established and causing harm. Horizon-scanning of invasive species is a particular type of rapid screening risk analysis based on the systematic examination of future potential threats, leading to the prioritisation of non-native species for further investigation (Roy et al. 2014). Horizon-scanning has been applied when prioritisation identifies a small fraction of species selected from a large list of scanned species, for which a thorough risk analysis is not feasible in a short period of time (Andreu and Vilà 2010; Roy et al. 2015; Roy et al. 2019). This is the case, for example, for testing the invasion risk of all ornamental plants commercialised within a country because the number of non-native plant taxa sold is very high.

A parsimonious way to perform a horizon-scanning analysis for ornamental plants is to use four of the most widely used criteria to identify potentially invasive species: climate matching, being invasive elsewhere, their potential impacts on the environment and their impacts on socioeconomic activities (Weber and Gut 2004; Otfinowski et al. 2007, Gassó et al. 2010; Blackburn et al. 2014; Roy et al. 2014).

As the number of non-native species being used as ornamentals is very high, but resources are limited to manage them all in the same way, it is necessary to create prioritisation lists of plant species identifying those that are (1) regulated invasive but still

commercialised, (2) potentially invasive with the risk of causing numerous impacts, (3) potentially invasive with few potential impacts, (4) probably safe because there is no potential to establish in the wild and (5) those for which there is insufficient information to classify them by their risk of invasion and impact (Dehnen-Schmutz 2011). This coarse screening is the basis for prioritising the potentially most invasive species and to later perform a more detailed risk assessment (Pheloung et al. 1999; Weber and Gut 2004; Andreu and Vilà 2010; Gassó et al. 2010), as well as for proposing a list of the least harmful species (Gederas et al. 2012).

Since many regulations expressly prohibit the commercialisation of listed species, it is expected that none of them is sold. However, regulation is not always effective, especially for the online plant trade (Humair et al. 2015). In fact, many nurseries continue to stock and supply invasive regulated species (Wirth et al. 2004; Cronin et al. 2017). In addition, nowadays most of the nurseries offer internet purchasing. This model of commerce is currently one of the most important sources of gardening plants (Humair et al. 2015). The online plant trade significantly increases transportation distance and propagule pressure of non-native species (Walters et al. 2006; Lenda et al. 2014; Humair et al. 2015). As an innovative approach, the Google Trends tool can be used to forecast consumption and commerce, which is a valuable source of information (Vosen and Schmidt 2011). Therefore, the level of interest in each ornamental species measured by Google Trends can provide information on the interest for a particular species by society in general. Google Trends provides information on how frequently a keyword or group of keywords has been searched for on the Internet. Resulting data are not necessarily composed of only people interested in buying the plant. In fact, it is possible that some of these searches are performed because they are looking for ways to control or manage already invasive species. In our study, we used Google Trends data to assess "popularity" or "interest", defined in a broad sense, as the data do not allow distinguishing whether plant name searches were motivated by Internet users' positive or negative views of a plant.

To our knowledge, this tool has not yet been used for the prevention of biological invasions.

In this paper, we perform a horizon-scanning analysis of the 914 commercial ornamental outdoor plant species in Spain from a total of 1063 taxa to facilitate policy implementation. The main aim is to generate six species lists based on their regulation and invasive status in Spain and elsewhere, climate matching between their native region and Spain, the magnitude of the environmental and socioeconomic impacts they might cause and their societal interest (Fig. 1):

- A Priority List that includes regulated (by Spain or the EU) invasive non-native species that were still commercially available in the Spanish peninsular territory (Spain, hereafter).
- An Attention List that includes climatically suitable non-regulated invasive in Spain and potentially invasive species (i.e. invasive elsewhere) with many potential impacts.
- A Watch List that includes climatically suitable non-regulated invasive in Spain and potentially invasive species (i.e. invasive elsewhere) with few potential impacts.

- A Green List that includes species with no climatic suitability and probably no potential to be invasive in Spain.
- An Uncertainty List that includes non-invasive species with probably no potential to be invasive that do not meet the requirements to be included in the Green List. It also includes species with known invasion status but with insufficient information available on impacts and non-native species with known invasion status but with insufficient information on climatic suitability or invasiveness elsewhere.
- A Data Deficient List with all the non-native species with no information about their invasion status and not enough data to classify them in any other list.

To rank the species of the Attention List, we conducted an in-depth analysis based on their risk of invasion and societal interest. The risk of invasion was scored according to the Australian weed risk assessment performed by Pheloung et al. (WRA 1999). This WRA protocol has been tested successfully for its consistent accuracy in different geographic regions (Gordon et al. 2008) including Spain (Gassó et al. 2010). Societal interest in non-native species was measured using Google Trends. We wanted to answer the following questions: Does the risk of invasion and interest to society grow across the different invasion status groups of species currently in Spain (i.e. not in the wild, casual, naturalised and invasive)? Does the number of potential environmental and socioeconomic impacts rise with increasing invasion status. Moreover, for each non-native species, we calculated a Priority Index based on the impacts, WRA score and interest of the species. We tested if the Priority Index increased with increasing invasion status of the species.

Material and methods

We compiled a database including the vast majority of ornamental outdoor plants with commercial use in gardening in the Spanish peninsular territory excluding the Canary and Balearic Islands (Spain, hereafter). We also included indoor plants that can survive and/or reproduce outdoors. However, we excluded strictly indoor plants because their ecological requirements might prevent survival outdoors. We included fruit trees as they are of ornamental use in public and private gardens and green areas, but we excluded vegetables used in horticulture. The list of taxa was compiled through the systematic consultation of catalogues from the 21 main Spanish nurseries (Appendix 1) between December 2015 and October 2016, which provide plants for sale across the country. The number of new taxa added to the database (Appendix 1) did not increase at all after the 15th nursery catalogue was consulted. The total number of taxa compiled was 1036, of which 914 were actual species. Hybrids or genus level taxa were not included in the analysis and infraspecific taxa were pooled into species.

According to their origin, we first discriminated between native species and non-native species in Spain. We then identified archaeophytes (i.e. species introduced be-

fore 1500 A.D.), following Pyšek et al. (2004). Archaeophytes were not included in the analysis because they are poorly recorded and, for many species, their non-native status is under discussion.

Species were further classified according to their invasion status in Spain, following the definitions recommended by Richardson et al. (2000): not in the wild, casual, established or naturalised (hereafter "naturalised"), invasive non-regulated in Spain or Europe (hereafter "invasive") or invasive regulated in Spain or Europe (hereafter "regulated"). Invasion status in Spain, as not in the wild, casual, naturalised or invasive, was based on the information provided in the Spanish Atlas of Invasive Non-native Plants (Sanz Elorza et al. 2004). The regulation status of the species, that in Spain involves the ban of possession, transport and commerce of living beings and propagules, was based on the Spanish Catalogue of Non-native Invasive Species (BOE 2013) and the List of Invasive Alien Species of Union Concern (European Commission 2016, 2017).

Once the non-native species were classified into these five invasion status groups (i.e. regulated invasive, invasive, naturalised, casual, not in the wild), we proceeded to perform the horizon-scanning to classify the species into the respective lists based on the flow diagram illustrated in Fig. 1 as follows:

All Regulated species were directly included in the Priority List, whereas invasive species were considered for impact assessment (see method below).

Naturalised species were identified as invasive elsewhere, based on the CABI Datasheets (2018) and the Global Invasive Species Database (Invasive Species Specialist Group 2015). Naturalised species that are invasive elsewhere were regarded as potentially invasive species and were considered for impact assessment. Naturalised species not invasive elsewhere were included in the Uncertainty List.

Casual and not in the wild species were screened for climatic suitability in Spain (see method below). For species climatically suitable somewhere in the country, with a medium to high level of confidence in the likelihood, we checked whether they were invasive elsewhere (Roy et al. 2014). Species that were not climatically suitable and not registered as invasive elsewhere, were included in the Green List (Dehnen-Schmutz 2011), commonly known as the "*white list"* by decision-makers. In contrast, species that were climatically suitable and were invasive elsewhere were regarded as potentially invasive species and thus considered for impact assessment. On the other hand, species that were climatically suitable but not invasive elsewhere and species that were invasive elsewhere but not climatically suitable were included in the Uncertainty List.

Finally, all the species naturalised or casual in Spain, for which we could not find sufficient data about being invasive elsewhere and those for which we have a low level of confidence in the likelihood of climatic suitability or no data at all, were included in the Uncertainty List. This list also includes species not in the wild that are invasive elsewhere rather than Spain, species that are not climatic suitable or species in which the level of confidence in the likelihood of climatic suitability is very low.

In contrast, the Data deficient list includes species not in the wild, with no data on status elsewhere and on climate suitability.

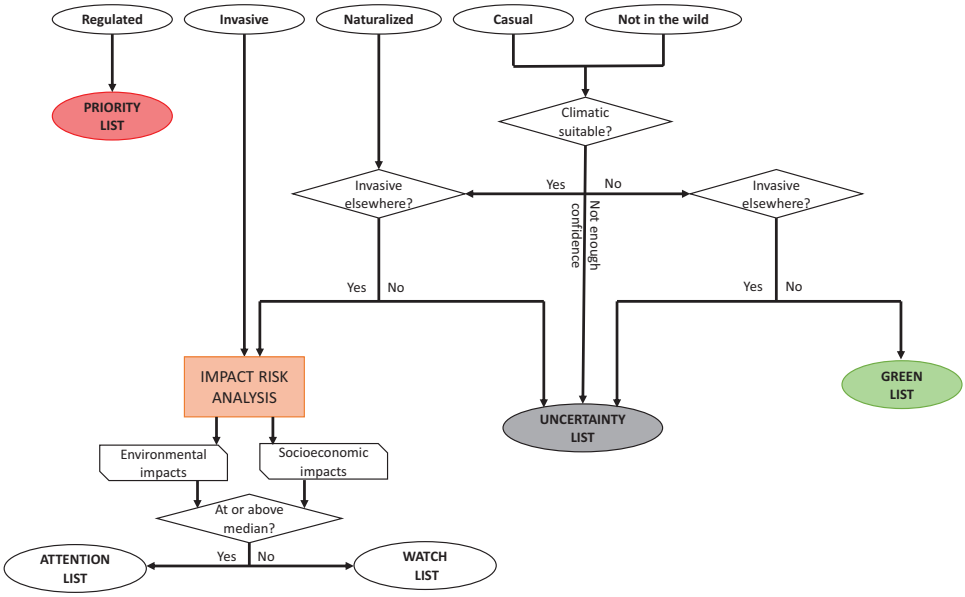


Figure 1. Flow diagram of horizon-scanning of commercial ornamental non-native plant species in Spain and their classification into respective lists. Colour codes correspond to those in Table 1.

Climatic suitability

The climate in Spain is a mosaic of three main climates: Oceanic in the NW, Mediterranean continental in the centre and Mediterranean maritime in the E and S of the country including semi-arid areas (Ninyerola et al. 2005). Furthermore, Spain is a mountainous country, in which elevations over 1500 m a.s.l. are common and the highest peak rises to 3480 m a.s.l. Mountainous areas impose sharp topographical-climatic gradients where these three climatic types gradually change to a Mountain climate, characterised by cold, strong winds and abundant rainfall or snowfall. We know from previous regional analyses that the establishment of non-native species is enhanced in mesic conditions (i.e. intermediate temperature and moisture levels), such as those close to coastal areas (Gassó et al. 2009, González-Moreno et al. 2014).

Precipitation was not considered as a criterion for climatic suitability because Spain has a wide rainfall range. Since our analysis is not spatially explicit, at the regional scale, there are suitable conditions for non-native species to establish and spread (González-Moreno et al. 2014). According to AEMET (2016), the town with the highest rainfall is Vigo (NW Spain), with an average of 1790 mm per year. The climatic station registering the lowest amount is Almería (SE Spain), with an average of 200 mm per year. Therefore, due to this wide range of rainfall in our study area, we did not consider tolerance to drought or waterlogging as climatic classification criteria for the risk of invasion at the country scale.

To follow the precautionary principle, our criteria on temperature suitability were based on the highest absolute minimum and the highest mean of the minimum in the coldest month. This implies that there are many territories in Spain that, having lower

minimum temperatures than the threshold chosen, will be less susceptible to invasion by the species of concern. In this way, we minimise the false negatives that may arise. Thus, we considered a plant to have climatic suitability to survive in Spain if it met two temperature criteria: (1) it can tolerate temperatures below the highest historical absolute minimum temperature in Spain, which was 0.2 °C in Almería (9 February 1935); and (2) it can tolerate temperatures below the highest mean minimum temperature in the coldest month in Spain, which in Tarifa is January at 10.8 °C (mean recorded from data between 1981 to 2010) (AEMET 2016). The air temperature tolerance for each species was consulted in the CABI Invasive Species Compendium (2018).

The level of confidence in the likelihood of climatic suitability was based on the quality of information available. A high level of confidence was assigned if both air temperature values were available; a medium level of confidence was assigned if only one of the temperature values was available but there was information on the species being naturalised or not elsewhere with similar climatic conditions to those in Spain (i.e. Mediterranean or temperate climate); and a low level of confidence was assigned if only one of the temperature values was available or if the species was naturalised or not elsewhere with similar climatic conditions to those in Spain.

Impact assessment

There are different ways to rate impacts in risk assessments. Some are based on their significance and intensity, some on the number of impacts (see table 3 in Vilà et al. 2019). To quantify the intensity of impacts requires a throughout screening of all the scientific literature, an aim that was above our man-power capacity. As we had many species to assess and our approach is by Horizon-scanning, we identified a broad range of potential impact types, including socioeconomic impacts. For each invasive or potentially invasive species, we assigned binary scores (yes/no) to the 11 potential impact mechanisms on the environment, following Blackburn et al. (2014): competition, hybridisation, disease transmission, parasitism, poisoning, toxicity and allelopathy, biofouling, interaction with other invasive non-native species, nutrient cycling, physical modification of the habitat, natural succession and disruption to food webs. We also included potential impacts on four socioeconomic aspects: human health (such as allergenic pollen), infrastructures, agriculture and forestry and other sectors (e.g. livestock, domestic animals). The vast majority of the data concerning impacts was retrieved from the CABI Invasive Species Compendium (2018). For cases in which the CABI compendium did not provide sufficient information, the Global Invasive Species Database (Invasive Species Specialist Group 2015) was consulted. Information on pollen allergenicity was found in the Allergome database (Mari et al. 2009).

