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Terrestrial Alien Flora of the Iberian Alboran Coast: Assessment, Attributes, and Future Implications

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Abstract: Although Mediterranean coastal regions in southern Spain have high floristic diversity and numerous Habitats of Community Interest (HCIs) identified by the European Union Directive Council, they are also vulnerable to invasive plants. In our study, we aimed to create a checklist of terrestrial alien taxa in the Iberian area of the Alboran coast, assess each species' current invasion, analyse the influence of environmental attributes on invasion, estimate the richness of alien species per HCI group, and evaluate each species' potential invasiveness based on its reproductive and dispersal attributes. The checklist that we developed includes 123 alien taxa, most belonging to the Asteraceae, Asparagaceae, and Poaceae families. Notably, 20% of the species are *super invaders* that occupy more than 20% of HCIs. We also identified *Aloe vera*, *Cylindropuntia* spp., *Agave salmiana*, *Opuntia* spp., and *Paspalum* spp. as incipient invaders with the potential for future expansion. Although most alien flora in the HCIs are not regulated by Spanish legislation (RDL 630/2013), monitoring and eradication plans are crucial. Advocating the cessation of using those plants in gardens and reducing anthropogenic pressure are also essential, as human activities worsen invasion dynamics and facilitate the introduction and establishment of invasive species.

Keywords: plant invasion; Mediterranean coast; Habitat of Community Interest; invasive species; coastal habitat; anthropisation; Málaga; Granada; invasiveness

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1. Introduction

The Mediterranean coastline has long been recognised as an area that faces significant anthropogenic pressure with profound ecological and biological implications [1]. Among those implications, the invasion of non-native plant species poses a substantial threat to the region's native ecosystems and biodiversity [2–6]. The terrestrial coastal areas of the Mediterranean Basin, exhibiting a remarkable diversity of alien species compared with other European coastlines, are particularly vulnerable to the establishment and spread of invasive plants [7,8]. Those invasions have far-reaching consequences for both the ecological integrity and functionality of such delicate terrestrial coastal ecosystems [9–11].

Within the Mediterranean Basin, the Alboran Sea area, given its location between Europe and Africa, stands out as an area of great biodiversity, especially in the coastal areas of Andalusia in southern Spain. There, the terrestrial coastal habitats of the provinces of Málaga and Granada represent a biogeographical transitional zone between Atlantic and Mediterranean coastal flora [12]. The area exhibits important floristic diversity and a host of Habitats of Community Interest (HCI) included in Annex I of the Habitats Directive (Council Directive 92/43/EEC), the legislative instrument that establishes a framework for the conservation of wild plant and animal species and natural habitats of interest to the European community (Council Directive 92/43/EEC) [13]. In general, HCIs are divided into nine major groups that together encompass an array of environmental variables, characteristics, and floristic compositions [14]. In the Iberian Alboran Sea area, the current classification [15] covers a wide gradient of ecosystems, from halophytic habitats and coastal sand dunes (i.e., Groups 1 and 2), to sandbanks covered by sea water (i.e., Group 3), sclerophyllous scrublands (i.e., Group 5), natural and semi-natural grassland (i.e., Group 6), calcareous fens (i.e., Group 7), and riparian forests (i.e., Group 9). For their part, the provinces of Málaga and Granada contain 26 HCIs, mostly in Groups 1 and 2, which provide numerous essential functions, help to reduce the territory's vulnerability to climate change, and thereby enhance its overall resilience [16–18]. One of the primary ecosystem services provided by coastal ecosystems, which act as natural barriers [19,20], is coastal protection against strong winds, waves, and sea-level rise. For that reason, it is important to preserve those ecosystems and protect them from invasive species.

The first steps towards conserving coastal habitats from terrestrial plant invasions are to collect information on all alien plants present and to conduct regional studies that serve as a basis for designing and prioritising appropriate future management strategies [8,21–24]. Such studies should provide information about species' geographical origin, biology, ecology, pathways of introduction, and degree of naturalisation or invasiveness. To date, however, only some studies have partly registered the presence of invasive alien plants on Mediterranean coastlines, including in protected natural areas [12,25], on Mediterranean islands [26], and on coastal dunes [27,28]. Other studies [29] have addressed specific coastal areas in the province of Málaga (i.e., 'Mouth of the Guadalhorce river'). Nevertheless, specific, in-depth studies on Málaga's and Granada's terrestrial coasts have yet to be conducted.

Previous studies on Mediterranean terrestrial coasts have also been based solely on data regarding the presence, not abundance, of alien species, despite the latter's importance for estimating invasiveness and understanding the potential impact of such species on the ecosystems which they inhabit [30,31]. In particular, impacts on native plants and native responses to invasion are critically affected by the local abundance of invasive species [10]. Some habitats are invaded by only one or a few species that have achieved high coverage as reptant lifeforms and have thus transformed the surrounding ecosystems [31]. Indeed, the abundance of a species is one of three attributes of invasiveness, along with geographical range and niche breadth [32]. It has been demonstrated that an alien species with greater niche breadth can tolerate different conditions, colonise new areas [33,34], and probably become an invader. Along the same lines, species with a greater geographical range are probably the result of greater dispersal capacity [35]. Species with high values in those three criteria are called *super invaders* [32]. A first step towards pinpointing a species' invasion in an area and prioritising efforts of conservation is identifying whether there are *super invaders* in the area and, if so, to plan to eradicate or control them. The study of *super invaders* also allows us to identify biological traits that make them prone to invasiveness or successful as invaders, including biotype, adaptability, tolerance to varying conditions, and efficient reproductive and/or dispersal mechanisms [33,36–38]. Knowing those traits allows us to establish a basis for predicting potentially invasive species in other areas [39].

Although the success of invasive plants depends on those intrinsic traits of species, it can also be influenced by extrinsic traits that favour invasion. For example, time of residence can increase the probability of invasion and has been associated with a wider distribution of alien plants [40]. Another factor facilitating invasion is the level of disturbances in the recipient ecosystem, such that more degraded ecosystems are more prone to invasions [21]. Along similar lines, the intentional introduction of some species for human activities or specific uses (e.g., silviculture, horticulture, and ornamental uses) can provide alien plants with more opportunities to colonise and expand from the source population [41,42]. Distinguishing the key attributes and factors related to plants' invasiveness is crucial for prioritising actions to curb invasion. By prioritising species based on their invasiveness, limited resources can be efficiently allocated, and efforts can be focused on eradicating or monitoring only the most significant invasive species.

Because registering invasive plants in the Mediterranean coastal zone is crucial for effective conservation and management strategies in such a unique coastal terrestrial environment, in our study we sought to develop an initial checklist of terrestrial vascular alien plant species for the Iberian coasts of the Alboran Sea (i.e., provinces of Málaga and Granada), including data regarding abundance, for use in preliminary quantitative and qualitative analyses conducted to manage areas therein. We focused on studying the invasiveness and related attributes of alien species along the coastline of Málaga and Granada, particularly within the HCIs of the Habitats Directive (Council Directive 92/43/EEC) [13]. To that end, we formulated five research questions:

1. Which alien species are present along the coastlines of Málaga and Granada?
2. What is the current invasion of alien species in the study area, and which attributes could influence their invasion?
3. Which HCI exhibits the greatest richness of alien species, and what is the occupancy of alien species in each HCI?
4. Which species have the potential to become invasive in the study area?
5. Which geographical areas along the coastlines of Málaga and Granada have the highest presence of invasive species?

To answer those questions, we first described the alien taxa present in the studied area. Second, we estimated the current invasion of the studied species based on local geographic range, number of HCIs occupied per species, and local abundance. In a follow-up, we assessed the influence of attributes such as biotype, biogeographical origin, pathways of introduction, and first year of introduction into the number of habitats occupied by the species. Third, we estimated the richness of alien species per HCI group and the occupancy of the alien species. Fourth, we estimated the potential invasiveness of species based on their reproductive and dispersal attributes, which we compared with the current invasion. Last, we created distribution maps for the most invasive species that can be used to manage and/or eradicate them from Mediterranean coastal areas, differentiating among 'eradication areas' and 'prevention areas'. Ultimately, our findings stand to broaden current understandings of the global challenge posed by invasive plants and provide valuable insights for developing targeted management strategies in Mediterranean coastal regions.

2. Materials and Methods

2.1. Study Area

The Alboran Sea area is located in the western Mediterranean Sea, between the coast of southern Spain and the north-eastern tip of Morocco. In our study, we focused on the Iberian part of the Alboran Sea, specifically the terrestrial coasts of the provinces of Málaga and Granada, covering approximately 66% of the Iberian part of the Alboran coast (Figure 1). We defined the area to be studied based on the maritime–terrestrial public domain (Law 22/1988) [43]. The area, including 254 km of coastline and totalling 57.26 km^2 in area, experiences a Mediterranean climate characterised by hot, dry summers and mild, wet winters. Summers are typically hot, with temperatures often exceeding 30 °C, while winters are mild and have average temperatures of approximately 15 °C. The mean annual precipitation is 400–600 mm [44]. The area comprises 26 terrestrial coastal ecosystems (i.e., HCIs), which are classified into several predefined groups: halophytic habitats (i.e., Group 1), coastal sand dunes (i.e., Group 2), freshwater habitats (i.e., Group 3), sclerophyllous scrublands (i.e., Group 5), natural and semi-natural grassland formations (i.e., Group 6), calcareous fens (i.e., Group 7), and riparian forests (i.e., Group 9). The HCIs' code names and its characteristics species in each HCI based on our fieldwork, the REDIAM [15], and the Habitats Directive (Council Directive 92/43/EEC) [13,45], are shown in the Supplementary Materials (Table S1).

2.2. Checklist of Vascular Alien Species

2.2.1. Data Collection

Data were collected during fieldwork conducted from 2021 to 2023 in the studied area. Given the area's relatively few natural and semi-natural locations due to anthropogenic influence, we performed an exhaustive sampling of all available natural and semi-natural sites in 299 localities across the area. In those localities, we recorded and mapped the presence of vascular alien plant taxa at each point using a handheld GPS and recorded their abundance based on the number of individuals present, categorised as 1–25 individuals, 25–50 individuals, 50–100 individuals, 100–500 individuals, or more than 500 individuals. Herbarium vouchers were identified and stored in the MGC Herbarium (GBIF, https://doi.org/10.15468/wnjg4w, accessed on 10 May 2020). Taxonomic nomenclature follows [46–48] and was combined with some taxonomic corrections [49].

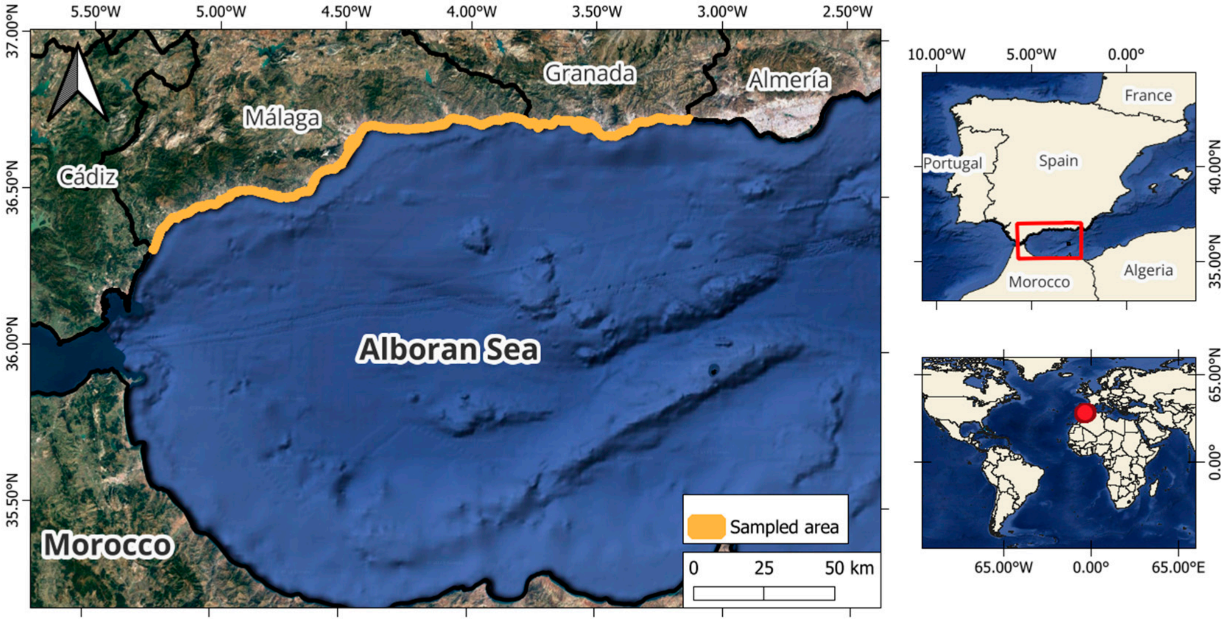

Figure 1. Study area, wherein orange represents the sampled area. Redbox shows location of the study area within the Iberian Peninsula.

To produce the most up-to-date checklist of alien flora, we complemented our data from fieldwork with herbarium records (i.e., based exclusively on preserved specimens) available from the GBIF for the studied area (GBIF occurrence data accessed on 10 May 2020 and downloaded at https://doi.org/10.15468/dl.6kbwc4 and https://doi.org/10.15468/dl.ckgpyr), and reviewed the literature filtered for the local associated toponymy [12,46–48,50] and also datasets [49,51,52].

We defined alien plant species as 'vascular and terrestrial plant taxa in each area whose presence there is due to intentional or unintentional human involvement, or which have arrived there without the help of people' [53]. By contrast, we defined naturalised species as 'alien species that are sometimes found in the wild and form persistent populations' [54]. Using those definitions, we selected alien species and naturalised species by consulting the literature [46,48,55–57]. From there, a taxon was considered to be an invasive species when the literature [46,51,52] indicated invasive behaviour outside its native range.

A literature review aided us in completing the information about the alien species, including reproductive attributes (i.e., sexual/asexual mechanisms and seed production) [51], dispersal attributes (i.e., long-distance dispersal and type of dispersal) [51,58], and biotype [46,48,55], and in considering the following categories: Chamaephyte, Chamaephyte reptant, Geophyte, Hemicryptophyte, Hemicryptophyte reptant, Phanerophyte, Therophyte, and Therophyte reptant. We obtained data regarding pathways of introduction from field observation (e.g., species near gardens) and historical uses reported in the literature [57]. Subsequently, we categorised that information according to the Convention on Biological Diversity's categories [59] as escape, release (i.e., introduction for different purposes), and transport-contaminant. The first year of introduction (i.e., residence time) was based on the literature [57], and when that information was unavailable, we used the oldest record detected in Spain with reference to deposited herbarium data. That information allowed us to classify the species as neophytes (i.e., introduced after the 15th century), recent neophytes (i.e., introduced before 1970), and archaeophytes (i.e., introduced before the 15th century). Biogeographical origin was also obtained from the literature [49] and grouped into seven biogeographical realms, namely Afrotropical, Australasian, Neotropical, Nearctic, Palearctic, Indomalayan, and Oceanian [60]. Moreover, we checked whether our alien species are included in Spanish legislation regarding invasive species [61] and therefore have an eradication plan.

2.2.2. Data Collection in HCIs

During our fieldwork, we also documented the floristic composition of the native plant associations and their immediate surroundings at every point, wherever alien species were present. To ensure a rigorous, structured analysis, we followed the phytosociological approach outlined the literature [62] for conducting systematic, comprehensive inventories of vegetation. Accordingly, we assigned a floristic ascription to each floristic inventory based on our list of characteristic species per HCI developed for the studied area (Table S2) and the list of associated syntaxa elaborated by the Habitats Directive (Council Directive 92/43/EEC) [13,14] and by The Vegetation of the Iberian Peninsula [45]. Performing this step allowed us to determine the correspondence of every sampled locality to a specific HCI or lack thereof (i.e., 'non-HCI' area).

2.3. Current Invasion and Attributes Related with the Occupied HCI

2.3.1. Current Invasion of Alien Species in the Studied Area

To estimate the current invasion of the alien taxa, we subjected our data from fieldwork to a previously published method [32] to classify the species into three categories: *super invaders*, *moderate invaders*, and *poor invaders.* This classification method, based on the current status of species in the studied area, utilises three criteria: local geographic range, number of habitats occupied, and local abundance. First, local geographic range was determined by calculating the percentage of the area occupied by each species relative to the total sampled area. To that end, we employed QGIS to construct a 25 m buffer around each sampled point. The total area formed by all polygons was estimated in square kilometres (total = 504,915 m^2). Subsequently, we applied the same procedure to points with records of the presence of species, created a buffer for each point, and calculated the area of all polygons. This process was repeated for each species and resulted in the area occupied exclusively by each species. The resulting values are expressed here as percentages. Second, the number of habitats occupied was determined by counting the number of HCIs (i.e., using the total number of HCIs in the studied area), with at least one point of occurrence per species. Those values are also expressed as percentages. Third, and last, for local abundance, we selected the maximum abundance value reported per species and re-categorised it into two groups: non-abundant species (<25 ind.) and abundant species (>25 ind.).