We compared the numeric results of potential environmental (0–11) and socioeconomic (0–4) impacts between the different invasion status groups of non-native species (i.e. not in the wild, casual, naturalised and invasive). We used R software to perform a multiple comparison using Tukey's range test, fitted in the generalised linear model (glm) by quasi-Poisson regression.

We consider median values for both environmental and socioeconomic impacts as the threshold for the classification between species with a high and low number of impacts. Species with environmental or socioeconomic impacts at or above the thresholds were included in the Attention List, while species with both environmental and socioeconomic impacts below the threshold formed the Watch List.

Societal interest analysis of Attention List species

Google is currently the most popular information search engine (Purcell et al. 2012) and it is quite useful for forecasting consumption and commerce (Vosen and Schmidt 2011). Google Trends (http://trends.google.es) has turned out to be a valuable tool to measure the level of interest of internet users on topics, species, events, questions etc., based on keywords and thus it has already been applied for this purpose in other research (Vosen and Schmidt 2011, Burivalova et al. 2018). Google Trends provides monthly data in a defined temporal range of regional trends of five keywords at a time, always relative to the highest value which is set to 100. We used Google Trends to analyse the level of interest of Spanish users in the Attention List species. We are aware that a species ranking high in interest does not necessarily mean that users are more interested in purchasing them. The reasons behind the searches for these species are not known, but they indicate how popular the species are in society in general.

To standardise those relative values, we used the R pack "gtrendsR" v. 1.4.2. We first made a systematic examination of the scientific names of every species listed in the Attention List in the temporal range from January 2004 to December 2016 to identify the species with the highest trend value. We used the scientific names to standardise our search; some species consulted do not have vernacular names in Spanish and some others may have different names. As the Google Trends tool allows entering 5 keywords at a time, we carried out a first examination forming one initial group of five species to analyse and taking the highest value species in this first group. Then, we compared this highest ranked species with the next four species and again selected the species with the highest value in this new group. Systematically repeating this algorithm with the rest of the species allowed us to identify the species with the highest trend value, *Robinia pseudoacacia*. The highest value for this species is set equal to 100 and this was assigned as our control species. Then, in a second systematic consultation of Google Trends, we obtained the trend data for the rest of the species by comparing each one with the control, in order to standardise the values.

For each species, we obtained a standard trend value (STV) as the highest value of the monthly trend in the complete temporal range of each species, relative to the optimal value of 100 of the control species. After that, we also performed a systematic consultation of Google Trends for the species in the Green List and the Priority List.

We compared differences in STV of the Attention List species across the different invasion status groups of species within the list (i.e. not in the wild, casual, naturalised

and invasive). We used R software to perform a multiple comparison using Tukey's range test, fitted in the generalised linear model (glm) by quasi-Poisson regression. We also compared the STV of the species in the Priority list and the Green list, in order to check whether the STV index correlates with invasion itself.

Invasion risk assessment of Attention List species

We used an adaptation of the invasion risk assessment (WRA) protocol (Pheloung et al. 1999) for Spain (Gassó et al. 2010) in order to rank the species in the Attention list. The WRA scores range from –14 (benign species) to 29 (maximum risk). Three levels of invasion risk were considered: rejected, species likely to be high risk (score > 6); accepted, species with a low score (< 1); and species that need further evaluation, those with intermediate scores (1–6).

We compared the scores of the WRA of the Attention List species across the different invasion status groups of species within the list (i.e. not in the wild, casual, naturalised and invasive). We used R software to perform a multiple comparison using Tukey's range test, fitted in the generalised linear model (glm) by quasi-Poisson regression.

Prioritisation of Attention List species

We calculated a Priority Index for each species in the Attention list based on impact assessment, WRA score and STV according to the following equation:

$$PI_i = \left(\frac{100 \times E_i}{11} + \frac{100 \times S_i}{4} + \frac{100 \times WRA_i}{29} + STV_i \right) / 4$$

where: PI_i = Priority Index for species *i*; E_i = number of environmental impacts for species *i*; S_i = number of socioeconomic impacts for species *i*; WRA_i = Weed Risk Assessment score for species *i*; STV_i = Standard Trend Value for species *i*.

The impact factors were relative to the 11 environmental and 4 socioeconomic impacts which represent the maximum possible impacts in the assessment. The WRA-factor was relative to 29, which is the maximum possible value in the WRA protocol. The STV is already represented as a percentage and thus no conversion is needed.

Within each invasion status group, we listed species in decreasing order of their Priority Index and highlighted those with a Priority Index at or above the median.

Data resources

The data underpinning the analysis, reported in this paper, are deposited in the Zenodo repository at https://doi.org/10.5281/zenodo.3367257 (Bayon and Vilà 2019).

Results

Of the 914 taxa identified to species, 199 were native to Spain and 15 were archaeophytes. Of the 700 remaining non-native species, we did not find sufficient information on invasion status, climatic suitability or invasiveness elsewhere for 430 species (Data deficient list; Appendix 4) in the consulted databases (Invasive Species Specialist Group 2015; CABI 2018). For the remaining 270 non-native species, 71 taxa were not in the wild, 99 were casual, 70 naturalised and 30 invasive in Spain. Of the invasive species in Spain, eight are regulated by the Spanish Catalogue of Non-native Invasive Species (BOE 2013) and one of them, *Pennisetum setaceum*, is also regulated by the List of Invasive Alien Species of Union Concern (2016, 2017).

Nineteen species not in the wild, 30 casual and 24 naturalised species are climatically suitable and invasive elsewhere and thus considered potential invaders. These species, in addition to the 22 already invasive non-regulated species, were assessed for impact (Table 1).

Impact Assessment

We assessed the potential impact of the above-mentioned 19 not in the wild, 30 casual, 24 naturalised and 22 invasive species that are climatically suitable and invasive elsewhere. The global median value for environmental impacts was three and the median for socioeconomic impacts was one. Therefore, species with impacts at or above these values were included in the Attention List. This included eleven not in the wild (58%), 22 casual (73%), 20 naturalised (83%) and 15 invasive species (68%). We did not find significant differences in the number of environmental or socioeconomic impacts across any pair of species status groups (Fig. 2).

Within each invasion status, the species with the highest number of environmental impacts included the invasive *Robinia pseudoacacia* (7), *Agave sisalana* (6) and *Elaeagnus angustifolia* (6); the naturalised *Ficus pumila* (7), *Ficus rubiginosa* (6), *Lupinus polyphyllus* (6) and *Sansevieria trifasciata* (6); the casual *Wisteria sinensis* (8) and *Grevillea robusta* (7); and the not in the wild *Nymphaea odorata* (7).

Species with the highest number of socioeconomic impacts were the invasive *Robinia pseudoacacia* (3), *Acacia longifolia* (3), *Eucalyptus globulus (*3) and *Lantana camara* (3); the naturalised *Lupinus polyphyllus* (3), *Rhus typhina* (3) and *Tagetes minuta* (3); the casual *Miscanthus sinensis* (3), *Portulaca oleracea* (3) and *Sesbania punicea* (3); and the not in the wild *Allamanda cathartica* (3).

Species listing

The 270 non-native species with available data were classified into the following five lists:

The Priority List contains eight regulated invasive species that were still commercially available in nurseries (Table 2).

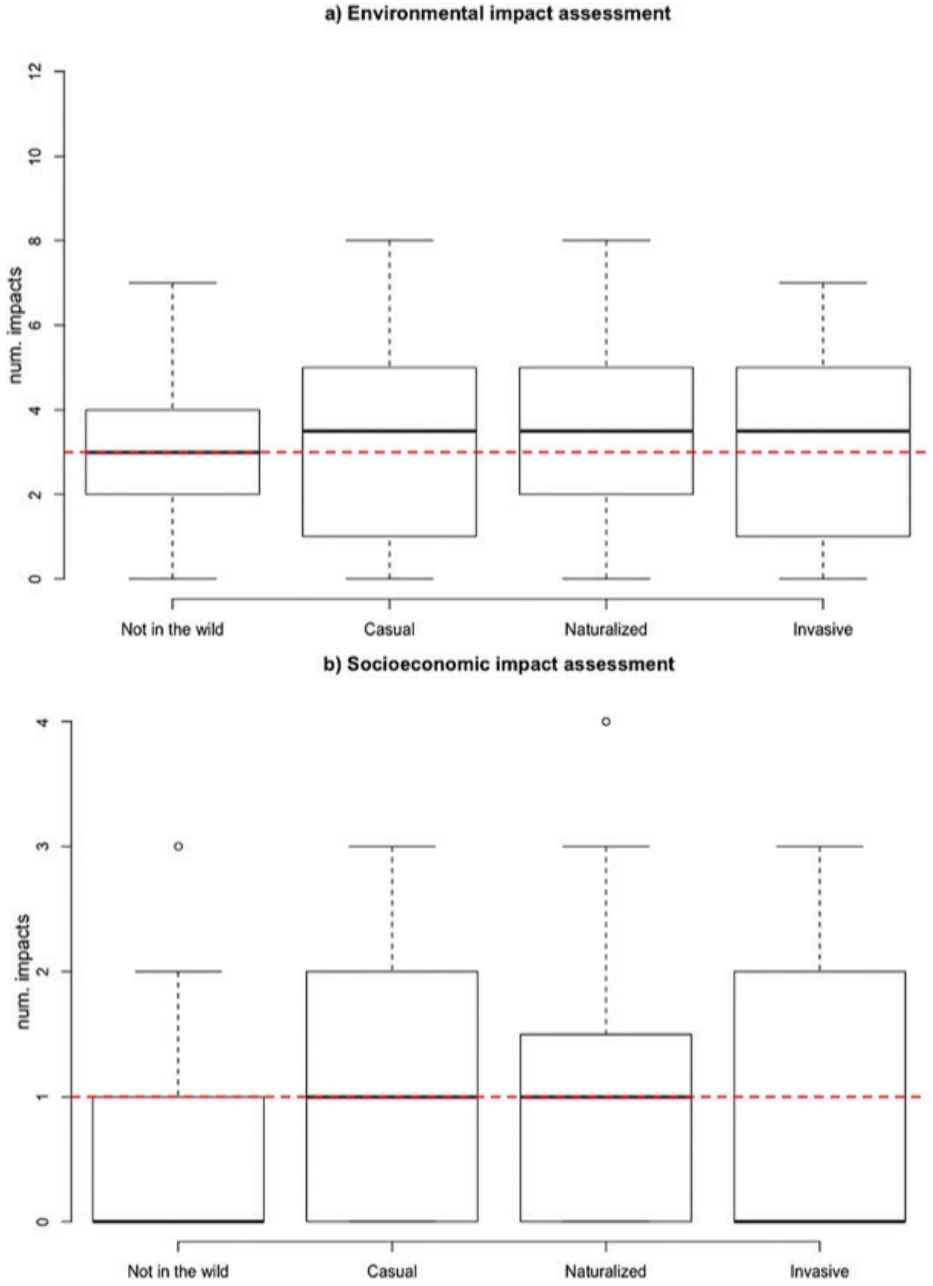


Figure 2. Environmental (a) and socioeconomic (b) impacts of invasive and potentially invasive ornamental plant species. P-values for Tukey's range tests for environmental impacts: not in the wild – casual: p = 0.833; not in the wild – naturalised: p = 0.498; not in the wild – invasive: p = 0.926; casual – naturalised: p = 0.904; casual – invasive: p = 0.997; naturalised – invasive: p = 0.845. P-values for Tukey's range tests for socioeconomic impacts: not in the wild – casual: p = 0.790; not in the wild – naturalised: p = 0.526; not in the wild – invasive: p = 0.916; casual – naturalised: p = 0.947; casual – invasive: p = 0.994; naturalised – invasive: p = 0.875. Dashed red line represents the global median of impacts and the threshold for species in the Attention List (at and above the line, Table 3) and Watch List (below the line, Appendix 2)

Table 1. Classification of commercial ornamental plant taxa in Spain according to their invasion status and climatic suitability. Colour codes correspond to those in Fig 1: Priority List (red, Table 2), Impact Risk Analysis (orange), Green List (green, Table 4) and Uncertainty List (grey, Appendix 3).

	N	Climatic suitable	Not Climatic suitable	Low confidence in likelihood on climatic suitability	Not enough information about climatic suitability	Invasive elsewhere	Not invasive elsewhere
Total taxa in nurseries	1036						
Taxa excluded	122						
Total species listed	914						
Native	199						
Archeophyte	15						
Non-native (non-archeophyte)	700						
Invasive – Regulated	8						
Invasive – Not Regulated	22						
Naturalised	70					24	46
Casual	100	36	2	4	58		
Casual – Climatic Suitable						30	6
Casual – Not Climatic Suitable						1	1
Not in the wild	71	34	10	27			
Not in the wild – Climatic Suitable						19	15
Not in the wild – Not Climatic Suitable						4	6
Data deficient	430						

Table 2. Priority List. Includes invasive species regulated by the Spanish Catalogue of Non-native Invasive Species (BOE 2013) or the List of Invasive Alien Species of Union Concern (European Commission 2016, 2017). Native distribution: Afr: Africa; As: Asia (Temperate); Aus: Australia; NAm: North America; SAm: South and Central America.

Species	Family	Native distribution	Regulated in Spain	Regulated in EU
Acacia dealbata	Fabaceae	Aus	Yes	No
Agave americana	Agavaceae	SAm	Yes	No
Ailanthus altissima	Simarubaceae	As	Yes	No
Buddleja davidii	Scrophulariaceae	As	Yes	No
Cortaderia selloana	Poaceae	SAm	Yes	No
Opuntia ficus-indica	Cactaceae	NAm	Yes	No
Pennisetum setaceum	**Poaceae**	**Afr**	**Yes**	**Yes**
Tradescantia fluminensis	Commelinaceae	SAm	Yes	No

The Attention List (Table 3) is composed of 68 species, including 11 not in the wild, 22 casual, 20 naturalised and 15 invasive.

The Watch List contains 27 species: eight not in the wild, eight casual, four naturalised and seven invasive, but below the threshold for environmental and socioeconomic impacts (Appendix 2).

The Green List is represented by only seven species: one casual and six not in the wild taxa that are not climatically suitable nor invasive elsewhere (Table 4). Finally, the Uncertainty List was formed by 161 species, in which: 46 are not in the wild (27 with low confidence on climatic suitability, 15 not invasive elsewhere but climatically

Table 3. Attention List. Includes all invasive and potentially invasive species with ≥ 3 environmental or ≥ 1 socio-economic potential impacts, classified as: a) not in the wild, b) casual, c) naturalised and d) invasive species, presented in decreasing Priority Index order. Native distribution: Afr: Africa; As: Asia (Temperate); AT: Asia (Tropical); Aus: Australia; Eur: Europe; NAm: North America; Pac: Pacific; SAm: South and Central America. Weed Risk Assessment (WRA): scores 1–6 indicate that the species needs further evaluation; scores > 6 indicate that the species is rejected. STV: Standard Trend Value (0-100). Priority Index is calculated following the equation: Priority index = ((100×*Ei*) / 11 + (100×*Si*) / 4 + (100×*WRA*) / 29 +STV) / 4 where: *Ei* = environmental impacts; *Si* = socioeconomic impacts. * Species with Priority Index ≥ 35 have been highlighted with an asterisk.

	Family	Native distribution	Impacts		WRA		Trends		Prior. Index
			Environment	Socio-economics	Score	Evaluation	STV	Evaluation	
a) Species not in the wild									
*Cinnamomum camphora**	Lauraceae	As	4	2	17	Reject	35	Less Interesting	**45**
*Cotoneaster horizontalis**	Rosaceae	As, AT	3	1	26	Reject	37	Less Interesting	**45**
*Physalis angulata**	Solanaceae	NAm, SAm, Pac	4	2	22	Reject	0	Not Interesting	**41**
*Allamanda cathartica**	Apocynaceae	SAm	4	3	11	Reject	0	Not Interesting	**37**
*Nymphaea odorata**	Nymphaeaceae	NAm	7	2	9	Reject	0	Not Interesting	**36**
*Leptospermum scoparium**	Myrtaceae	Aus	3	1	13	Reject	43	Less Interesting	**35**
Cornus sericea	Cornaceae	NAm	4	1	22	Reject	0	Not Interesting	**34**
Berberis thunbergii	Berberidaceae	As	4	1	12	Reject	27	Less Interesting	**32**
Alocasia macrorrhizos	Araceae	AT	4	0	13	Reject	0	Not Interesting	**20**
Euonymus fortunei	Celastraceae	As	4	0	7	Reject	0	Not Interesting	**15**
Archontophoenix cunninghamiana	Arecaceae	Aus	4	0	4	Evaluating	0	Not Interesting	**13**
b) Casual species									
*Portulaca oleracea**	Portulacaceae	Afr, EUr	4	3	15	Reject	54	Interesting	**54**
*Cestrum nocturnum**	Solanaceae	SAm	4	2	9	Reject	80	Very Interesting	**49**
*Wisteria sinensis**	Fabaceae	As	8	2	9	Reject	43	Less Interesting	**49**
*Kalanchoe daigremontiana**	Crassulaceae	Afr	5	1	22	Reject	37	Less Interesting	**46**
*Pinus radiata**	Pinaceae	NAm	3	2	12	Reject	60	Interesting	**45**
*Nandina domestica**	Berberidaceae	As, AT	5	2	9	Reject	43	Less Interesting	**42**
*Casuarina equisetifolia**	Casuarinaceae	Aus	5	2	7	Reject	45	Less Interesting	**41**
*Miscanthus sinensis**	Poaceae	AT	6	3	9	Reject	0	Not Interesting	**40**
*Paulownia tomentosa**	Paulowniaceae	As, AT	4	1	19	Reject	27	Less Interesting	**38**
*Zantedeschia aethiopica**	Araceae	Afr	0	1	15	Reject	70	Interesting	**37**
*Physalis peruviana**	Solanaceae	SAm	5	2	8	Reject	22	Not Interesting	**36**
*Grevillea robusta**	Proteaceae	Aus	7	1	2	Evaluating	45	Less Interesting	**35**
*Sesbania punicea**	Fabaceae	SAm	2	3	13	Reject	0	Not Interesting	**35**
Gypsophila paniculata	Caryophyllaceae	As, Eur	6	1	6	Evaluating	17	Not Interesting	**29**
Eugenia uniflora	Myrtaceae	SAm	5	0	18	Reject	0	Not Interesting	**27**

	Family	Native distribution	Impacts		WRA			Trends	Prior. Index
			Environment	Socio-economics	Score	Evaluation	STV	Evaluation	
Spiraea japonica	Rosaceae	As, AT	4	0	11	Reject	28	Less Interesting	**26**
Tecoma stans	Bignoniaceae	NAm, SAm	4	1	11	Reject	0	Not Interesting	**25**
Prunus serotina	Rosaceae	NAm	6	0	12	Reject	0	Not Interesting	**24**
Morus nigra	Moraceae	As	3	0	4	Evaluating	45	Less Interesting	**22**
Eucalyptus sideroxylon	Myrtaceae	Aus	3	0	14	Reject	0	Not Interesting	**19**
Yucca aloifolia	Agavaceae	NAm	3	1	4	Evaluating	0	Not Interesting	**17**
Cereus uruguayanus	Cactaceae	SAm	3	0	3	Evaluating	0	Not Interesting	**9**
c) Naturalised species									
*Lupinus polyphyllus**	Fabaceae	NAm	6	3	27	Reject	0	Not Interesting	**56**
*Canna indica**	Cannaceae	SAm	8	1	24	Reject	35	Less Interesting	**54**
*Rhus typhina**	Anacardiaceae	NAm	5	4	15	Reject	0	Not Interesting	**49**
*Phragmites australis**	Poaceae	NAm	2	2	27	Reject	35	Less Interesting	**49**
*Tagetes minuta**	Asteraceae	NAm	4	3	22	Reject	0	Not Interesting	**47**
*Imperata cylindrica**	Poaceae	AT	7	1	24	Reject	0	Not Interesting	**43**
*Ficus pumila**	Moraceae	AT	3	3	5	Evaluating	35	Less Interesting	**39**
*Phoenix canariensis**	Arecaceae	Afr	4	1	6	Evaluating	71	Interesting	**38**
*Melia azedarach**	Meliaceae	AT, Aus	4	0	12	Reject	71	Interesting	**37**
*Psidium cattleianum**	Myrtaceae	SAm	6	1	20	Reject	0	Not Interesting	**37**
Albizia julibrissin	Fabaceae	As	3	0	14	Reject	62	Interesting	**34**
Ficus rubiginosa	Moraceae	Aus	6	1	7	Reject	26	Less Interesting	**32**
Broussonetia papyrifera	Moraceae	As	5	2	2	Evaluating	27	Less Interesting	**32**
Ziziphus jujuva	Rhamnaceae	As, AT, Aus	5	1	17	Reject	0	Not Interesting	**32**
Pennisetum villosum	Poaceae	Afr	3	0	25	Reject	0	Not Interesting	**28**
Sansevieria trifasciata	Asparagaceae	Afr	4	0	12	Reject	35	Less Interesting	**28**
Bacopa monnieri	Plantaginaceae	NAm, SAm, As, Eur	2	1	16	Reject	10	Not Interesting	**27**
Adiantum raddianum	Pteridaceae	SAm	3	1	13	Reject	7	Not Interesting	**26**
Atriplex semibaccata	Amaranthaceae	Aus	3	0	15	Reject	0	Not Interesting	**20**
Annona cherimola	Annonaceae	SAm	1	1	0	Accepted	0	Not Interesting	**9**
d) Invasive species									
*Robinia pseudoacacia**	Fabaceae	NAm	7	3	15	Reject	100	Very Interesting	**73**
*Lantana camara**	Verbenaceae	SAm	5	3	25	Reject	67	Interesting	**68**
*Eucalyptus globulus**	Myrtaceae	Aus	4	3	21	Reject	35	Less Interesting	**55**
*Acacia longifolia**	Fabaceae	Aus	4	3	23	Reject	0	Not Interesting	**48**
*Acacia saligna**	Fabaceae	Aus	5	1	22	Reject	23	Not Interesting	**42**
*Leucaena leucocephala**	Fabaceae	NAm	5	0	21	Reject	35	Less Interesting	**38**
*Elaeagnus angustifolia**	Elaeagnaceae	As	6	0	21	Reject	19	Not Interesting	**36**
*Lonicera japonica**	Caprifoliaceae	As, AT	3	1	14	Reject	39	Less Interesting	**35**

	Family	Native distribution	Impacts		WRA		STV	Trends	Prior. Index
			Environment	Socio-economics	Score	Evaluation		Evaluation	
*Agave sisalana**	Agavaceae	SAm	6	2	10	Reject	0	Not Interesting	**35**
Psidium guajava	Myrtaceae	NAm	4	1	19	Reject	0	Not Interesting	**32**
Gleditsia triacanthos	Fabaceae	NAm	4	0	10	Reject	41	Less Interesting	**28**
Phormium tenax	Xanthorrhoeaceae	Pac	3	0	10	Reject	35	Less Interesting	**24**
Bidens aurea	Asteraceae	NAm	1	2	5	Evaluating	18	Not Interesting	**24**
Stenotaphrum secundatum	Poaceae	Afr	5	0	13	Reject	0	Not Interesting	**23**
Pasiflora caerulea	Passifloraceae	SAm	3	0	6	Evaluating	0	Not Interesting	**12**

Table 4. Green List. Includes non-native non-invasive species with very low invasion potential. Native distribution: As: Asia (Temperate); AT: Asia (Tropical); SAm: South and Central America. Status in Spain: N: Not in the wild, C: Casual.

Species	Family	Native distribution	Status in Spain
Averrhoa carambola	Oxalidaceae	AT	N
Celosia argentea	Amaranthaceae	AT	N
Ficus benjamina	Moraceae	AT	N
Mangifera indica	Anacardiaceae	As – AT	N
Nelumbo nucifera	Nelumbonaceae	AT	N
Pogostemon helferi	Lamiaceae	AT	N
Senna corymbosa	Fabaceae	SAm	C

suitable, four not climatically suitable but invasive elsewhere), 69 are casual (4 with low confidence on climatic suitability, 58 with no available information on climatic suitability, six not invasive elsewhere but climatically suitable and one not climatically suitable but invasive elsewhere) and 46 are naturalised not invasive elsewhere (Appendix 3).

Societal interest analysis of Attention List species

In the Google Trends systematic examination of the 68 Attention List species, maximum trend values were observed for *Robinia pseudoacacia* – March 2004 – and therefore we used this record as our control species.

Within the Attention list, the most noteworthy species (higher STV) included: the invasive *Robinia pseudoacacia* (100) and *Lantana camara* (67); the naturalised *Phoenix canariensis* (71) and *Melia azedarach* (71); the casual *Cestrum nocturnum* (80) and *Zantedeschia aethiopica* (70); and, far from the previous groups, the not in the wild *Leptospermum scoparium* (43). Complete results of the STV analysis are shown in Table 3. There were no significant differences in STV between any pair of invasion status groups of species (Fig. 3). Similarly, there were no differences between the species in the Priority list and the Green List (p=0.967).

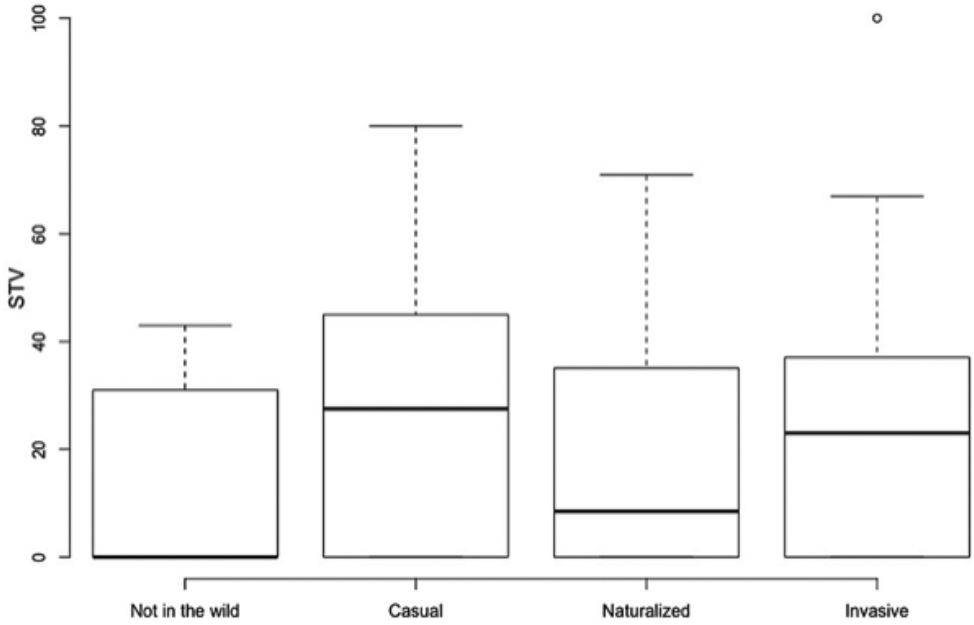


Figure 3. Society interest in ornamental non-native plant species classified by their invasion status. STV: Standard Trend Value. P-values for Tukey's range tests: not in the wild – casual: p = 0.373; not in the wild – naturalised: p = 0.783; not in the wild – invasive: p = 0.436; casual – naturalised: p = 0.794; casual – invasive: p = 1; naturalised – invasive: p = 0.860.

Invasion risk assessment of Attention List species

In the WRA, all species in the Attention List were rejected, except for 11 that required further evaluation and only one, *Annona cherimola*, that was accepted (Table 3).

Within each invasion status, the highest WRA scores were for the invasive *Lantana camara* (25), *Acacia longifolia* (23), *Acacia saligna* (22), *Elaeagnus angustifolia* (21), *Eucalyptus globulus* (21) and *Leucana leucocephala* (21); the naturalised *Phragmites australis* (27), *Lupinus polyphyllus* (27), *Pennistum villosum* (25), *Canna indica* (24) and *Imperata cylindrica* (24); the casual *Kalanchoe daigremontiana* (22), *Pawlownia tomentosa* (19) and *Eugenia uniflora* (18); and the not in the wild *Cotoneaster horizontalis* (26), *Cornus sericea* (22) and *Physalis angulata* (22). For every invasion status, the species requiring further evaluation accounted for less than 25%. There were no significant differences in WRA scores between any pair of invasion status groups of species (Fig. 4).