Next, classifications of current invasion were defined based on the relative positions of the values for local geographic range, number of habitats occupied, and local abundance in relation to their respective threshold values. The threshold values were determined as the 0.75th percentile of the local geographic range and the 0.75th percentile of the number of HCI occupied (Figure S1). Last, following the literature [32], we identified the species according to their current invasion as follows:

- *Super invaders*, meaning abundant species with HCI percentages and occupied areas above threshold values;
- *Moderate invaders*, meaning either scarce species with HCI percentages and occupied areas above the threshold values or abundant species with HCI percentages and occupied areas below the threshold values; this category also includes scarce or abundant species with HCI percentages above the threshold value but occupied area percentages below the threshold value;

- *Poor invaders*, meaning scarce species with HCI percentages and occupied areas below the threshold value. For further details, see [32].

2.3.2. Relationship between the Attributes of Species and Number of Occupied HCIs

To assess the influence of the attributes of biotype, origin, pathway of introduction, and first year of introduction, we employed a generalised linear model with a negative binomial distribution for the number of HCIs occupied by alien species as a response variable ($\chi^2 = 301.25$, $p = 0.8701$). Statistical analysis was performed in R version 3.4.1 [63] with the glm.nb function from MASS package [64].

2.4. Richness and Occupancy of Alien Species per HCI

We estimated the richness of alien species per HCI by counting the number of alien species reported in each of the 26 HCIs in the studied area. From there, we estimated the richness of alien species by regrouping the 26 HCIs into 10 groups, based on our expertise about the ecological features and their floristic composition. The new list with the group names and compositions of the HCIs appears in the Supplementary Materials (Table S2).

Next, we defined occupancy as the proportion of sites wherein an alien species was found, and to assess each species' occupancy in the established HCI groups, we first calculated the percentage of total points per species present in each HCI group, after which we conducted a chi-square (χ^2) test to determine whether the differences in percentages per group were statistically significant. We repeated the same procedure to estimate the HCI's richness in terms of species classified as *super invaders*, *moderate invaders*, and *poor invaders* (see Section 2.3), that is, we calculated the percentage of species in each category within each HCI group and subsequently tested the differences between those categories using a chi-square test in R version 3.4.1 [63] with the chi-square function.

2.5. Potentially Invasive Species

To estimate the potential invasiveness of alien species recorded in our fieldwork, we examined the species' reproductive attributes (i.e., sexual vs. asexual reproduction) and dispersal characteristics (i.e., long-distance dispersal and type of dispersal). Based on that assessment, we categorised the species into three groups—*high invasiveness*, *medium invasiveness*, and *low invasiveness*—based on the literature [51,57] and our fieldwork. First, attributes were categorised according to established criteria [36,37,65]. Therein, *high-invasiveness species* (i.e., highly invasive species) are species that exhibit both sexual and prolific asexual reproduction, in addition to being dispersed over long distances by wind or animals; *medium-invasiveness species* (i.e., invasive species) are species with either only sexual or asexual reproduction and which are assisted in their dispersal by animals, wind, or water, or species possessing both sexual and asexual reproduction but that demonstrate unassisted dispersal or a non-specific type of dispersal; and *low-invasiveness species* (i.e., likely non-invasive at present) are species that rely solely on sexual reproduction and have unassisted or non-specific dispersal types. Second, when a species was reported to have both sexual and asexual reproduction in the literature, but we did not observe asexual reproduction in the studied area, we re-evaluated the categories based on our fieldwork and have reported only sexual reproduction and adjusted the final category accordingly. Similarly, if a species was reported in the literature to be dispersed by certain animals but those dispersal agents were not present in the area, then we also took that information into consideration.

To identify potentially invasive species in the studied area, we compared the classification of potential invasiveness (i.e., based on reproductive and dispersal attributes) with the current invasion already estimated. Next, we conducted a chi-square test to evaluate the significance of the differences and to assess whether the potential invasiveness (i.e., reproductive and dispersal attributes) affected the current invasion of species in the area.

2.6. Heat Distribution Maps and Management

Last, we created distribution maps for the most invasive species (i.e., *super invaders*) and potentially invasive species (see Section 2.5) in the study area based on the recorded presence of those species and by employing QGIS version 3.30.2. Specifically, we represented areas with the highest recorded presence of invasive species as the most invaded areas. In addition, we employed a systematic approach to delineate zones for the management and prevention of invasive species entry. For this purpose, the records of the presence of invasive species encompassing both *super invaders* and *potentially invader* species were overlapped with the shapefiles of Natural Protected Areas for Andalucia (Protected Natural Areas by RENPA, Law 2/1989, de 18 de julio) [66,67] and Natura 2000 sites Special Areas for Conservation (SAC) designated by the Habitats Directive Habitats Directive (Council Directive 92/43/EEC) [13,68]. This method made it possible to perform a zoning, distinguishing between areas where eradication plans are necessary, 'eradication areas', and areas where prevention plans could still be effective, 'prevention areas'.

'Eradication areas' were stablished based on the presence of at least 50% of the maximum recorded invasive species richness for the total protected areas. Conversely, 'prevention areas' were identified as locations where the invasive species richness constituted less than 50%. These areas often encompass regions characterized by either low species richness or a limited number of records on invasive species' presence. Furthermore, we applied the same criteria to classify non-protected areas, extending our efforts to identify zones for management and prevention beyond legally protected regions. Additionally, we identified which 'eradication' and 'prevention areas' were a priority to be managed. When an 'eradication area' was detected, the highest number of *super invaders* was designated as a top priority, while in 'prevention areas', we considered the highest number of potential invaders.

3. Results

3.1. Checklist of Terrestrial Alien Taxa (Naturalised and Invasive) in the Alboran Sea Area

In our fieldwork, we identified 96 alien terrestrial vascular plant taxa in the studied area. To that, we added 27 new taxa previously reported in the GBIF herbarium records for the area. The complete Checklist of Alien Plant Taxa records are shown in Supplementary Materials (Table S3). Of the total taxa, 12.5% of species were reported as naturalised species and 45.02% as invasive species. In the last category, only 14.08% of the taxa were reported as invasive species in Spanish legislation [61].

The alien taxa belonged to 43 taxonomic families and 86 genera. The families Asteraceae, Asparagaceae, and Poaceae had the most species, with 12, 12, and 11, respectively, followed by Amaranthaceae, Cactaceae, and Fabaceae, with seven species each. The most common biotype was phanerophyte (42.97%), followed by therophyte (16.05%) and chamaephyte (11.57%). The most common origins of the alien flora in the studied area were the American continent (35.92%) and African continent (26.06%), where the families Aizoaceae, Cactaceae, Solanaceae, and Asparagaceae are the families of the most invasive and naturalised species reported. More than 60% of the alien species exhibited both asexual and sexual reproduction; 83% of the alien species were found to disperse their diaspores by air, water, or animals, whereas the others were found to disperse through autochory or a non-specific dispersal syndrome. In terms of residence time, approximately 64% of alien species were neophytes, 24% were recent neophytes, and the rest were archaeophytes.

Regarding abundance, 26% of the alien taxa were recorded as having at least one point with more than 500 individuals (Figure 2). The most common taxa (i.e., appearing at >15% of all sampled points) and the most abundant ones (i.e., >500 individuals) were *Arundo donax* L., *Oxalis pes-caprae* L., and *Acacia saligna* (Labill.) H.L. Wendl. (Figure 2). By contrast, species such as *Aizoon pubescens* Eckl. & Zeyh., *Paspalum vaginatum* Sw., *Paspalum urveillei*, *Stenotaphrum secundatum* (Walter) Kuntze, *Kleinia neriifolia* Haw., and *Cortaderia selloana* (Schult. & Schult.f.) Asch. & Graebn. were not generally prevalent in the studied area but presented high abundance (i.e., >500 individuals) where they were recorded.

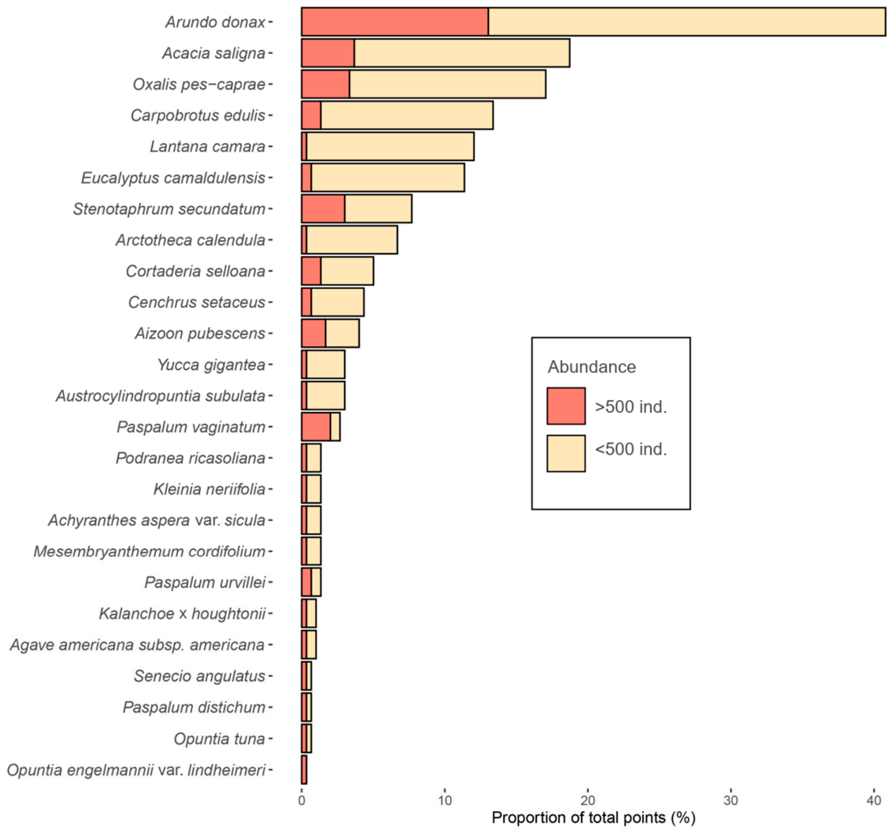

Figure 2. Percentage of points of the species and their abundance values relative to the total points sampled.