Prioritisation of Attention List species

The median value of Priority Indices was 35. Species with a Priority Index ≥ 35 are highlighted in Table 3. Within each invasion status, the highest Priority Indices in invasive species were found for *Robinia pseudoacacia* (73), *Lantana camara* (68) and

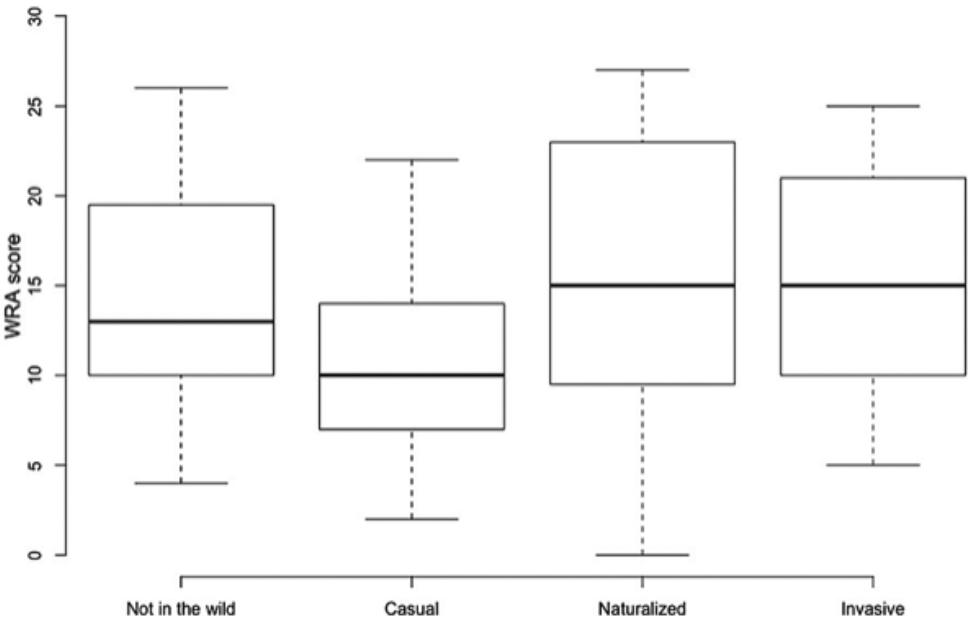


Figure 4. Weed risk assessment (WRA) score in ornamental non-native plant species classified by their invasion status in Spain. P-values for Tukey's range tests: not in the wild – casual: p = 0.392; not in the wild – naturalised: p = 0.983; not in the wild – invasive: p = 0.951; casual – naturalised: p = 0.101; casual – invasive: p = 0.086; naturalised – invasive: p = 0.997.

Eucalyptus globulus (55); in naturalised species *Lupinus polyphyllus* (56) and *Canna indica* (54); in casual species *Portulaca oleracea* (54), *Cestrum nocturnum* (49) and *Wisteria sinensis* (49); and in not in the wild species *Cinnamimum camphora* (45) and *Cotoneaster horizontalis* (45). There were no significant differences between any pair of invasion status groups of species (Fig. 5).

Discussion

Nurseries and the commercial introduction of non-native plant species are the main deliberate pathways for plant invasions (Van Kleunen et al. 2018). Some of the most harmful invasive plant species in the wild are non-native species introduced for commercial purposes (Hulme 2007). In Spain, non-native plants represent the vast majority of species sold by nurseries (77%) and 30 of these species have been reported as invasive in the peninsular territory of Spain. The regulation of non-native invasive plant species is necessary. However, nurseries often do not fully comply with commercial restrictions (Wirth et al. 2004; Cronin et al. 2017; Touza et al. 2014). Besides the Spanish (BOE 2013) and European (European Commission 2016, 2017) regulations on non-native invasive species and similar to what happens in other countries, there are eight regulated species that, although being regulated, were still commercially available

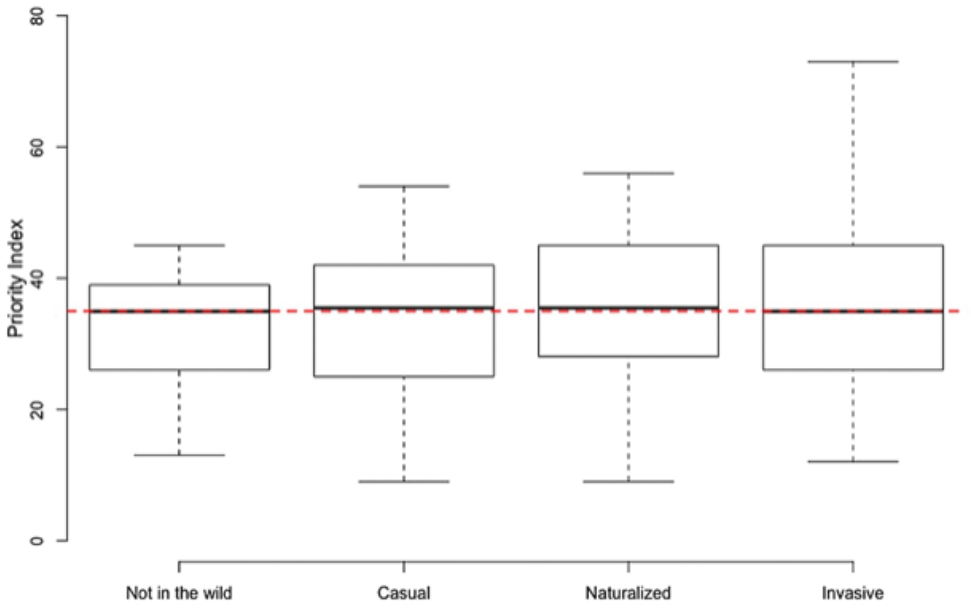


Figure 5. Priority Index in ornamental non-native plant species classified by their invasion status in Spain. P-values for Tukey's range tests: not in the wild – casual: p = 0.981; not in the wild – naturalised: p = 0.860; not in the wild – invasive: p = 0.633; casual – naturalised: p = 0.958; casual – invasive: p = 0.748; naturalised – invasive: p = 0.953. Dashed red line represents the global median of Priority Index (=38). Species at or above this line should be considered in prioritisation, as shown in table 3.

in the country at the time of this study (Appendix 1), as indicated in the Priority List. One of them, *Pennisetum setaceum*, was also been included under European regulation, although this inclusion is more recent than the study of the nurseries for this study. Therefore, there is a pressing need to enforce the current legislation, as well as to raise public awareness to prohibit the trade of these species.

Furthermore, because the deliberate transport, commerce and planting of non-native plant species can be controlled, all the invasive and potentially invasive species compiled into the Attention List could be considered for regulation, following the advice of the European Parliament and Council (2014). While some of these species have been introduced to provide an immediate economic benefit, such as *Eucalyptus globulus* and other species of the same genus (Touza et al. 2014), their impacts on the environment, as well as on some human activities besides the forestry sector, suggest that their regulation should be considered. In addition, the costs derived from the control of invasive species can be quite significant (Pimentel et al. 2005) and are not compensated for by their economic benefits.

The levels of potential impacts of species in the Attention List are independent of their invasion status in Spain. That is, current non-invasive species have the potential to cause as many impacts as invasive species. This result supports previous empirical studies indicating that invasiveness does not always translate to impacts (Ricciardi

and Cohen 2007). Despite the fact that some of these species were introduced a long time ago and are already invasive, such as *Ailanthus altissima* introduced into Spain in 1818 or *Acacia dealbata* in 1824 (Sanz Elorza et al. 2004), others have possibly been introduced recently as ornamental plants and thus have not had enough time for establishment and dispersal (Pemberton and Liu 2009). As a precautionary measure to avoid their impacts, there is a need to prevent the introduction of any non-native species listed in the Attention List and to conduct a complete risk assessment to study the possibility of their being regulated.

As the threshold number of environmental and socioeconomic impacts required for a species to be included or not in the Attention List is based on median values, it may exclude some species that have high risks of invasion despite a low number of impact types or species with still unknown impacts. In fact, the Watch List contains species that are well known to be invasive elsewhere, such as *Acer negundo* or *Eriobotrya japonica*, which cause few, but important, impacts. More detailed research on the potential type of impacts of the species in the Watch List, as well as conducting a WRA for these species, would allow for more adequate prioritisation of these species that are of major concern after those in the Priority and Attention Lists.

We are confident that the potential invasion of Attention List species is robust given the positive results of the WRA, in which only one of the 68 species listed was classified as accepted (i.e. low invasion risk). The proportion of species rejected by the WRA was very high and similar in all status groups of species, with a likely low incorporation of false positives (Andreu and Vilà 2010). Furthermore, our WRA analysis warns that species which are not in the wild, still have the potential to become invasive, reaching scores as high as those of already naturalised or invasive plants.

Likewise, with our analysis on the STV, we cannot infer causality between societal interest and increased commerce. In fact, the STV is not a good predictor of invasion status; the absence of differences between STV of the species in the Priority list and the Green list shows that the STV is not related with invasion. Nevertheless, greater interest, as reflected in Google statistics, can still be an indicator of increased consumption and trade (Vosen and Schmidt 2011) and greater interest might promote greater propagule pressure and greater potential to become established (Dehnen-Schmutz et al. 2007a; Johnston et al. 2009; Blackburn et al. 2013; García-Díaz et al. 2015). Thus, we think that the STV continues to have value, not as a predictor of invasion, but as a factor to be considered during prioritisation of the species within each invasion group.

Our approach is similar to previous Horizon-scanning analyses for non-native species (Roy et al. 2014, Roy et al. 2019) with the differences being that, in our study case, all the species are already in the region of analysis and the scoring is based on more parameters than just their potential to establish and cause impacts. We provide a Priority Index that includes the risk of invasion, the level of potential impacts and the popularity of the species. Therefore, it offers an integrative score that may be of interest to environmental administrations and management services as a valuable tool to support decision-making. The homogeneity in the Priority Index across the invasion status groups of species confirms that the potential for invasion and the impact

risks are independent of the actual invasion status of the species (Roberts et al. 2011; Gassó et al. 2010). Therefore, this index may even be useful for identifying current non-invasive species that, even if not in the wild, are potentially invasive. Indeed, our species Prioritisation List has already been used to identify species with the potential to be invasive in Gibraltar, an overseas territory of the United Kingdom which buys all its ornamental plants from neighbouring Spain according to the UKOTs Horizon Scanning and Biosecurity Workshop that took place on 21–24 January 2019 (K. Bensusan, pers. Com).

We also generated an Uncertainty List composed of species that probably do not represent an immediate invasion risk. For fifty-six percent of the species listed, we lack sufficient confidence in the likelihood of climatic suitability (or we have no information about it). Even if the species in the Uncertainty List do not become established in Spain due to their climatic requirements, or they are not invasive elsewhere, we need to be aware that these two criteria can change over time. For example, a particular climate change scenario could cause climatically unsuitable species to become suitable in the future (Mainka and Howard 2010).

Unfortunately, we could not find information on the status, invasive potential and climatic suitability of 61% of the non-native species sold in nurseries. There is a worrying possibility that the Data Deficient List includes some potentially invasive species that are not considered in the two major databases consulted (CABI Datasheets 2018; Invasive Species Specialist Group 2015). Additional research, as well as consultation of the primary literature, is needed to allow reclassifying species from the Data Deficient List, a task that would require the expertise of a larger team of scientists (Roy et al. 2019; González-Moreno et al. 2019). The immediate task would be to use the new available GLONAF database to identify invasive species elsewhere (van Kleunen et al. 2019).

Finally, we provide a Green List of non-native species with very low invasion potential. Promoting preferences for non-invasive species in horticulture can be a valuable endeavour in order to make regulations easier to comply with (Gagliardi and Brand 2007). Involving the horticultural industry in the dissemination of plant invasion risks and in the development of regulations has been shown to be effective (Humair et al. 2014). This Green List can be a starting point for the establishment of voluntary codes of conduct amongst nursery owners (Reichard 2004; Gagliardi and Brand 2007; Robinson et al. 2017). However, it is prudent not to forget that propagule pressure is an important factor determining invasion (Lockwood et al. 2005; 2009; Johnston et al. 2009).

If species in the Green List are planted frequently, in large quantities and in many locations, this scenario can be changed. For this reason, the Green List presented here is short and tentative; further and more in-depth research is needed on the Uncertainty List so as to possibly enlarge this Green List. Planting native species will always be the preferable alternative.

The present research is preliminary in nature and the authors are aware of the clear limitations of the conclusions. However, we consider it can be a very useful and complete tool to establish priorities in long lists of species for which not much information is available and it represents a good starting point for more thorough and detailed risk

analyses that allow the improvement and implementation of new and more efficient forms of regulation of invasive species.

Based on our prioritization list analysis, we provide the following recommendations: 1) there is a need to reinforce the current legislation and implement systems that guarantee its compliance regarding the species of the Priority List; 2) invasive species in the Attention List should be considered for regulation; 3) established, casual and not in the wild species in the Attention List, especially those with higher Priority Index values, should be included in a monitoring programme to prevent future invasions; 4) species in the Watch List should be included in an early warning programme if they are not yet in the wild and monitored if they are already established in a few localities; 5) species in the Uncertainty List require further evaluation in order to be reclassified into Attention, Watch or Green Lists; finally 6) species in Data Deficient List require further information on their status, invasive potential or climatic suitability in order to be reclassified into Attention, Watch or Green lists.

This research also reveals the limited responsibility and awareness by some commercial nurseries regarding the sale of invasive species. A better monitoring and tracking system for the species for sale and more rigorous inspections in nurseries are very necessary (Touza et al. 2014). Citizen awareness through the dissemination of knowledge about invasive non-native species, as well as citizen science projects working with gardeners, can be useful tools to reduce their demand and consumption as suggested in other studies (Reichard 2004; Gagliardi and Brand 2007; Robinson et al. 2017; Dehnen-Schmutz and Conroy 2018). Having a national registry of ornamental plant species available for sale and the requirement of a risk analysis for the introduction of new species in it, is also a recommendation to be considered.