3.2. Current Invasion Degree of Alien Species Based on Geographic Range, Amount of Habitat Occupied by the Species, and Local Abundance

Of the total number of alien species found in the field sample, 19.5% were classified as *super invaders*, 39% as *moderate invaders*, and 41% as *poor invaders* (Figure 3). Among the *super invaders*, the highest values for both coverage area and number of HCIs occupied were found for *Arundo donax* and *Acacia saligna*, which occupied more than 20% of the studied area and more than 70% of the HCIs with high abundance (i.e., >500 individuals) (Figure 3). Other *super invaders*, including *Eucalyptus camaldulensis* Dehnh. And *Oxalis pes-caprae* L., occupied more than 60% of the total HCIs. The *super invaders*, *Carpobrotus edulis* (L.) L. Bolus and *Lantana camara* L. were present in more than 40% of the total HCIs and occupied more than 10% of the invaded area. By contrast, *Aizoon pubescens*, *Stenotaphrum secundatum*, and *Agave americana* covered less than 10% of the invaded area and occupied less than 30% of the total HCIs.

Among the *moderate invaders*, *Cylindropuntia × tetracantha*, *Cylindropuntia leptocaulis*, and *Kleinia nerifolia* were especially abundant. Although others such as *Paspalum vaginatum* and *Agave sisalana* Perrine ex Engelm. were abundant, they occupied only approximately 2.3% of the total area and appeared in only slightly more than 23% of the total HCIs.

Last, the category of *poor invaders* comprised species such as *Ailanthus altissima* (Mill.) Swingle, *Phoenix canariensis* H.Wildpret, and *Washingtonia filifera* (Rafarin) H.Wendl. ex de Bary. Those species occupied less than 10% of the HCIs and less than 1.5% of the total area studied. The list of species and their classifications appear in the Supplementary Materials (Table S4).

Relationship between Attributes of Species and Number of Occupied HCIs

The pathway of introduction and year of introduction were significantly associated with a higher current invasion ($p < 0.005$, Table 1). Moreover, species with an earlier year of introduction were present in more HCIs. Additionally, species with a pathway of introduction classified as 'release' had the highest number of occupied HCIs, followed by primarily ornamental species categorised under the 'escape' pathway (Figure S2).

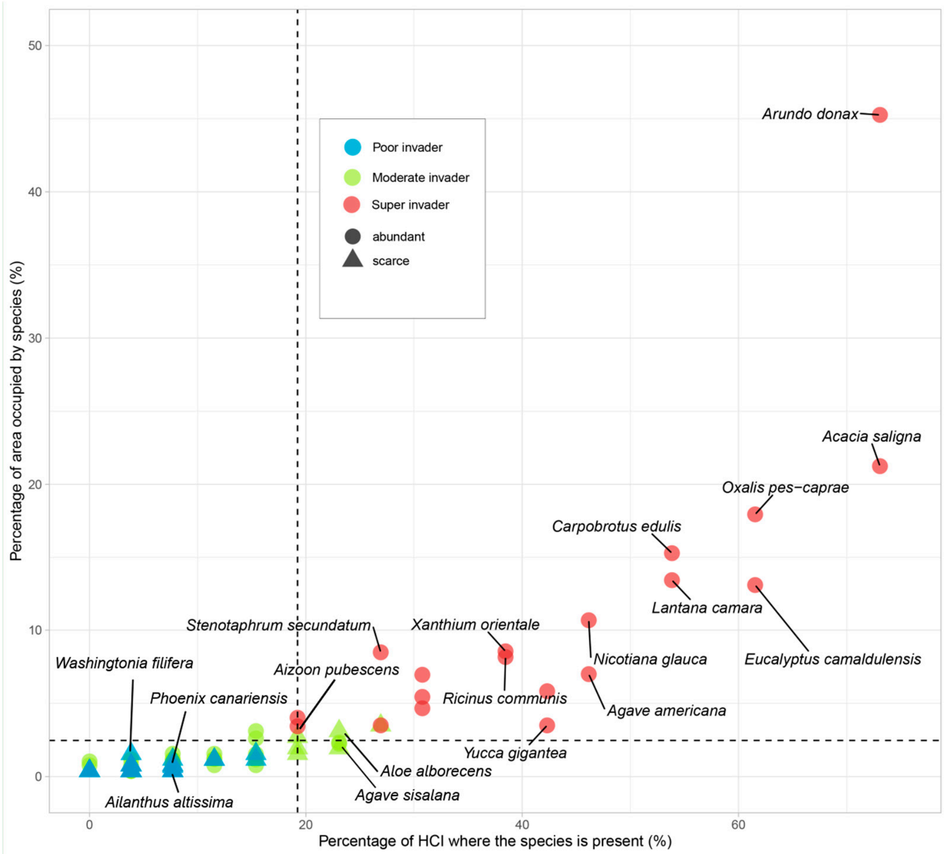

Figure 3. Classification of alien species (dots) according to the values of local geographic range, local habitat breadth, and local abundance in relation to their respective threshold values. Dotted lines represent the threshold at the 0.75th percentile for each variable, which equals 2.53% for the percentage of area occupied and 19.23% for the percentage of HCI occupied. Form represents maximum abundance reported per species. Circle: abundant (i.e., >25 individuals), triangle: not abundant.

Table 1. Analysis of deviance for the generalised linear model that relates the number of occupied HCIs with attributes of species: pathway of introduction [59] (i.e., escape, release, or transport-contaminant), biogeographical origin [49,51] (i.e., Afrotropical, Australasian, Neotropical, Nearctic, Palearctic, Indomalayan, and Oceanian), and biotype [48,51,55,57] (i.e., Chamaephyte, Chamaephyte reptant, Geophyte, Hemicryptophyte, Hemicryptophyte reptant, Phanerophyte, Therophyte, and Therophyte reptant). *df*: degrees of freedom. * Significant results at $p < 0.05$.

Variable	*df*	Deviance	Residual *df*	Residual Deviance	*p*
First year of introduction	1	5.794	82	116.533	0.016081 *
Introduction pathway	2	11.116	80	105.416	0.003856 *
Biogeographical origin	8	11.446	72	93.97	0.177677
Biotype	7	10.209	65	83.761	0.17702

3.3. Richness and Occupancy of Alien Species per HCI

The HCI group with the highest richness of alien species was 2M, specifically in dunes with low shrubs, where more than 50 alien taxa were found (Figure 4), including *Aloe arborescens* Mill., *Carpobrotus edulis* (L.) L. Bolus, *Arctotheca calendula* (L.) Levyns, and *Opuntia tuna* (L.) Mill., in more than 50% of their total points. The second highest richness of alien species was observed in HCI groups 1H and 1A (1A: habitats of *Limonium* spp., 1H: halophilous or halo-nitrophilous vegetation), with more than 35 alien species each (Figure 4) and where *Senecio angulatus* L. f., *Malephora crocea* (Jacq.) Schwantes, *Cylindropuntia leptocaulis*, *Kalanchoe* × *houghtonii*, *Nicotiana glauca*, and *Kleinia neirifolia* showed a high presence in the 1A and 1H HCIs, while *Heliotropum curassavicum* L. and *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. preferred the HCI group 1He*. Moreover, *Cylindropuntia* × *tetracantha* and *Opuntia tuna* were observed in the HCI group 5M*.