Acknowledgements

This study was funded by the project IMPLANTIN (CGL2015-65346-R). Á. Bayón is hired by the Biological Station of Doñana (EBD-CSIC) thanks to a Grant for Predoctoral Contracts for the Training of Doctors 2015 awarded by the Ministerio de Ciencia, Innovación y Universidades of Spain and co-financed by the European Social Fund (BES-2015-072929). We thank P. Castro, O. Godoy and F. Essl, S. Vanderhoeven, P. Hulme and the associated editor for comments on previous versions of the manuscript and J. Arroyo for tutoring the thesis project at the University of Seville.

References

AEMET (2016) AEMET (Agencia Estatal de Meteorología). http://www.aemet.es/es/servicios-climaticos/datosclimatologicos [Accessed 22 May 2016]

Andreu J, Vilà M (2010) Risk analysis of potential invasive plants in Spain. Journal for Nature Conservation 18: 34–44. https://doi.org/10.1016/j.jnc.2009.02.002

Bayón Á, Vilà M (2019) Dataset of Horizon scanning to identify invasion risk of ornamental plants marketed in Spain [Data set]. Neobiota. Zenodo. http://doi.org/10.5281/zenodo.3367257

Blackburn TM, Essl F, Evans T, et al. (2014) A unified classification of alien species based on the magnitude of their environmental impacts. PLOS Biology12(5): e1001850. https://doi.org/10.1371/journal.pbio.1001850

Blackburn TM, Prowse TAA, Lockwood JL, Cassey P (2013) Propagule pressure as a driver of establishment success in deliberately introduced exotic species: Fact or artefact? Biological Invasions 15: 1459–1469. https://doi.org/10.1007/s10530-013-0451-x

BOE (2013) Real Decreto 630/2013, de 2 de agosto, por el que se regula el Catálogo español de especies exóticas invasoras. BOE 185: 56764–56786

Burivalova Z, Butler RA, Wilcove DS (2018) Analyzing Google search data to debunk myths about the public's interest in conservation. Frontiers in Ecology and the Environment 16(9):509–514. https://doi.org/10.1002/fee.1962

CABI (2018) Invasive Species Compendium. CAB International, Wallingford. https://www.cabi.org/isc [Accessed 30 Jan 2016]

Chrobock T, Kempel A, Fischer M, van Kleunen M (2011) Introduction bias: Cultivated alien plant species germinate faster and more abundantly than native species in Switzerland. Basic and Applied Ecology 12: 244–250. https://doi.org/10.1016/j.baae.2011.03.001

Convention on Biological Diversity (2010) Strategic Plan for Biodiversity 2011–2020. https://www.cbd.int/sp/default.shtml [Accessed 12 May 2016]

Cronin K, Kaplan H, Gaertner M, et al. (2017) Aliens in the nursery: assessing the attitudes of nursery managers to invasive species regulations. Biological Invasions 19: 925–937. https://doi.org/10.1007/s10530-016-1363-3

Dehnen-Schmutz K (2011) Determining non-invasiveness in ornamental plants to build green lists. Journal of Applied Ecology 48: 1374–1380. https://doi.org/10.1111/j.1365-2664.2011.02061.x

Dehnen-Schmutz K, Conroy J (2018) Working with gardeners to identify potential invasive ornamental garden plants: testing a citizen science approach. Biological Invasions 20: 3069–3077. https://doi.org/10.1007/s10530-018-1759-3

Dehnen-Schmutz K, Touza J, Perrings C, Williamson M (2007) A century of the ornamental plant trade and its impact on invasion success. Diversity and Distributions 13: 527–534. https://doi.org/10.1111/j.1472-4642.2007.00359.x

European Commission (2016) Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016 adopting a list of invasive alien species of Union concern pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council.

European Commission (2017) Commission Implementing Regulation (EU) 2017/1263 of 12 July 2017 updating the list of invasive alien species of Union concern established by Implementing Regulation (EU) 2016/1141 pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council.

European Parliament and the Council of the European Union (2014) Regulation (EU) No 1143/2014 of 22 October on the prevention and management of the introduction and spread of invasive alien species. Official Journal of the European Union. L 317/35 – 317/55.

Gagliardi JA, Brand MH (2007) Connecticut Nursery and Landscape Industry Preferences for Solutions to the Sale and Use of Invasive Plants. HortTechnology 17: 39–45. https://doi.org/10.21273/HORTTECH.17.1.39

García-Díaz P, Ross JV, Ayres C, Cassey P (2015) Understanding the biological invasion risk posed by the global wildlife trade: propagule pressure drives the introduction and establishment of Nearctic turtles. Global Change Biology 21: 1078–91. https://doi.org/10.1111/gcb.12790

Gassó N, Basnou C, Vilà M (2010) Predicting plant invaders in the Mediterranean through a weed risk assessment system. Biological Invasions 12: 463–476. https://doi.org/10.1007/s10530-009-9451-2

Gassó N, Sol D, Pino J, Dana ED, Lloret F, Sanz-Elorza M, Sobrino E, Vilà M (2009) Exploring species attributes and site characteristics to assess plant invasions in Spain. Diversity and Distribution 15: 50–58. https://doi.org/10.1111/j.1472-4642.2008.00501.x

Gederas L, Moen TL, Skjelseth S, Larsen L-K (Eds) (2012) Alien species in Norway – with the Norwegian Black List 2012. The Norwegian Biodiversity Information Centre, Norway.

González-Moreno P, Diez JD, Ibáñez I, Font X, Vilà M (2014) Plant invasions are context-dependent: multiscale effects of climate, human activity and habitat. Diversity and Distributions 20: 720–731. https://doi.org/10.1111/ddi.12206

Gordon DR, Onderdonk DA, Fox AM, Stocker RK (2008) Consistent accuracy of the Australian weed risk assessment system across varied geographies. Diversity and Distributions 14: 234–242. https://doi.org/10.1111/j.1472-4642.2007.00460.x

Hulme PE (2007) Biological invasions in Europe: drivers, pressures, states, impacts and responses. Issues in Environmental Science and Technology 25: 56–80. https://doi.org/10.1039/9781847557650-00056

Humair F, Humair L, Kuhn F, Kueffer C (2015) E-commerce trade in invasive plants. Conservation Biology 29: 1658–1665. https://doi.org/10.1111/cobi.12579

Humair F, Siegrist M, Kueffer C (2014) Working with the horticultural industry to limit invasion risks: the Swiss experience. EPPO Bulletin 44: 232–238. https://doi.org/10.1111/epp.12113

Invasive Species Specialist Group ISSG (2015) The Global Invasive Species Database. Version 2015.1. http://www.issg.org/database [Accessed 23 May 2016]

Johnston EL, Piola RF, Clark GF (2009) The Role of Propagule Pressure in Invasion Success. In: Rilov G, Crooks JA (Eds) Biological Invasions in Marine Ecosystems. Ecological Studies (Analysis and Synthesis) 204: 133–151. https://doi.org/10.1007/978-3-540-79236-9_7

Lenda M, Skórka P, Knops JMH, et al. (2014) Effect of the internet commerce on dispersal modes of invasive alien species. PLOS One 9: e99786. https://doi.org/10.1371/journal.pone.0099786

Leung B, Roura-Pascual N, Bacher S, et al. (2012) TEASIng apart alien species risk assessments: a framework for best practices. Ecology Letters 15: 1475–1493. https://doi.org/10.1111/ele.12003

Lockwood JL, Cassey P, Blackburn TM (2009) The more you introduce the more you get: the role of colonization pressure and propagule pressure in invasion ecology. Diversity and Distributions 15: 904–910. https://doi.org/10.1111/j.1472-4642.2009.00594.x

Lockwood JL, Cassey P, Blackburn T (2005) The role of propagule pressure in explaining species invasions. Trends in Ecology and Evolution 20: 223–228. https://doi.org/10.1016/j.tree.2005.02.004

Mack RN, Simberloff D, Lonsdale WM, et al. (2000) Biotic Invasions: Causes, Epidemiology, Global Consequences, and Control. Ecological Applications 10: 689. https://doi.org/10.2307/2641039

Mainka SA, Howard GW (2010) Climate change and invasive species: double jeopardy. Integrative Zoology 5(2):102–111. https://doi.org/10.1111/j.1749-4877.2010.00193.x

Maurel N, Hanspach J, Kühn I, et al. (2016) Introduction bias affects relationships between the characteristics of ornamental alien plants and their naturalization success. Global Ecology and Biogeography 25: 1500–1509. https://doi.org/10.1111/geb.12520

Niinemets Ü, Peñuelas J (2008) Gardening and urban landscaping: significant players in global change. Trends in Plant Science 13: 60–65. https://doi.org/10.1016/j.tplants.2007.11.009

Ninyerola M, Pons X, Roure JM (2005) Atlas climático digital de la Península Ibérica. Metodología y aplicaciones en bioclimatología y geobotánica. Universidad Autónoma de Barcelona, Bellaterra.

Otfinowski R, Kenkel NC, Dixon P, Wilmshurst JF (2007) Integrating climate and trait models to predict the invasiveness of exotic plants in Canada's Riding Mountain National Park. Canadian Journal of Plant Science 87(5): 1001–1012. https://doi.org/10.4141/CJPS07117

Parker JD, Torchin ME, Hufbauer RA, et al. (2013) Do invasive species perform better in their new ranges? Ecology 94: 985–994. https://doi.org/10.1890/12-1810.1

Pemberton RW, Liu H (2009) Marketing time predicts naturalization of horticultural plants. Ecology 90: 69–80. https://doi.org/10.1890/07-1516.1

Pheloung PC, Williams PA, Halloy SR (1999) A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. Journal of Environmental Management 57: 239–251. https://doi.org/10.1006/jema.1999.0297

Pimentel D, Zuniga R, Morrison D (2005) Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273–288. https://doi.org/10.1016/j.ecolecon.2004.10.002

Purcell K, Brenner J, Rainie L (2012) Search Engine Use 2012. In: Pew Research Center Internet and Technology. http://www.pewinternet.org/2012/03/09/search-engine-use-2012 [Accessed 22 Jan 2018]

Pyšek P, Richardson D M, Rejmánek M, Webster G, Williamson M, Kirschner J (2004) Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon 53: 131–143. https://doi.org/10.2307/4135498

Reichard SH (2004) Conflicting Values and Common Goals: Codes of Conduct to Reduce the Threat of Invasive Species. Weed Technology 18: 1503–1507. https://doi.org/10.1614/0890-037X(2004)018[1503:CVACGC]2.0.CO;2

Ricciardi A, Cohen J (2007) The invasiveness of an introduced species does not predict its impact. Biological Invasions 9: 309–315. https://doi.org/10.1007/s10530-006-9034-4

Richardson DM, Pyšek P, Rejmanek M, et al. (2000) Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6: 93–107. https://doi.org/10.1046/j.1472-4642.2000.00083.x

Roberts W, Harrod O, Mitterdorfer B, Pheloung P (2011) Regulating invasive plants and use of weed risk assessments. Current Opinion in Environmental Sustainability 3(1–2): 60–65. https://doi.org/10.1016/j.cosust.2010.11.007

Robinson BS, Inger R, Crowley SL, Gaston KJ (2017) Weeds on the web: conflicting management advice about an invasive non-native plant. Journal of Applied Ecology 54: 178–187. https://doi.org/10.1111/1365-2664.12712

Roy HE, Bacher S, Essl F, et al. (2019) Developing a list of invasive alien species likely to threaten biodiversity and ecosystems in the European Union. Global Change Biology 25: 1032–1048. https://doi.org/10.1111/gcb.14527

Roy HE, European Commission, Directorate-General for the Environment, CEH (Centre of Ecology and Hydrology) (2015) Invasive alien species: prioritising prevention efforts through horizon scanning: final report. Publications Office, Luxembourg.

Roy HE, Peyton J, Aldridge DC, et al. (2014) Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. Global Change Biology 3859–3871. https://doi.org/10.1111/gcb.12603

Sanz Elorza M, Dana ED, Sobrino E (Eds) (2004) Atlas de las Plantas Alóctonas Invasoras en España. Dirección General para la Biodiversidad, Madrid.

Simberloff D, Martin J-L, Genovesi P, et al. (2013) Impacts of biological invasions: what's what and the way forward. Trends in Ecology and Evolution 28: 58–66. https://doi.org/10.1016/j.tree.2012.07.013

Touza J, Pérez-Alonso A, Chas-Amil ML, Dehnen-Schmutz K (2014) Explaining the rank order of invasive plants by stakeholder groups. Ecological Economics 105: 330–341. https://doi.org/10.1016/j.ecolecon.2014.06.019

Van Kleunen M, Dawson W, Essl F, et al. (2015) Global exchange and accumulation of non-native plants. Nature 525: 100–103. https://doi.org/10.1038/nature14910

Van Kleunen M, Essl F, Pergl J, et al. (2018) The changing role of ornamental horticulture in alien plant invasions. Biological Reviews 93(3): 1421–1437 https://doi.org/10.1111/brv.12402

Van Kleunen M, Pyšek P, Dawson W, et al. (2019) The Global Naturalized Alien Flora (GloNAF) database. Ecology 100: e02542. https://doi.org/10.1002/ecy.2542

Vilà M, Gallardo B, Preda C, et al. (2019) A review of impact assessment protocols of non-native plants. Biological Invasions 21: 709–723. https://doi.org/10.1007/s10530-018-1872-3

Vosen S, Schmidt T (2011) Forecasting private consumption: survey-based indicators vs. Google trends. Journal of Forecasting 30: 565–578. https://doi.org/10.1002/for.1213

Walters LJ, Brown KR, Stam WT, Olsen JL (2006) E-commerce and Caulerpa: unregulated dispersal of invasive species. Frontiers in Ecology and the Environment 4: 75–79. https://doi.org/10.1890/1540-9295(2006)004[0075:EACUDO]2.0.CO;2