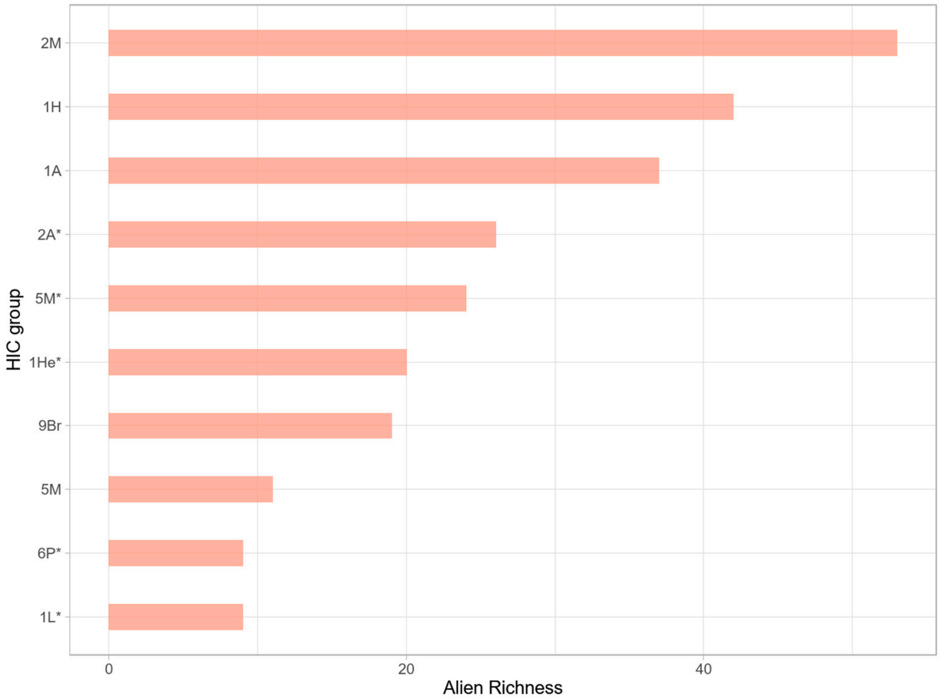

Figure 4. Richness of alien species by HCI group (1A: Habitats of *Limonium* spp. 1H: halophilous or halonitrophilous vegetation, 1He: saline edaphohygrophilous vegetation, 1L: calcareous fens, 2A: dunes with tall shrubs and pine trees, 2M: dunes with low shrubs, 5M: sclerophyllous scrubland, 5M*: relict shrubland, 6P: Mediterranean grassland, 9Br: riparian forest (edaphohygrophilous vegetation). * Refers to HCI groups that include at least one priority HCI designed by [13] and included in the Supplementary Materials (Table S2).

Thirty-nine taxa (i.e., 40% of all taxa) were also present in areas with no HCI representation or 'non-HCI' areas (Figure 4, Table S4), and species such as *Eclipta prostrata* (L.) L., *Acacia dealbata* A.Cunn., *Parkinsonia aculeata* L., and *Paspalum distichum* L. were present only in those 'non-HCI' areas By contrast, the least richness of alien species was found in the HCI group 1L, which represents calcareous fens and has a reduced distribution in the area studied.

In general, the chi-square test showed that for the HCI groups 1H (i.e., halophilous or halonitrophilous vegetation) and 2M (i.e, dunes with low shrubs), the proportion of *super*, *moderate*, and *poor invaders* did not vary significantly ($p > 0.05$, Table 2). By contrast, the HCI group 1A (i.e., habitats of *Limonium* spp.) had a majority of *moderate invaders* such as *Kalanchoe* × *houghtonii* D.B.Ward, while the HCI groups 5M*, 6P*, 9Br, 1He*, 1L*, and 2A* exhibited a majority of *super invader* species (Figure 5, Table 2), including *Eucalyptus camaldulensis*, *Oxalis pes-caprae*, *Carpobrotus edulis*, *Agave americana*, *Acacia saligna*, *Lantana camara*, *Arundo donax*, and *Nicotiana glauca*. Moreover, other species such as *Ricinus communis* L., *Opuntia tuna*, and *Cenchrus setaceus* (Forssk.) Morrone were found in the HCI groups 5M* and 6P*, in addition to the previously mentioned species. Meanwhile, species such as *Aizoon pubescens*, *Eucalyptus camaldulensis*, and *Stenotaphrum secundatum* were found in the HCI group 9Br.

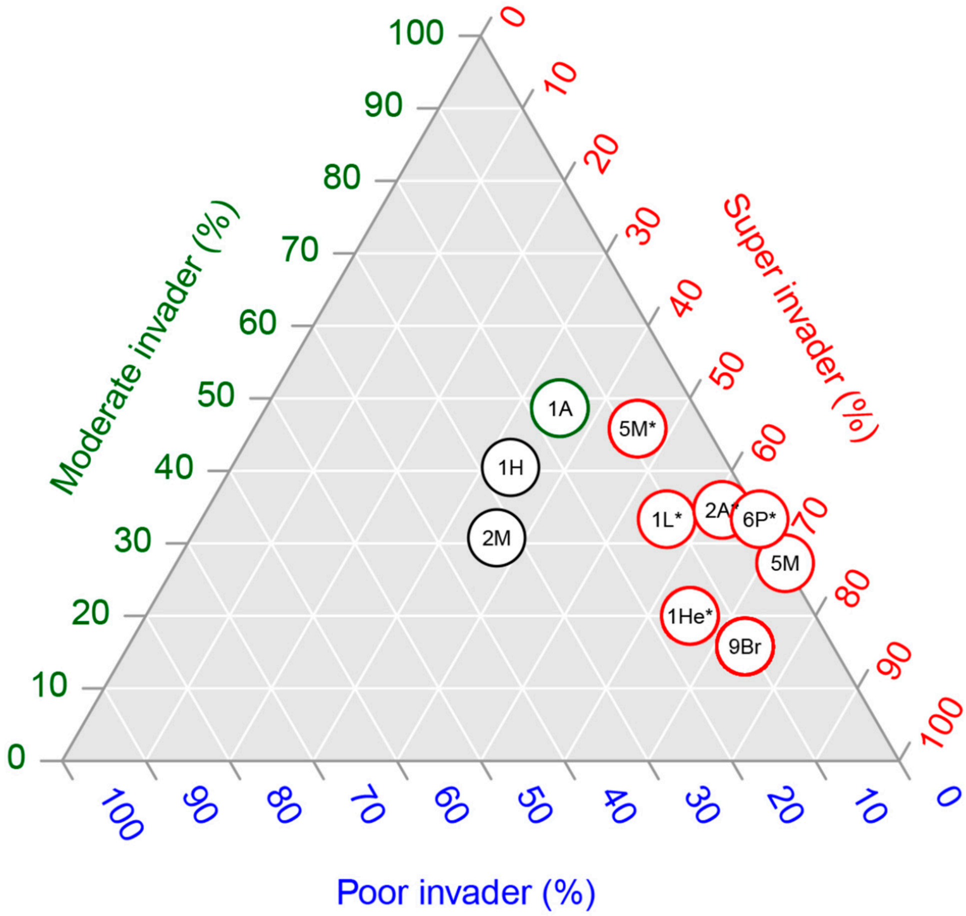

Figure 5. HCI groups represented by the proportion of alien species composition and the three categories of invasiveness (i.e., *super invader*, *moderate invader*, and *poor invader*). Red circles indicate HCI groups where the proportion of *super invaders* was significantly higher, whereas green circles denote HCI groups with a significantly higher proportion of *moderate invaders*. Black circles represent HCI groups where the differences in the proportions of *super*, *moderate*, and *poor invaders* were not statistically significant. 1A: Habitats of *Limonium* spp., 1H: halophilous versus halonitrophilous vegetation, 1He: Saline edaphohygrophilous vegetation, 1L: vegetation in flooded or wetland areas, 2A: dunes with tall shrubs and pine trees, 2M: dunes with low shrubs, 5M: sclerophyllous scrubland, 5M*: relict shrubland, 6P: Mediterranean grassland, 9Br: riparian forests (i.e., edaphohygrophilous vegetation). * Refers to HCI groups that include at least one priority HCI designed by [13] and included in the Supplementary Materials (Table S2).

3.4. Potentially Invasive Species

Based on their reproductive and dispersal attributes, 72 alien species (83%) exhibited invasive characteristics, of which 50% were classified as having *medium invasiveness* and 33% as having *high invasiveness*. Only 15 species (approx. 17%) were classified as having *low invasiveness*. The list of species and the classification appear in Table S4.

According to the relationship between the current invasion in the studied area and the classification of invasiveness obtained (i.e., based on reproductive and dispersal attributes), we identified 21 alien taxa as potentially invasive in the future (Table 3). Although they are currently considered to be *moderate invaders*, they exhibit attributes of *high invasiveness.* Some of those species are *Agave americana* subsp. *americana*, *Agave sisalana*, *Agave fourcroydes*, *Aloe arborescens*, *Asparagus* spp., *Cylindropuntia* spp., *Ipomea* spp., *Opuntia engelmannii* var. *lindheimeri*, *Opuntia tuna*, *Paspalum* spp., *Senecio angulatus*, *Tropaeolum majus*, *Kleinia neirifolia*, and *Passiflora caerulea*.

Table 2. HCI groups by the proportion of alien species composition and the three categories of invasiveness (i.e., *super invader*, *moderate invader*, and *poor invader*). 1A: Habitats of *Limonium* spp., 1H: halophilous versus halonitrophilous vegetation, 1He: saline edaphohygrophilous vegetation, 1L: vegetation in flooded or wetland areas, 2A: dunes with tall shrubs and pine trees, 2M: dunes with low shrubs, 5M: sclerophyllous scrubland, 5M*: relict shrubland, 6P: Mediterranean grassland, 9Br: riparian forests (i.e., edaphohygrophilous vegetation). * Refers to HCI groups that include at least one priority HCI designed by [13] and included in the Supplementary Materials (Table S2).

HCI Group	Super Invader (%)	Moderate Invader (%)	Poor Invader (%)	χ^2	*p*
1A	35.14	48.65	16.22	16.46	2.66×10^{-4}
1H	33.33	40.48	26.19	2.97	2.26×10^{-1}
1He*	65	20	15	45.50	1.31×10^{-10}
1L*	55.56	33.33	11.11	30.38	2.52×10^{-7}
2A*	64	32	4	54.08	1.80×10^{-12}
2M	37.25	29.41	33.33	0.97	6.15×10^{-1}
5M	72.73	27.27	0	81.74	1.77×10^{-18}
5M*	52.38	38.1	9.52	27.44	1.10×10^{-6}
6P*	66.67	33.33	0	67.34	2.38×10^{-15}
9Br	73.68	15.79	10.53	72.85	1.51×10^{-16}
No HIC	35.9	38.46	25.64	2.48	2.89×10^{-1}

Table 3. Number of species within each category of invasiveness and the classification of their current invasion.

	Super Invader	Moderate Invader	Poor Invader
High invasiveness	6	21	3
Medium invasiveness	11	10	21
Low invasiveness	1	3	11

By contrast, the congruence between classifications was higher for species *with low invasiveness*, 11 of which were classified as *poor invaders*. Furthermore, 11 species with *medium invasiveness* were effectively classified *as moderate invaders*, and only 6 species with *high invasiveness* were *super invaders* (Table 3). Most *high-invasiveness species* were classified as *moderate invaders*. The differences and congruences in the number of species between current invasion and invasiveness classification were statistically significant (Table 3, χ^2 = 23.075, *df* = 4, *p* = 0.00012).

3.5. Heat Distribution Maps

The heat distribution maps for *super invaders* and potentially invasive species appear in the Supplementary Materials (Figures S3–S10) and show the most invaded areas.

3.6. Most Invaded Areas and Management

The Ecological Reserve 'Dunas de Marbella' and Punta la Mona cliffs emerged as the most heavily invaded protected areas, as depicted in Figure 6. In addition, several protected wetland areas, such as the mouth of the 'Guadalhorce River', 'Manilva River', 'Padron River', 'Guadalmansa River', and 'Real River', have displayed substantial records of invasive species (Figure 6A). Our zoning method identified the 'mouth of Padron River', 'Dunas de Marbella', and the 'mouth of Guadalhorce' as 'eradication areas', due to the presence of at least four invasive species per area (Table S5). Special attention was warranted for the 'mouth of the Guadalhorce River', where all of the detected invasive species were *super invaders*. As such, it was highlighted as a top priority for eradication efforts. The remaining protected areas were designated as 'prevention areas' (Table S5). Within these prevention areas, top priority included 'Punta de la Mona' which showed the highest potential invader richness (Figure 6B).

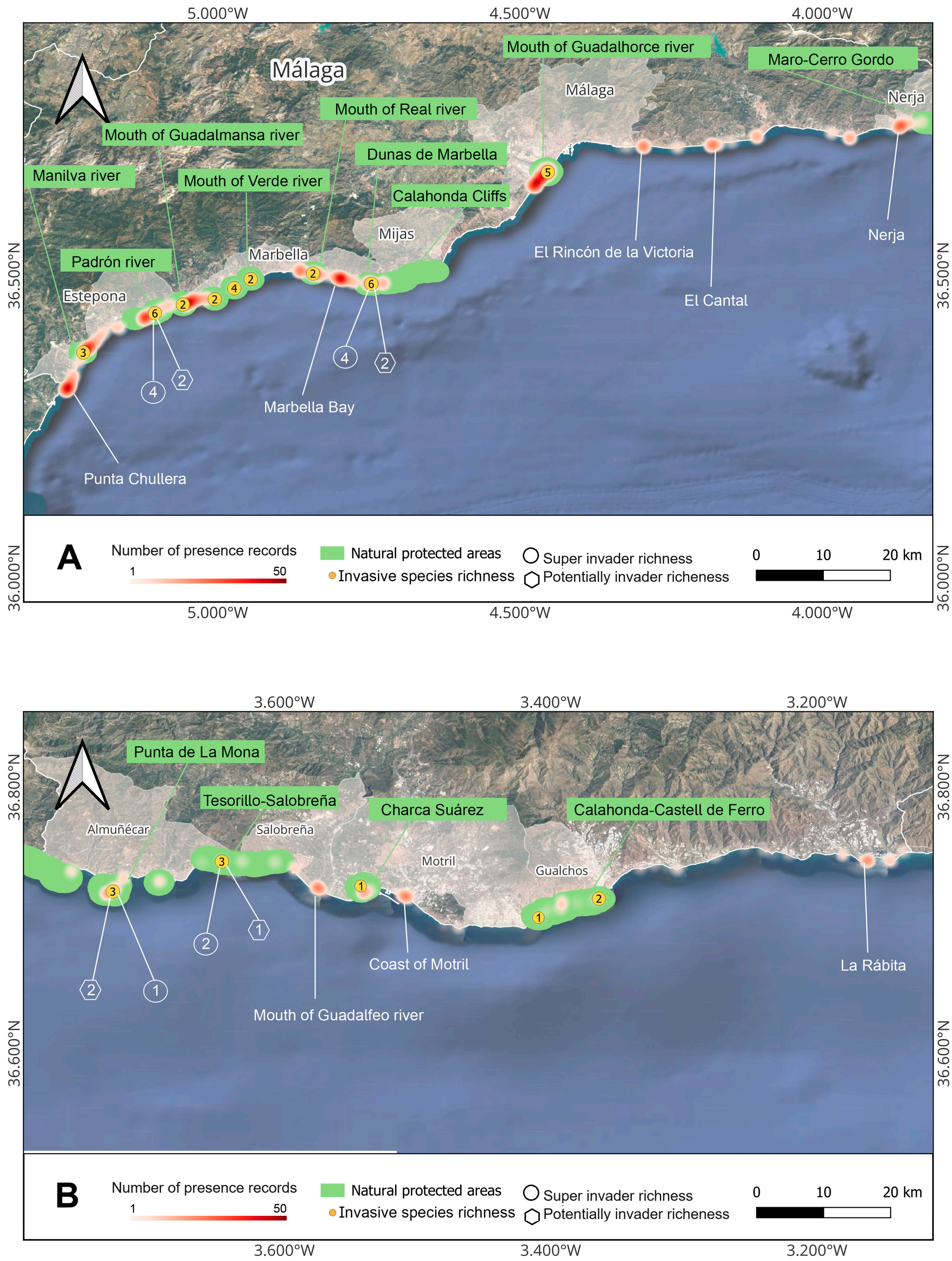

Figure 6. (**A**) Geographic areas with recorded presence of *super invaders* and potentially invasive species along natural protected areas on the coasts of the province of Málaga. (**B**) Geographic areas with recorded presence of *super invaders* and potentially invasive species along natural protected areas on the coasts of the provinces of Granada. Natural protected areas correspond to the shapefiles of Natural Protected Areas for Andalucía (Protected Natural Areas by RENPA, Law 2/1989, de 18 de julio) [66,67] and Natura 2000 sites Special Areas for Conservation (SAC) designated by the Habitats Directive Habitats Directive (Council Directive 92/43/EEC) [13,68]. In this, the natural protected areas are represented with 1 km buffer to better visualization. Darker red shades represent locations with over 50 records of invasive species' presence, while lighter shades indicate fewer than 50 records. Yellow points denote invasive species richness in each protected area. Numbers in white empty circles represent super invader richness, and white empty diamonds represent potentially invasive species richness. Yellow circles without invasive species richness breakdown (i.e., white circles and diamonds) solely denote super invader richness.

As for non-protected areas in the province of Málaga, the most heavily invaded regions were identified in Punta Chullera, Marbella Bay, the surroundings of the 'mouth of the Guadalhorce River', the limestone cliffs of El Cantal (el Rincón de la Victoria), and Nerja (Figure 6A). In the province of Granada, the most invaded non-protected areas encompassed the wetlands of the 'mouth of the Guadalfeo River', the coastal areas of Motril, and La Rábita (Figure 6B). These areas exhibited a significant concentration of invasive species, with most of these species classified as *super invaders*. Consequently, these regions have been identified as 'eradication areas'.