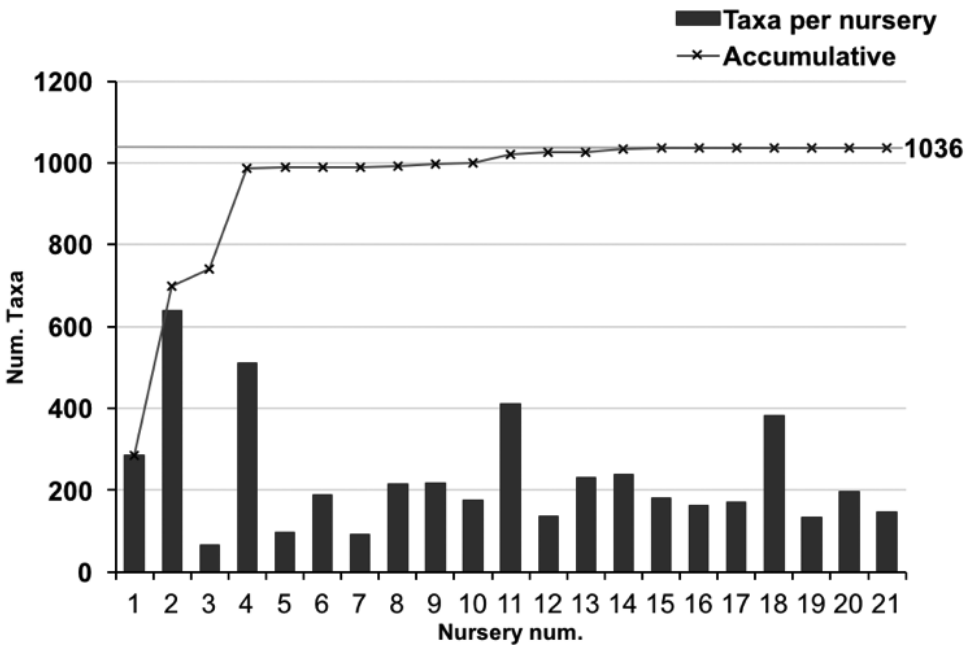
Weber E, Gut D (2004) Assessing the risk of potentially invasive plant species in central Europe. Journal for Nature Conservation 12: 171–179. https://doi.org/10.1016/j.jnc.2004.04.002

Wirth FF, Davis KJ, Wilson SB (2004) Florida Nursery Sales and Economic Impacts of 14 Potentially Invasive Landscape Plant Species. Journal of Environmental Horticulture 22: 12–16. https://doi.org/10.24266/0738-2898-22.1.12

Appendix 1

Table A1. Nurseries. The list of taxa was compiled through the systematic consultation of Spanish nursery catalogs which provide information on plants for sale. As shown in the graph below, the number of taxa did not increase after the 15th catalog was consulted. Our database included a total of 1036 taxa from 21 nurseries. Notice that these nurseries are distributed across all biogeographic regions of mainland Spain.

	Nursery	Source	Access date	Province	Num. taxa
1	Viveros Plantamus	https://plantamus.com	11/12/15	A Coruña	286
2	Viveros Sanchez	http://viverossanchez.com	01/04/16	Guadalajara	638
3	Viveros Maiplant	http://www.maiplant.com	02/23/16	Alicante	66
4	Alberola Viveros	http://www.alberolaviveros.com	02/23/16	Valencia	510
5	Viveros Bargues	http://www.viverosbargues.com	02/24/16	Valencia	97
6	Viveros Rucat	http://www.viverosrucat.es	01/26/16	Madrid	189
7	Viveros Veron	http://viverosveron.com	01/26/16	Zaragoza	92
8	Garden Center Campo Grande	http://www.campogrande.es	01/31/16	Valladolid	214
9	Plantas del Sueve	http://www.delsueve.com	02/01/16	Asturias	217
10	Viveros Urkiondo	http://www.urkiondo.com	02/09/16	Guipuzkoa	174
11	Viveros Barra	http://viverosbarra.es	05/01/16	Leon	410
12	Viveros Coplant	http://www.coplant.es	05/20/16	Pontevedra	137
13	Viveros Borrazas	http://www.viverosborrazas.com	06/11/16	A Coruña	231
14	Viveros Zuaime	http://www.viveroszuaime.es	06/14/16	Granada	238
15	Viveros Sevilla	http://www.viverossevilla.com	06/16/16	Sevilla	180
16	Viveros Ferca	http://viverosferca.com	07/28/16	Ciudad Real	162
17	Viveros Ibañez	http://www.viverosibanez.es	09/20/16	Zaragoza	171
18	Viveros Corma	http://www.corma.es	09/30/16	Barcelona	383
19	Viveros Canós	http://viveroscanos.com	09/30/16	Badajoz	132
20	Viveros Perica	http://viverosperica.com	10/03/16	La Rioja	195
21	Viveros Ametza	http://www.viverosametza.com	10/03/16	Navarra	147



asdasd

Appendix 2

Table A2. Watch list. The Watch List includes invasive and potentially invasive species with potential impacts below median; classified as: a) not in the wild, b) casual, c) naturalized and d) invasive species. Native distribution: Afr: Africa; As: Asia (Temperate); AT: Asia (Tropical); Aus: Australia; NAm: North America; SAm: South and Center America.

	Family	Native distribution	Impacts	
			Environment	Socioeconomics
a) Species not in the wild				
Berberis darwinii	Berberidaceae	SAm	2	0
Euonymus alata	Celastraceae	As	2	0
Ficus elastica	Moraceae	As	2	0
Fraxinus americana	Oleaceae	NAm	0	0
Gunnera manicata	Gunneraceae	SAm	2	0
Pyrus calleryana	Rosaceae	As, AT	0	0
Thevetia peruviana	Apocynaceae	NAm, SAm	0	0
Zelkova serrata	Ulmaceae	As, AT	0	0
b) Casual species				
Ageratum houstonianum	Asteraceae	SAm	0	0
Aloe vera	Liliaceae	Afr	0	0
Corymbia citriodora	Myrtaceae	Aus	0	0
Erigeron karvinskianus	Asteraceae	SAm	0	0
Lagerstroemia indica	Lythraceae	As, AT	2	0
Salix babylonica	Salicaceae	As	0	0
Salvia microphylla	Lamiaceae	NAm	1	0
Trachycarpus fortunei	Arecaceae	As	1	0
c) Naturalized species				
Alpinia zerumbet	Zigimberaceae	AT	2	0
Berberis aquifolium	Berberidaceae	NAm	1	0
Parthenocissus quinquefolia	Vitaceae	NAm	0	0
Passiflora edulis	Passifloraceae	SAm	2	0
d) Invasive species				
Acer negundo	Aceraceae	NAm	1	0
Cyperus alternifolius	Cyperaceae	Afr	0	0
Eriobotrya japonica	Rosaceae	As	0	0
Eucalyptus camaldulensis	Myrtaceae	Aus	1	0
Oenothera biennis	Onagraceae	NAm	1	0
Pelargonium capitatum	Geraniaceae	Afr	2	0
Tropaeolum majus	Tropaeolaceae	SAm	0	0

Appendix 3

Table A3. Uncertainty list. The Uncertainty List includes non-invasive and potentially non-invasive species which lack sufficient information, or those that do not meet the requirements to be included in the Green List; classified as: a) not in the wild, b) casual, and c) naturalized species. Native distribution: Afr: Africa; As: Asia (Temperate); AT: Asia (Tropical); Aus: Australia; Eur: Europe; NAm: North America; Pac: Pacific; SAm: South and Center America. Invasive elsewhere and climate suitability: Y: yes; N: no; Confidence in the likelihood of climatic suitability: H: high; M: med.

	Family	Native distribution	Invasive elsewhere	Climate suitability	Confidence
a) Species not in the wild					
Agave vivipara	Agavaceae	SAm	Y	Y	**L**
Anubias barteri	Araceae	Afr	N	N	**L**
Anubias hastifolia	Araceae	Afr	Y	N	**L**
Anubias heterophylla	Araceae	Afr	Y	N	**L**
Bacopa caroliniana	Plantaginaceae	NAm	N	Y	**L**
Bismarckia nobilis	Arecaceae	Afr	N	N	**L**
Blyxa japonica	Hydrocharitaceae	NAm	**N**	Y	H
Brahea armata	Arecaceae	NAm	N	Y	**L**
Brahea edulis	Arecaceae	NAm	N	Y	**L**
Butia capitata	Arecaceae	SAm	N	Y	**L**
Cabomba furcata	Cabombaceae	SAm	N	Y	**L**
Campanula portenschlagiana	Campanulaceae	Eur	**N**	Y	H
Carex buchananii	Cyperaceae	Aus	N	Y	**L**
Chamaedorea seifrizii	Arecaceae	NAm	N	Y	**L**
Clematis montana	Ranunculaceae	As	**N**	Y	M
Cordyline australis	Asparagaceae	Aus	N	Y	**L**
Corymbia ficifolia	Myrtaceae	Aus	N	Y	**L**
Cotinus coggygria	Anacardiaceae	As	**N**	Y	H
Cryptostegia madagascariensis	Apocynaceae	Afr	Y	**N**	H
Cycas revoluta	Cycadaceae	As	N	Y	**L**
Delonix regia	Fabaceae	Afr	Y	**N**	H
Euphorbia lactea	Euphorbiaceae	SAm	Y	**N**	M
Ficus lyrata	Moraceae	Afr	**N**	Y	M
Ficus microcarpa	Moraceae	Aus	Y	Y	**L**
Freesia alba	Iridaceae	Afr	**N**	Y	M
Fuchsia magellanica	Onagraceae	SAm	Y	**N**	M
Gardenia jasminoides	Rubiaceae	As, AT	**N**	Y	M
Gaultheria mucronata	Ericaceae	SAm	N	Y	**L**
Gaura lindheimeri	Onagraceae	NAm	**N**	Y	M
Geum coccineum	Rosaceae	Eur	**N**	Y	M
Glossostigma elatinoides	Phrymaceae	Aus	**N**	Y	H
Lilaeopsis brasiliensis	Apiaceae	SAm	N	Y	**L**
Liriope muscari	Liliaceae	As, NAm	N	Y	**L**
Livistona chinensis	Arecaceae	As	Y	N	**L**
Lonicera pileata	Caprifoliaceae	As	N	Y	**L**
Loropetalum chinense	Hamamelidaceae	As	**N**	Y	M
Mayaca fluviatilis	Mayacaceae	SAm	N	Y	**L**

	Family	Native distribution	Invasive elsewhere	Climate suitability	Confidence
Myoporum tetrandrum	Scrophulariaceae	Aus	N	Y	**L**
Ophiopogon japonicus	Asparagaceae	As	**N**	Y	H
Opuntia microdasys	Cactaceae	NAm	**N**	Y	H
Perovskia atriplicifolia	Lamiaceae	As	**N**	Y	M
Pittosporum tenuifolium	Pittosporaceae	Pac	N	Y	**L**
Pogostemon stellatus	Lamiaceae	AT, Aus	N	N	**L**
Rotala wallichii	Lythraceae	As	N	Y	**L**
Serenoa repens	Arecaceae	NAm	N	Y	**L**
Vaccinium corymbosum	Ericaceae	NAm	**N**	Y	M
b) Casual species					
Acacia baileyana	Fabaceae	Aus	N	**NA**	**NA**
Acer campestre	Sapindaceae	Afr, Eur	N	**NA**	**NA**
Aloe arborescens	Liliaceae	Afr	N	**NA**	**NA**
Aloe maculata	Liliaceae	Afr	**N**	Y	H
Aloysia citrodora	Verbenaceae	SAm	**N**	Y	H
Anthriscus cerefolium	Apiaceae	Eur	N	**NA**	**NA**
Artemisia dracunculus	Asteraceae	As, Eur, NAm	N	**NA**	**NA**
Brachychiton populneus	Malvaceae	Aus	N	**NA**	**NA**
Caesalpinia gilliesii	Fabaceae	SAm	N	**NA**	**NA**
Callistemon citrinus	Myrtaceae	Aus	N	**NA**	**NA**
Calocedrus decurrens	Cupressaceae	NAm	N	**NA**	**NA**
Campsis radicans	Bignoniaceae	NAm	N	**NA**	**NA**
Catalpa bignonioides	Bignoniaceae	NAm	N	**NA**	**NA**
Catharanthus roseus	Apocynaceae	Afr	N	**NA**	**NA**
Cedrus deodara	Pinaceae	As	N	**NA**	**NA**
Cedrus libani	Pinaceae	Eur	N	**NA**	**NA**
Cercis siliquastrum	Fabaceae	Eur	N	**NA**	**NA**
Coffea arabica	Rubiaceae	Afr	N	**NA**	**NA**
Crassula ovata	Crassulaceae	Afr	**N**	Y	M
Cupressus arizonica	Cupressaceae	NAm	N	**NA**	**NA**
Cupressus macrocarpa	Cupressaceae	NAm	N	**NA**	**NA**
Cydonia oblonga	Rosaceae	Eur	N	**NA**	**NA**
Diospyros kaki	Ebenaceae	As	N	**NA**	**NA**
Eucalyptus gunnii	Myrtaceae	Aus	N	**NA**	**NA**
Euonymus japonicus	Celastraceae	As	N	**NA**	**NA**
Euphorbia candelabrum	Euphorbiaceae	Afr	N	**NA**	**NA**
Helianthus annuus	Asteraceae	NAm	N	**NA**	**NA**
Hibiscus rosa-sinensis	Malvaceae	As	N	**NA**	**NA**
Hibiscus syriacus	Malvaceae	As	N	**NA**	**NA**
Hyacinthus orientalis	Asparagaceae	Afr, AT	N	**NA**	**NA**
Jacaranda mimosifolia	Bignoniaceae	SAm	N	**NA**	**NA**
Jasminum nudiflorum	Oleaceae	As	N	**NA**	**NA**
Jasminum officinale	Oleaceae	As	**N**	Y	H
Juglans nigra	Juglandaceae	NAm	N	**NA**	**NA**
Koelreuteria paniculata	Sapindaceae	As	N	**NA**	**NA**
Lagunaria patersonii	Malvaceae	Aus	N	**NA**	**NA**
Larix decidua	Pinaceae	Eur	N	**NA**	**NA**