4. Discussion

4.1. Checklist of Terrestrial Alien Taxa of the Alboran Sea Area

We have developed the first checklist of vascular alien plant species in the Mediterranean terrestrial coastal habitats of the Iberian Alboran Sea area. Our findings, highlighting the considerable invasion of terrestrial coastal habitats, underscore the pressing need for proactive management strategies. Notably, certain HCIs such as sand dunes and areas with halophilous and halonitrophilous vegetation, including the priority ones with arborescent scrubs such as *Maytenus* species, have demonstrated a heightened susceptibility to invasion. Various factors and species attributes emerge as potential drivers of the success of invasion in the studied area, specifically dispersal characteristics, reproductive characteristics, pathway of introduction, and residence time.

The considerable representation of Asteraceae and Poaceae families in the invasive species detected aligns with patterns observed in several parts of the world, including the Mediterranean region [69–73]. By contrast, the abundance of species in the Asparagaceae family was an exception to the global pattern, possibly due the historical ornamental uses of plants in that botanical family in the Mediterranean region [74]. At the same time, we found a substantial presence of alien taxa, both naturalised and invasive, from the American and African continents, primarily belonging to the Arecaceae, Aizoaceae, and Crassulaceae families, which is consistent with the findings of other studies [70,75] and may reflect historical introductions and the utilisation of Mediterranean coastal ecosystems for various purposes over time [76]. The human-mediated activities that have shaped the Mediterranean landscape, including urbanisation, agriculture, and trade, have likely played a pivotal role in facilitating the spread of alien species in the region [77,78]. In that light, the high abundance of gramineous species in the *Paspalum* genera and *Stenotaphrum secundatum*, which are often used as turf grass in coastal areas [47,51], is concerning given their clear invasive behaviour. Species with high abundance in some localities of the territory, including *Kleinia neriifolia* Haw., *Cortaderia selloana*, and *Aizoon pubescens*, should be monitored.

4.2. Current Invasion and Attributes Related to Occupied HCI

Nearly one-quarter of the identified alien species were categorised as *super invaders*. This classification indicates that the species have invaded more than 19% of the sampled HCIs and are widespread, abundant, and generalist or with great adaptability within the studied area [32]. Although highly abundant, those *super invaders* all show a gradient in the extent of the areas and habitats that they occupy. Notably, species such as *Arundo donax*, *Acacia saligna*, *Oxalis pes-caprae*, *Austrocylindropuntia subulata*, and *Lantana camara* occupy greater areas and diverse HCIs in the area, as consistent with their patterns of invasion observed in past studies [79–83]. Conversely, *Aizoon pubescens*, *another super invader* in the area, demonstrated high abundance but did not occupy as extensive an area or as many varied habitats as the abovementioned *super invaders*. A factor that determines the extent of area and habitat occupied by a species can be the time since introduction, as species given sufficient time to disperse and adapt can colonise different habitats [40,84]. This trend has also been found in Italy [80] and is supported by our generalised linear model, which reveals that species introduced earlier (i.e., archaeophytes) tend to occupy more habitats than more recent neophytes, as exemplified by *Aizoon pubescens*, introduced circa 1970 [57].

It is important to highlight that the lesser extent of the area occupied by that species does not necessarily mean less impact. In fact, other authors [29] have reported *Aizoon pubescens* as a highly problematic species in natural areas such as the 'mouth of the Guadalhorce River', and in the 'mouth of the Vélez River' in southern Spain, where it forms extensive creeping tapestries with a high degree of homogeneity, a characteristic that it shares with *Stenotaphrum secundatum*. Even so, neither species is covered by Spanish legislation [61] (i.e., RDL 360/2013) and thus lacks a control or eradication plan.

A significant factor of the expansion of invasive species is their horticultural or ornamental use and their release into natural or non-natural spaces for specific purposes [75,85]. Our results confirm this understanding, particularly for the species introduced through the 'release' pathway. In our study, species introduced through the 'release' pathway [59] were also found in a greater number of HCIs. Some of those species include *Cenchrus setaceus*, planted ornamentally along roadsides for the stabilisation of slopes [86]; *Eucalyptus calmadulensis*, planted to repopulate trees and for use in the paper cellulose industry; and *Carpobrotus edulis*, planted to stabilise dunes [87,88]. Species introduced accidentally, including ornamental species that escape from cultivation, constituted the second most populous group that has invaded more HCIs. This finding aligns with past findings which showed that the utilisation or release of those species likely increased the number of propagules, thereby elevating the probability of invasion [75,85,89].

4.3. Richness and Occupancy of Alien Species per HCI

Two HCI groups—dunes with small shrubs and the halonitrophilous vegetation group—stood out as the groups with the highest richness of alien species, in that order. This finding concurs with past results from the Mediterranean region [21,83] and northern Spain [90]. The pattern could be due to their location in the interface between urban areas and beaches as regions subjected to significant anthropogenic pressure, both historically and more recently due to tourism and urban expansion [91,92]. The trend might also be partly explained by the fact that shrublands provide a less hostile environment for plants than rocky cliffs, ledges, and dunes, which make them more susceptible to invasion, primarily due to the greater availability of stable soil than in dunes. However, dunes are also highly dynamic ecosystems that are subject to constant natural changes and susceptible to anthropogenic impacts, such as residential development, tourism, and recreation parks [92], which possibly create vacant niches that become conducive to invasive species [78,90,93].

The HCI group with the third highest number of alien species was the cliffs group. Cliffs represent a highly hostile ecosystem for plant life due to marine aerosol winds, high salinity, high solar exposure, and the absence of soil [15,94]. Those ecosystems are of great relevance and regional priority for conservation because they are the habitats for regional endemic plants such as *Limonium* spp. [15]. Beyond that, the invasive alien species detected in our study may indicate source–sink dynamics, in which invasive plants in nearby gardens or roads act as source populations that send propagules to the cliff areas. Such movement could reduce the dispersal barrier into those habitats and promote invasion [93,95,96]. Some alien species commonly found in the ecosystem included *Cylindropuntia leptocaulis*, *Kleinia neirifolia*, *Cortaderia selloana*, *Cylindropuntia* × *tetracantha*, *Opuntia tuna*, *Oxalis pes-caprae*, and *Ipomoea indica*, which also exhibited characteristics of high abundance (i.e., >100 individuals) and *high invasiveness,* which could facilitate their expansion and invasion in the ecosystem. Nevertheless, *Kleinia* species and *Austrocylindropuntia subulata* are not governed by law (RDL 630/2013), despite the urgent need to manage those species and limit their use in gardens or else face significant impacts on terrestrial coastal ecosystems.

It is important to know not only which HCI groups have the highest number of alien taxa but also the invasiveness of those taxa. On that count, our results show that some HCI groups with priority HCIs—for example, the flooded or wetland vegetation group (1L*) and the high shrub and pine woodland dunes group (2A*)—have a relatively high number of *super invader* species, including *Eucalyptus camaldulensis*, *Oxalis pes-caprae*, *Carpobrotus edulis*, *Agave americana*, *Acacia saligna*, *Lantana camara*, *Arundo donax*, and *Nicotiana glauca*.

Other priority HCIs, including the relict sclerophyllous scrubland group (5M*) and the Mediterranean grassland group (6P*), also exhibited the presence of the aforementioned *super invaders*, with the addition of *Ricinus communis*, *Opuntia tuna*, and *Cenchrus setaceus*. This trend aligns with what has been reported regarding invasive species in coastal terrestrial habitats in Spain and Italy [12,69,78,82,90]. Although most of those species are not governed by Spanish law (i.e., RDL 630/2013), including them in such legislation could be a first step towards limiting their ornamental or other uses that promote the spread of invaders. Moreover, those species are cosmopolitan, ruderal, and generalist, which may indicate that some of those HCIs are affected by high anthropic pressure [97–99]. In that light, a second step could be to reduce anthropic pressure in those ecosystems, which is the ultimate cause of the invasive presence in natural or semi-natural areas [100].

It is essential to include the abovementioned species, recognised as *super invaders* in priority HCIs, in management and eradication plans. Especially noteworthy are *Arundo donax*, *Aizoon pubescens*, *Stenotaphrum secundatum*, *Lantana camara*, and *Ricinus communis*, which are species with the greatest international presence as global invaders [75]. Among other detrimental effects, those invasive plant species could impact floristic compositions, reduce biodiversity, alter soil nutrients, and degrade habitats in the Mediterranean Basin [83], all of which can lead to significant economic losses. Indeed, of the total cost caused by invasive species between 1990 and 2017 in Mediterranean Basin (i.e., $27.31 billion), one-third was caused by plants [101].