	Family	Native distribution	Invasive elsewhere	Climate suitability	Confidence
Lepidium sativum	Brassicaceae	Afr	N	**NA**	**NA**
Ligustrum ovalifolium	Oleaceae	As	N	**NA**	**NA**
Lobelia erinus	Campanulaceae	Afr	N	**NA**	**NA**
Lycium barbarum	Solanaceae	As	N	**NA**	**NA**
Malus domestica	Rosaceae	As	N	**NA**	**NA**
Mimosa pudica	Fabaceae	SAm	Y	Y	**L**
Monstera deliciosa	Araceae	SAm	N	**NA**	**NA**
Origanum majorana	Lamiaceae	As, Eur	N	**NA**	**NA**
Phytolacca dioica	Phytolaccaceae	SAm	N	**NA**	**NA**
Pinus canariensis	Pinaceae	Afr	N	**NA**	**NA**
Pinus strobus	Pinaceae	NAm	N	**NA**	**NA**
Pistacia vera	Anacardiaceae	As, Eur	N	**NA**	**NA**
Pittosporum tobira	Pittosporaceae	As	N	**NA**	**NA**
Plumbago auriculata	Plumbaginaceae	Afr	N	**NA**	**NA**
Populus simonii	Salicaceae	As	N	**NA**	**NA**
Prunus armeniaca	Rosaceae	NAm	N	**NA**	**NA**
Prunus domestica	Rosaceae	Eur	N	**NA**	**NA**
Pseudotsuga menziesii	Pinaceae	NAm	N	**NA**	**NA**
Ruta graveolens	Rutaceae	Eur	N	**NA**	**NA**
Salvia splendens	Lamiaceae	SAm	Y	**N**	M
Sedum sexangulare	Crassulaceae	Eur	**N**	Y	H
Sedum spurium	Crassulaceae	Eur	N	**NA**	**NA**
Solanum pseudocapsicum	Solanaceae	SAm	N	**NA**	**NA**
Spathodea campanulata	Bignoniaceae	SAm	Y	N	**L**
Syringa vulgaris	Oleaceae	Eur	N	**NA**	**NA**
Tagetes erecta	Asteraceae	NAm	**N**	Y	M
Tagetes patula	Asteraceae	SAm	N	**NA**	**NA**
Thunbergia alata	Acanthaceae	Afr	Y	N	**L**
Tipuana tipu	Fabaceae	SAm	N	**NA**	**NA**
Ulmus pumila	Ulmaceae	As, AT	Y	Y	**L**
Washingtonia filifera	Arecaceae	NAm	N	**NA**	**NA**
Zinnia elegans	Asteraceae	SAm	N	**NA**	**NA**
c) Naturalized species					
Actinidia chinensis	Actinidiaceae	As	**N**		
Aeonium arboreum	Crassulaceae	Afr	**N**		
Aesculus hippocastanum	Sapindaceae	Eur	**N**		
Alnus cordata	Betulaceae	Eur	**N**		
Ammannia coccinea	Lythraceae	NAm	**N**		
Anethum graveolens	Apiaceae	Afr	**N**		
Anthurium scherzerianum	Anthuriaceae	As-Eur	**N**		
Aptenia cordifolia	Aizoaceae	Afr	**N**		
Aquilegia vulgaris	Ranunculaceae	As, Eur	**N**		
Austrocylindropuntia cylindrica	Cactaceae	SAm	**N**		
Bougainvillea glabra	Nyctaginaceae	SAm	**N**		
Cedrus atlantica	Pinaceae	Afr	**N**		
Cerastium tomentosum	Caryophyllaceae	Eur	**N**		
Chamaecyparis lawsoniana	Cupressaceae	NAm	**N**		

	Family	Native distribution	Invasive elsewhere	Climate suitability	Confidence
Chamaedorea elegans	Arecaceae	NAm	**N**		
Crataegus azarolus	Rosaceae	Afr, As, Eur	**N**		
Cuminum cyminum	Apiaceae	Eur	**N**		
Cupressus sempervirens	Cupressaceae	Eur	**N**		
Erysimum odoratum	Brassicaceae	Eur	**N**		
Euphorbia milli	Euphorbiaceae	Afr	**N**		
Hydrangea macrophylla	Hydrangeaceae	As	**N**		
Hydrocotyle verticilata	Araliaceae	NAm	**N**		
Hypericum calycinum	Hypericaceae	Eur	**N**		
Impatiens walleriana	Balsaminaceae	Afr	**N**		
Laburnum anagyroides	Fabaceae	Eur	**N**		
Lonicera nitida	Caprifoliaceae	AS	**N**		
Mespilus germanica	Rosaceae	As, Eur	**N**		
Parthenocissus tricuspidata	Vitaceae	As, AT	**N**		
Pelargonium graveolens	Geraniaceae	Afr	**N**		
Pelargonium peltatum	Geraniaceae	Afr	**N**		
Petroselinum crispum	Apiaceae	Eur	**N**		
Phoenix dactylifera	Arecaceae	As	**N**		
Physocarpus opulifolius	Rosaceae	NAm	**N**		
Picea abies	Pinaceae	Eur	**N**		
Picea omorika	Pinaceae	Eur	**N**		
Prunus cerasifera	Rosaceae	Eur	**N**		
Prunus laurocerasus	Rosaceae	As	**N**		
Pyrostegia venusta	Bignoniaceae	SAm	**N**		
Quercus rubra	Fagaceae	NAm	**N**		
Salix viminalis	Salicaceae	Eur	**N**		
Sequoiadendron giganteum	Cupressaceae	NAm	**N**		
Styphnolobium japonicum	Fabaceae	As	**N**		
Tamarix parviflora	Tamaricaceae	Afr	**N**		
Vitis vinifera	Vitaceae	Eur	**N**		
Washingtonia robusta	Arecaceae	NAm	**N**		
Yucca gloriosa	Agavaceae	NAm	**N**		

Appendix 4

Table A4. **Data deficient list.** The Data Deficient List includes species for which we did not have sufficient data for analysis. Native distribution: Afr: Africa; As: Asia (Temperate); AT: Asia (Tropical); Aus: Australia; Eur: Europe; NAm: North America; Pac: Pacific; SAm: South and Center America.

Species with deficient data	Family	Native distribution
Abelia chinensis	Caprifoliaceae	As
Abelia floribunda	Caprifoliaceae	Nam
Abies concolor	Pinaceae	NAm
Abies koreana	Pinaceae	As
Abies nordmanniana	Pinaceae	As, Eur
Abies procera	Pinaceae	NAm
Acacia floribunda	Fabaceae	Aus
Acacia pendula	Fabaceae	Aus
Acca sellowiana	Myrtaceae	SAm
Acer palmatum	Sapindaceae	As
Acer rubrum	Sapindaceae	NAm
Acer saccharinum	Sapindaceae	NAm
Acorus gramineus	Acoraceae	AT, AS
Actinidia arguta	Actinidiaceae	As
Actinidia deliciosa	Actinidiaceae	As
Adenium obesum	Apocynaceae	Afr
Aechmea fasciata	Bromeliaceae	SAm
Agapanthus africanus	Amaryllidaceae	Afr
Agave attenuata	Agavaceae	SAm
Agave bracteosa	Agavaceae	NAm
Agave filifera	Agavaceae	SAm
Agave guiengola	Agavaceae	SAm
Agave horrida	Agavaceae	SAm
Agave lechuguilla	Agavaceae	SAm
Agave macroacantha	Agavaceae	SAm
Agave salmiana	Agavaceae	SAm
Agave victoriae-reginae	Agavaceae	SAm
Agave xylonacantha	Agavaceae	SAm
Allagoptera arenaria	Arecaceae	SAm
Allium schoenoprasum	Amaryllidaceae	NAm
Alocasia wentii	Araceae	Aus
Aloe marlothii	Liliaceae	Afr
Aloe variegata	Xanthorrhoeaceae	Afr
Alpinia caerulea	Zigimberaceae	Aus
Alternanthera peruensis	Amaranthaceae	SAm
Alternanthera reinekii	Amaranthaceae	SAm
Alternanthera rosaeivolia	Amaranthaceae	SAm
Anacardium occidentale	Anacardiaceae	SAm
Andromeda polifolia	Ericaceae	Eur, As, NAm
Anemanthele lessoniana	Poaceae	Aus
Anemone blanda	Ranunculaceae	Eur
Anisodontea capensis	Malvaceae	Afr

Species with deficient data	Family	Native distribution
Aphelandra squarrosa	Acanthaceae	SAm
Arabis alpina	Brassicaceae	AT
Araucaria araucana	Araucariaceae	SAm
Araucaria heterophylla	Araucariaceae	Aus
Archontophoenix alexandrae	Arecaceae	Aus
Archontophoenix purpurea	Arecaceae	Aus
Arctotis fastuosa	Asteraceae	Afr
Arenga engleri	Arecaceae	AT
Argyranthemum frutescens	Asteraceae	Afr
Arrojadoa rhodantha	Cactaceae	SAm
Asparagus setaceus	Asparagaceae	Afr
Aspidistra elatior	Asparagaceae	AT
Athyrium nipponicum	Athyriaceae	As
Aucuba japonica	Garryaceae	As
Balantium antarcticum	Dicksoniaceae	Aus
Banksia integrifolia	Proteaceae	Aus
Bauhinia purpurea	Fabaceae	SAm
Beaucarnea recurvata	Asparagaceae	SAm
Begonia cucullata	Begoniaceae	AT
Begonia rex	Begoniaceae	AT
Berberis julianae	Berberidaceae	As
Berberis microphylla	Berberidaceae	SAm
Bergenia cordifolia	Saxifragaceae	As
Beschorneria yuccoides	Agavaceae	NAm
Betula papyrifera	Betulaceae	NAm
Betula utilis	Betulaceae	As
Boronia crenulata	Rutaceae	Aus
Boswellia carterii	Burseraceae	Afr
Brachychiton acerifolius	Malvaceae	Aus
Brachychiton bidwillii	Malvaceae	Aus
Brachychiton discolor	Malvaceae	Aus
Brachychiton rupestris	Malvaceae	Aus
Brachyscome multifida	Asteraceae	Aus
Brasiliopuntia brasiliensis	Cactaceae	SAm
Bulbine frutescens	Liliaceae	Afr
Butia eriospatha	Arecaceae	SAm
Butia yatai	Arecaceae	SAm
Buxus microphylla	Buxaceae	As
Callistemon viminalis	Myrtaceae	Aus
Callistephus chinensis	Asteraceae	As
Callitropsis nootkatensis	Cupressaceae	NAm
Calothamnus quadrifidus	Myrtaceae	Aus
Camellia japonica	Theaceae	As
Camellia sasanqua	Theaceae	As
Campanula carpatica	Campanulaceae	Eur
Campanula isophylla	Campanulaceae	Eur
Carex comans	Cyperaceae	Aus
Carica papaya	Caricaceae	SAm

Species with deficient data	Family	Native distribution
Carissa macrocarpa	Apocynaceae	Afr
Carya illinoinensis	Juglandaceae	NAm
Caryota maxima	Arecaceae	Eur
Caryota mitis	Arecaceae	AT
Caryota urens	Arecaceae	AT
Casimiroa edulis	Rutaceae	SAm
Catalpa bungei	Bignoniaceae	As
Ceanothus integerrimus	Rhamnaceae	NAm
Ceiba speciosa	Malvaceae	SAm
Celtis occidentalis	Cannabaceae	NAm
Cephalocereus senilis	Cactaceae	NAm
Cercidiphyllum japonicum	Cercidiphyllaceae	As
Cereus jamacaru	Cactaceae	SAm
Ceropegia woodii	Apocynaceae	Afr
Chaenomeles japonica	Rosaceae	As
Chamaecyparis obtusa	Cupressaceae	As
Chamaecyparis pisifera	Cupressaceae	As
Chamaecyparis thyoides	Cupressaceae	NAm
Chambeyronia macrocarpa	Arecaceae	Aus
Chamelaucium uncinatum	Myrtaceae	Aus
Chlorophytum comosum	Agavaceae	Afr
Choisya ternata	Rutaceae	NAm
Citronella mucronata	Cardiopteridaceae	SAm
Citrus limetta	Rutaceae	As
Citrus medica	Rutaceae	AT
Citrus reticulata	Rutaceae	As
Cleistocactus strausii	Cactaceae	SAm
Cleyera japonica	Pentaphylacaceae	As
Cocos nucifera	Arecaceae	Afr, AT, SAm, Pac
Codiaeum variegatum	Euphorbiaceae	AT
Convolvulus cneorum	Convolvulacea	Eur, Afr
Copernicia alba	Arecaceae	SAm
Cordyline fruticosa	Asparagaceae	AT
Cordyline indivisa	Asparagaceae	Aus
Coreopsis grandiflora	Asteraceae	NAm
Cornus controversa	Cornaceae	As
Cornus forida	Cornaceae	NAm
Cornus kousa	Cornaceae	As
Corylus colurna	Betulaceae	As, Eur
Corylus maxima	Betulaceae	Eur
Cotoneaster coriaceus	Rosaceae	AT
Cotoneaster dammeri	Rosaceae	As
Cotoneaster salicifolius	Rosaceae	As
Crassula sarcocaulis	Crassulaceae	Afr
Crotalaria capensis	Fabaceae	Afr
Cryptocoryne albida	Araceae	AT
Cryptocoryne parva	Araceae	AT
Cryptocoryne pygmaea	Araceae	AT

Species with deficient data	Family	Native distribution
Cryptocoryne tonkinensis	Araceae	AT
Cryptocoryne walkeri	Araceae	AT
Cryptocoryne wendtii	Araceae	AT
Cryptomeria japonica	Cupressaceae	As
Cuphea hyssopifolia	Lythraceae	NAm
Cussonia spicata	Araliaceae	Afr
Cycas circinalis	Cycadaceae	AT
Cyclamen persicum	Primulaceae	Eur
Cyperus papyrus	Cyperaceae	Afr
Dasylirion lucidum	Asparagaceae	NAm
Dasylirion serratifolium	Asparagaceae	NAm
Delosperma congestum	Aizoaceae	Afr
Dianthus chinensis	Caryophyllaceae	As
Dieffenbachia seguine	Araceae	SAm
Dionaea muscipula	Droseraceae	NAm
Dioon edule	Zamiaceae	NAm
Dombeya tiliacea	Malvaceae	Afr
Dracaena braunii	Asparagaceae	Afr
Dracaena draco	Asparagaceae	Afr
Dracaena fragans	Asparagaceae	Afr
Dracaena reflexa	Asparagaceae	Afr
Drosanthemum speciosum	Aizoaceae	Afr
Dypsis decaryi	Arecaceae	Afr
Dypsis decipiens	Arecaceae	Afr
Dypsis lutescens	Arecaceae	Afr
Ecchinodorus tenellus	Alismataceae	NAm
Echinocactus grusonii	Cactaceae	NAm
Echinocereus nivosus	Cactaceae	NAm
Echinodorus ozelot	Alismataceae	NAm
Echinodorus paniculatus	Alismataceae	NAm
Echinodorus parviflora	Alismataceae	NAm
Echinodorus tenellus	Alismataceae	NAm
Echinopsis eyriesii	Cactaceae	SAm
Echinopsis huascha	Cactaceae	SAm
Echinopsis macrogona	Cactaceae	SAm
Egeria najas	Hydrocharitaceae	SAm
Ensete ventricosum	Musaceae	Afr
Epipremnum aureum	Araceae	AT
Erythrina caffra	Fabaceae	Afr
Erythrina crista-galli	Fabaceae	SAm
Erythrina falcata	Fabaceae	SAm
Escallonia macrantha	Escalloniaceae	SAm
Espostoa guentheri	Cactaceae	SAm
Espostoa lanata	Cactaceae	SAm
Eucalyptus coccifera	Myrtaceae	Aus
Eucalyptus nitens	Myrtaceae	Aus
Eucalyptus parvifolia	Myrtaceae	Aus
Eugenia brasiliensis	Myrtaceae	SAm