4.4. Potentially Invasive Species as a Growing Threat

With the aim to predict invasiveness, multiple studies have shown a connection between the success of invasive plant species and intrinsic attributes related to their dispersal and reproduction [36,37,102]. In our case, attributes of *high invasiveness*, such as dispersal by animals or wind, along with abundant sexual and asexual reproduction, seem to have played a significant role in their current invasion. In fact, 73% of alien species without those attributes (i.e., *low-invasiveness species*) were *poor invaders*. For that reason, those attributes can be regarded as good predictors of the risk of invasion. However, most species with *high invasiveness*, and therefore possessing both attributes, were instead determined to be *moderate invaders* and currently failing to fully express their potential invasiveness in terms of abundance or area and habitats occupied. Extrinsic factors may synergistically interact with attributes of species and influence the invasion process; they include residence time, level of disturbance, propagule pressure resulting from plant use, and site-specific environmental conditions [21,40,41,103]. Those abundant *moderate invaders* with *high invasiveness* could expand their actual distributions and cause potential impacts in ecosystems and habitats. Among those species, *Cylindropuntia* × *tetracantha*, *Cylindropuntia leptocaulis*, *Opuntia tuna*, *Opuntia engelmannii* var. *lindheimeri*, *Kleinia nerifolia*, *Paspalum vaginatum*, *Agave americana* subsp. *americana*, *Agave sisalana*, and *Asparagus asparagoides* have been reported to be naturalised and invasive in similar ecosystems in the U.S. state of California and in Africa, Europe, and Australia [104–109]. For those reasons, the species should be given special attention due to the high abundance detected in the territory, which could be the first step for a future invasion in that particular Mediterranean area.

The invasion process is dynamic and can vary based on the site and the receptor habitat or native plant community [21,39,110]. Moreover, the current degree of invasion (i.e., *super*, *moderate*, or *poor invader*) is a snapshot of the data gathered at the time of data collection and thus subject to change in the future, given favourable extrinsic conditions [111]. Enhancing predictions may necessitate site-specific variables. Added to that, acquiring those variables can be challenging, whereas the attributes of species are a more accessible, stable source of insight into invasive potential which can aid the development of preventive measures.

4.5. The Most Invaded Areas and Implications for Management

In the analysis of our results, we observed that the western coast of the province of Malaga exhibits the highest invasion levels, with greater species richness of invasive species and a significant concentration of their presence records compared to the eastern coast in Granada. This disparity can be attributed to higher human pressure on natural coastal habitats on the western side, which can be attributed to tourism, urbanisation, and industry. These high invasion levels on the western coast could have a considerable impact on habitats and ecosystems, extending to affect the ecosystem services provided by these habitats [2,9,112]. These environmental impacts may lead to potential losses of unique vegetation and plant communities in this important Mediterranean region. Among the most invaded protected areas in the western coast, the Ecological Reserve 'Dunas de Marbella' and its surroundings stand out due to the high presence of taxa with Atlantic distribution, which inhabit only in this part of Málaga [45], and the presence of HCIs of Group 2, i.e., dunes. The 'mouth of the Guadalhorce River' is remarkable due to the high presence of HCIs of high ecological importance of Groups 1 and 2, despite its limited area [25] and the presence of halophytic associations which are reducing their distribution in Andalusia due to the high environmental pressure that these ecosystems endure. This impact is increasing due to the invasive species [29].

Environmental impacts can also have social consequences, as the invasion of plant species in these habitats could affect the aesthetics of natural and recreational areas used by humans. Given that several studied areas here are a tourist destination, a decrease in tourism could have economic implications for the local economy. Moreover, these habitats are essential for birds and other animals and crucial for pollination, and the invasion of plant species can disrupt these ecological associations [112]. Additionally, the eradication of these invasive species carries economic costs, both in terms of the efforts required and in restoring the damage caused [98]. To our knowledge, there is a notable absence of studies on the impacts within our study area. We strongly encourage future research efforts to delve deeper into this topic in order to inform the development of policies and well-informed decisions in the environmental sector.

In the case of the eastern coast, it is crucial to implement preventive management measures to avoid invasion levels from reaching those observed on the western coast. Our findings underscore the need to monitor alien species and include them in early invasion prevention programs, with a particular focus on the areas where they are currently found and from where they could potentially spread. Our heat maps allowed us to clearly identify 'prevention areas', such as 'Punta de la Mona'. Additionally, these areas are highlighted due to the presence of relict species like *Gymnosporia senegalensis* subsp. *europaea* (Boiss.) Rivas Goday & Rivas Mart., along with other species protected by Andalusian law (RD 139/2011), such as *Limonium malacitanum* B. Díez and *Salvia granatensis* B.T. Drew (=*Rosmarinus tomentosus* Hub.-Mor. & Maire) [113].

Efforts should be concentrated on eradicating invasive species, especially in the priority 'eradication zone' at the 'mouth of the Guadalhorce River' on the western coast. Meanwhile, on the eastern coast, the focus should be on prevention in the identified 'priority areas'.

In summary, our findings have significant relevance for conservation practitioners and decision makers. We provide valuable insights into the current state of invasion dynamics in Mediterranean coastal ecosystems, shedding light on which alien species are the most successful invaders and which habitats are the most invaded. Our findings emphasize the importance of reducing anthropic changes and pressures on natural and semi-natural areas. Human actions, such as urbanisation and landscaping, have contributed to the spread of invasive species. By recognizing this connection, we can emphasize the importance of responsible land use and conservation practices. Engaging in scientific outreach and education programs can also play a pivotal role in preventing the proliferation of invasive species through gardens and other means. Additionally, proactive management of alien plant species is crucial for the conservation of HCIs. We hope that our findings contribute to ongoing efforts to mitigate the impacts of biological invasions and safeguard the ecological integrity of such invaluable coastal ecosystems.

5. Conclusions

- The terrestrial coast of Málaga and Granada (i.e., the Alboran sea area) exhibit 123 alien plant taxa belonging to 43 taxonomic families and 86 genera. The families Asteraceae, Asparagaceae, and Poaceae present the greatest number of taxa. Most of the alien taxa are neophytes from the American and African continents.
- Almost 20% of the species were classified as *super invaders*, meaning that they are abundant species invading more than 20% of the HCIs present in the coastal areas of Málaga and Granada. *Arundo donax*, *Acacia saligna*, *Oxalis pes-caprae*, *strocylindropuntia subulate*, *Carpobrotus edulis*, *Lantana camara*, *Aizoon pubescens*, and *Stenotaphrum secundatum* are some examples to consider.
- Residence time and intentional introduction for specific uses show a positive and significative effect on the number of HCIs occupied by alien plant species along the terrestrial coasts of Málaga and Granada.
- The HCI groups most invaded are dunes with low shrubs, halophilous or halonitrophilous vegetation, and cliff habitats of *Limonium* spp., with more than 30 alien species each.
- Along the terrestrial coast of Málaga and Granada, 21 alien taxa are present that may be invasive in the future. Some of those species are *Cylindropuntia* × *tetracantha*, *Cylindropuntia leptocaulis*, *Opuntia tuna*, *Opuntia engelmannii* var. *lindheimeri*, *Kleinia nerifolia*, *Paspalum vaginatum*, *Agave americana* subsp. *americana*, *Agave sisalana*, *Asparagus asparagoides.*, *Agave sisalana*, *Agave fourcroydes*, *Aloe arborescens*, *Cylindropuntia* spp., *Ipomea* spp., *Opuntia engelmannii* var. *lindheimeri*, *Opuntia tuna*, *Paspalum* spp., *Senecio angulatus*, and *Tropaeolum majus*.
- The heat distribution maps show that the areas most invaded in the province of Málaga are the Ecological Reserve 'Dunas de Marbella', the 'mouth of the Guadalhorce River' and surroundings, El Cantal, and Nerja. In Granada, eradication zones include the 'mouth of the Guadalfeo River', coastal areas of Motril, and La Rábita.
- Prevention areas include the Punta de la Mona in Granada, while eradication areas in Málaga include the protected area the 'mouth of the Guadalhorce River' and surroundings, and also, several localities such as El Cantal, and Nerja.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/d15111120/s1, Table S1: Characteristics Species Composition of Habitats of Community Interest (HCIs) Based on Our Phytosociological Expertise in the Studied Area; Table S2: Classification of Habitat of Community Interest (HCI) groups; Figure S1: Schematic representation of the method used to estimate current invasion degree based on [32]; Table S3: Checklist of Alien Plant Taxa Records in the Studied Area; Table S4: Attributes of Alien Plant Species and Their Frequency within Habitat of Community Interest (HCI) groups; Figure S2: Number of Habitats of Community Interest (HCIs) occupied by species, categorised by species introduction pathway ($p < 0.03556$); Figures S3–S10: Heat distribution maps depicting *super invaders* and potentially invasive species; Table S5: Total number of invasive species (super invader or potential invader) by geographic area (protected or non-protected) and zonification. * Current invasion categories follow our classification obtained in the Sections 3.2 and 3.4 of the manuscript. Area follows the classification used in Section 2.6 of the manuscript.

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