Species with deficient data	Family	Native distribution
Euphorbia abyssinica	Euphorbiaceae	Afr
Euphorbia avasmontana	Euphorbiaceae	SAm
Euphorbia baioensis	Euphorbiaceae	Afr
Euphorbia ingens	Euphorbiaceae	Afr
Euphorbia martinae	Euphorbiaceae	Afr
Euphorbia pseudocactus	Euphorbiaceae	Afr
Euphorbia pulcherrima	Euphorbiaceae	SAm
Euphorbia trigona	Euphorbiaceae	Afr
Euryops chrysanthemoides	Asteraceae	Afr
Euryops pectinatus	Asteraceae	Afr
Exacum affine	Gentianaceae	Afr
Fatsia japonica	Araliaceae	As
Felicia amelloides	Asteraceae	Afr
Ferocactus emoryi	Cactaceae	NAm
Ferocactus glaucescens	Cactaceae	NAm
Ferocactus gracilis	Cactaceae	NAm
Ferocactus pilosus	Cactaceae	NAm
Ficus macrophylla	Moraceae	Aus
Firmiana simplex	Malvaceae	As, AT
Fissidens fontanus	Flissidentaceae	NAm
Fontinalis antipyretica	Fontanilaceae	NAm
Fortunella japonica	Rutaceae	As
Gazania splendens	Asteraceae	Afr
Gelsemium sempervirens	Gelsemiaceae	NAm
Genista lydia	Fabaceae	Eur
Ginkgo biloba	Ginkgoaceae	As
Grevillea juniperina	Proteaceae	Aus
Grevillea lanigera	Proteaceae	Aus
Griselinia littoralis	Griseliniaceae	Aus
Hamamelis virginiana	Hammamelidaceae	NAm
Handroanthus chrysanthus	Bignoniaceae	SAm
Hardenbergia comptoniana	Fabaceae	Aus
Haworthia fasciata	Xanthorrhoeaceae	Afr
Hebe diosmifolia	Plantaginaceae	Aus
Hebe odora	Plantaginaceae	Aus
Hebe topiaria	Plantaginaceae	Aus
Hedera algeriensis	Araliaceae	Afr
Hedera canariensis	Araliaceae	Afr
Hottonia inflata	Primulaceae	NAm
Howea forsteriana	Arecaceae	Pac
Hoya carnosa	Asclepiadaceae	AT, Aus
Hydrangea paniculata	Hydrangeaceae	As
Hydrocotyle tripartita	Araliaceae	Aus
Impatiens hawkeri	Balsaminaceae	Aus
Jasminum grandiflorum	Oleaceae	Afr, AT
Jasminum meznyi	Oleaceae	As
Jubaea chilensis	Arecaceae	SAm
Juniperus chinensis	Cupressaceae	As

Species with deficient data	Family	Native distribution
Juniperus horizontalis	Cupressaceae	NAm
Juniperus scopulorum	Cupressaceae	NAm
Juniperus squamata	Cupressaceae	As
Justicia brandegeeana	Acanthaceae	SAm
Kalanchoe beharensis	Crassulaceae	Afr
Kalanchoe blossfeldiana	Crassulaceae	Afr
Kerria japonica	Rosaceae	As
Koelreuteria bipinnata	Sapindaceae	As
Lampranthus spectabilis	Aizoaceae	Afr
Leucanthemum paludosum	Asteraceae	Eur
Leucothoe fontanesiana	Ericaceae	NAm
Licuala grandis	Arecaceae	Aus
Ligustrum japonicum	Oleaceae	As
Liquidambar styraciflua	Hammamelidaceae	NAm
Liriodendron tulipifera	Magnoliaceae	NAm
Litchi chinensis	Sapindaceae	AT
Livistona australis	Arecaceae	Aus
Lobelia cardinalis	Campanulaceae	NAm
Lomariopsis lineata	Lomaropsidaceae	AT, Aus
Lophophora williamsii	Cactaceae	NAm
Macrozamia communis	Cicadaceae	Aus
Magnolia denudata	Magnoliaceae	As
Magnolia grandiflora	Magnoliaceae	NAm
Magnolia stelllata	Magnoliaceae	As
Malpighia emarginata	Malpighiaceae	SAm
Malus floribunda	Rosaceae	As
Mammillaria geminispina	Cactaceae	NAm
Mammillaria magnifica	Cactaceae	NAm
Mammillaria rhodantha	Cactaceae	NAm
Melaleuca ericifolia	Myrtaceae	Aus
Melaleuca linearis	Myrtaceae	Aus
Melocactus neryi	Cactaceae	SAm
Melocactus zehntneri	Cactaceae	SAm
Mentha crispata	Lamiaceae	Cosm
Metasequoia glyptostroboides	Taxodiaceae	As
Metrosideros excelsa	Myrtaceae	Aus
Micranthemum callitrichoides	Scrophulariaceae	SAm
Micranthemum micranthemoides	Scrophulariaceae	NAm
Micromeria fructicosa	Lamiaceae	Eur
Microsorum pteropus	Polypodiaceae	AT
Morus australis	Moraceae	AT
Musa acuminata	Musaceae	AT, Aus
Musa basjoo	Musaceae	As
Myriophyllum mattogrossense	Haloragidaceae	SAm
Myrtillocactus geometrizans	Cactaceae	NAm
Nannorrhops ritchieana	Arecaceae	As
Nasella tenuissima	Poaceae	SAm
Nemesia strumosa	Scrophulariaceae	Afr

Species with deficient data	Family	Native distribution
Nertera granadensis	Rubiaceae	SAm, Pac
Nolina longifolia	Asparagaceae	NAm
Nyssa sylvatica	Cornaceae	NAm
Opuntia macrocentra	Cactaceae	NAm
Opuntia pubescens	Cactaceae	SAm
Oreocereus celsianus	Cactaceae	SAm
Oreocereus doelzianus	Cactaceae	SAm
Oreocereus leucotrichus	Cactaceae	SAm
Osmanthus heterophyllus	Oleaceae	As
Ostrya carpinifolia	Betulaceae	Eur
Pachira aquatica	Bombacaceae	SAm
Pachycereus marginatus	Cactaceae	NAm
Pachycereus pecten-aboriginum	Cactaceae	NAm
Pachycereus pringlei	Cactaceae	NAm
Pachypodium lamerei	Apocynaceae	Afr
Pachysandra terminalis	Buxaceae	As
Pandanus utilis	Pandanaceae	Afr
Pandorea jasminoides	Bignoniaceae	Aus
Panicum virgatum	Poaceae	NAm
Parajubaea cocoides	Arecaceae	SAm
Parajubaea torrallyi	Arecaceae	SAm
Parrotia persica	Hamamelidaceae	Eur
Passiflora incarnata	Passifloraceae	SAm
Passiflora manicata	Passifloraceae	SAm
Pelargonium grandiflorum	Geraniaceae	Afr
Pellia epiphylla	Pelliaceae	As, Eur, NAm, Afr
Pennisetum alopecuroides	Poaceae	As, AT, Aus
Pennisetum messiacum	Poaceae	Afr
Pennisetum orientale	Poaceae	Afr, AT
Pentas lanceolata	Rubiaceae	Afr
Pereskiopsis rotundifolia	Cactaceae	NAm
Persea americana	Lauraceae	SAm
Phanera variegata	Fabaceae	AT
Philodendron bipinnatifidum	Araceae	SAm
Philodendron tuxtla	Araceae	SAm
Phlox subulata	Polemoniaceae	NAm
Phoenix reclinata	Arecaceae	Afr
Phoenix roebelenii	Arecaceae	As, AT
Phoenix theophrasti	Arecaceae	Eur
Phyllostrachys aurea	Poaceae	As
Picea glauca	Pinaceae	NAm
Picea koraiensis	Pinaceae	As
Picea pungens	Pinaceae	NAm
Pieris japonica	Ericaceae	As, AT
Pilosocereus leucocephalus	Cactaceae	NAm
Pilosocereus pachycladus	Cactaceae	SAm
Pinus brutia	Pinaceae	Eur
Pinus mugo	Pinaceae	SAm

Species with deficient data	Family	Native distribution
Pinus palustris	Pinaceae	NAm
Pistacia atlantica	Anacardiaceae	Afr
Pistacía chinensis	Anacardiaceae	As
Platanus orientalis	Platanaceae	Eur
Plectranthus verticillatus	Lamiaceae	Afr
Plumeria alba	Apocynaceae	SAm
Plumeria rubra	Apocynaceae	SAm
Polaskia chichipe	Cactaceae	NAm
Polaskia chula	Cactaceae	NAm
Polianthes tuberosa	Amaryllidaceae	SAm
Polygala myrtifolia	Polygalaceae	Afr
Portulaca umbraticola	Portulacaceae	NAm
Primula obconica	Primulaceae	As
Pritchardia hillebrandii	Arecaceae	Pac
Prunus serrulata	Rosaceae	As
Prunus subhirtella	Rosaceae	As
Pseudophoenix sargentii	Arecaceae	NAm
Pterocarya fraxinifolia	Juglandaceae	Eur
Puya chilensis	Bromeliaceae	SAm
Pyrus pyrifolia	Rosaceae	As
Quercus palustris	Fagaceae	NAm
Radermachera sinica	Bignoniaceae	AT
Ranunculus asiaticus	Ranunculaceae	Eur, Afr
Ravenala madagascariensis	Strelitziaceae	Afr
Ravenea rivularis	Arecaceae	Afr
Rhapidophyllum hystrix	Arecaceae	NAm
Rhapis excelsa	Arecaceae	As
Rhododendron arboreum	Ericaceae	AT
Rhododendron molle	Ericaceae	As
Ribes nigrum	Grossulariaceae	Eur
Ribes sanguineum	Grossulariaceae	NAm
Rotala rotundifolia	Lythraceae	AT
Roystonea regia	Arecaceae	NAm
Rubus spectabilis	Rosaceae	NAm
Russelia equisetiformis	Scrophulariaceae	NAm
Sabal mexicana	Arecaceae	NAm
Sabal minor	Arecaceae	NAm
Sabal palmetto	Arecaceae	NAm
Salix integra	Salicaceae	As
Salix matsudana	Salicaceae	As
Sansevieria perrottii	Asparagaceae	Afr
Schefflera arboricola	Araliaceae	AT
Scindapsus pictus	Araceae	AT
Sedum spectabile	Crassulaceae	As
Selaginella lepidophylla	Selaginellaceae	NAm
Sequoia sempervirens	Cupressaceae	NAm
Skimmia japonica	Rutaceae	As
Sorbus intermedia	Rosaceae	Eur

Species with deficient data	Family	Native distribution
Sorbus torminalis	Rosaceae	Eur, Afr
Staurogyne repens	Acanthaceae	SAm
Stenocarpus sinuatus	Proteaceae	Aus
Stephanotis floribunda	Apocynaceae	Afr
Stetsonia coryne	Cactaceae	SAm
Stevia rebaudiana	Asteraceae	SAm
Strelitzia nicolai	Stelitziaceae	Afr
Strelitzia reginae	Stelitziaceae	Afr
Syagrus romanzoffiana	Arecaceae	SAm
Syagrus yungasensis	Arecaceae	SAm
Symphoricarpos orbiculatus	Caprifoliaceae	NAm
Taxiphyllum alternans	Hypnaceae	AT
Taxiphyllum barbieri	Hypnaceae	AT
Taxodium distichum	Taxodiaceae	NAm
Tetraclinis articulata	Cupressaceae	Afr
Thuja occidentalis	Cupressaceae	NAm
Thuja plicata	Cupressaceae	NAm
Thymus citriodorus	Lamiaceae	Cosm
Tilia americana	Malvaceae	NAm
Tilia tormentosa	Malvaceae	Eur
Tillandsia flabellata	Bromeliaceae	SAm
Trachelospermum jasminoides	Apocynaceae	As, AT
Trachycarpus martianus	Arecaceae	As
Trithrinax campestris	Arecaceae	SAm
Ugni molinae	Myrtaceae	SAm
Utricularia graminifolia	Lentibulariaceae	AT
Vaccinum macrocarpon	Ericaceae	NAm
Vallisneria americana	Hydrocharitaceae	NAm
Vallisneria caulescens	Hydrocharitaceae	Aus
Veitchia joannis	Arecaceae	Aus
Vesicularia dubyana	Hypnaceae	AT
Vesicularia montagnei	Hypnaceae	AT
Viburnum davidii	Adoxaceae	As
Viburnum plicatum	Adoxaceae	As
Viburnum sargentii	Adoxaceae	As
Vriesea splendens	Bromeliaceae	SAm
Weigela florida	Diervillaceae	As
Wodyetia bifurcata	Arecaceae	Aus
Xerochrysium bracteatum	Asteraceae	Aus
Yucca elephantipes	Agavaceae	SAm
Yucca filamentosa	Agavaceae	NAm
Yucca filifera	Agavaceae	NAm
Yucca glauca	Agavaceae	NAm
Yucca rostrata	Agavaceae	NAm
Zamia furfuracea	Zamiaceae	NAm
Zamioculcas zamiifolia	Araceae	Afr
Zelkova carpinifolia	Ulmaceae	Eur