

Article

Beyond Ornament: Ecosystem Services and Disservices of Cultivated Ornamental Flora on the Circum-Sicilian Islands

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Abstract

Ornamental flora is often appreciated for its aesthetic and recreational value, overlooking its ecological functions. This study provides the first comprehensive assessment of ecosystem services and disservices delivered by cultivated ornamental plants across all the islands of the circum-Sicilian archipelago. We surveyed the vascular flora characterizing each island, compiling a checklist of 402 taxa. For each taxon, we recorded biological traits, beneficial services (e.g., wildlife food, human food, habitat provision, beekeeping, erosion control, green fencing, and medicinal interest), and disservices (naturalization, toxicity to humans, pets, or livestock, and allergenicity). The island of Ustica hosts the highest number of taxa (217), followed by the island of Lipari (213), while the islands of Marettimo (95) and Alicudi (96) are the poorest. Remarkably, 329 taxa are potential sources of medicine, 326 provide wildlife habitats, 299 are of beekeeping interest, 218 are suitable for living fences, 212 contribute to erosion control, 192 supply fruits for wild birds, 130 human food, and 86 livestock forage. Spatial analysis of ornamental flora reveals that the island of Favignana has the highest proportional cover (11%) with moderate clustering, the islands of Ustica and Panarea display more dispersed, larger patches, and the islands of Lipari and Salina show strongly aggregated small patches. These results demonstrate that ornamental plants perform substantial regulatory and provisioning services, and their spatial arrangement further modulates ecological outcomes.

Keywords: small islands; checklist; ornamental plants; biological traits; human well-being; Mediterranean area



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1. Introduction

Historical evidence indicates that sustained relationships between human populations and ornamental flora have persisted over extended temporal scales. Despite this, human perception stayed narrow across generations guided more by looks than function. Trees, shrubs, and flowers in gardens, along streets, or around homes have been prized mainly for making landscapes look better, giving shade, pleasing us with scents and colors, or showing off the owner’s social standing [1–5]. Ornamental plants also carry out ecological services that matter a great deal.

These past few decades reveal how urban greenery, mainly shaped by cultivated decorative species, performs a wide range of key ecological functions. Shading, releasing

moisture, and stabilizing temperatures all contribute to moderating local climates. Dust particles, nitrogen compounds, and CO₂ vanish more easily where such plants grow, improving air conditions. Noise levels drop noticeably near dense plantings. Root networks hold soil firmly, preventing washouts during rain. Rainfall slows down as leaves catch droplets, allowing gradual absorption into the earth below. Nectar, fruit, and seeds feed creatures ranging from bees to sparrows, and hidden corners among stems offer safety and breeding sites [6–8]. Even in tightly packed urban zones, gardens and tree-lined streets bring important cultural, psychological, and social benefits fostering community interaction [9–11]. Viewed closely, these ornamentals emerge not merely as decoration but as active contributors to nature's balance within human-altered landscapes.

Despite their well-documented benefits, ornamental plants may also present certain challenges that require careful consideration. Although they enhance urban landscapes, support biodiversity, and provide cultural and psychological benefits, some species can have adverse effects, particularly due to allergenic pollen production. For example, taxa such as *Pinus halepensis* Mill., *P. pinea* L., *Cupressus sempervirens* L., *Olea europaea* L., *Populus nigra* L., and *P. alba* L. may release pollen that triggers allergic reactions, potentially contributing to respiratory issues among urban populations. Some carry toxins harmful to people, animals, or household pets, creating hazards near schools, parks, or communal green areas [12–15]. Beyond individual cases, worldwide movement of ornamental plants often introduces non-native species that later spread uncontrollably. With naturalization, such species often dominate native vegetation and alter ecosystems, reducing regional biological diversity [16–18]. Because of this shift, careful landscape design must balance benefits from cultivated plants while limiting their unintended consequences.

Though ornamental plants play roles in ecological, social, and economic systems, most data emerge from research centered on plant invasions or natural spread [19–21]. As a result, ornamentals have often been seen mainly as potentially troublesome alien species rather than as a subject worth studying on its own. This has led to scattered knowledge and a lack of systematic work documenting the taxa grown in urban and suburban settings. Progress in studying decorative plants across southern Italy boosted just recently. One investigation focused on Apulia [22], delivering a detailed overview of cultivated trees and herbs. Another covered Sicily, revising earlier records with new field data [23]. A third contribution examined Basilicata, mapping plantings in public spaces [24]. These surveys link together documented greenery found along roadsides, within urban parks, and in private areas. Trees, shrubs, and flowering perennials received equal attention. Findings emerged separately yet align closely in method and making patterns in planting choices clearer.

Small islands make up a particularly interesting case that has been little explored from this angle. Their limited size, rich uniqueness, and species absent beyond their shores, combined with sensitivity to ecological shifts, make them special spots for observation [25–27]. When alien decorative plants arrive in a territory, consequences grow fast—a species contained in continental yards might break free here, invade native growths, and disrupt ancient equilibriums built during long separation [28]. Meanwhile, on these lands marked by thin soils and deep human reshaping, cultivated greenery sometimes holds slopes at bay, shields fields from gusts, feeds fading insect partners, and delivers herbs or nourishment where little remains. Islands balance risk against need differently [29].

Scattered near Sicily, places like the islands of Ustica, Lipari, Salina, Vulcano, Alicudi, and Filicudi, along with Favignana, Levanzo, and Marettimo from the Egadi archipelago, plus Pantelleria and Lampedusa, form a cluster rarely studied in this context. During six decades, shifts in how people live and use land have reshaped them sharply [30]. Farming practices that long defined terrain through vines, olives, and cultivated fields

slowly faded; instead, unchecked building followed rising tourist numbers [31]. Yet greener spaces emerged too: parks by shores, plants beside roads, resorts' lawns, as well as personal spots, homes tucked into foliage, balconies heavy with blooms, and tiny garden patches just outside towns. Nowadays, ornamental species make up most of what people grow, replacing once common fruit trees, veggies, herbs, or feed crops meant for practical use [30]. Toughness matters more than looks when selecting these garden plants, though this is rarely stated outright [32]. Exposure to salt-laden gusts, scorching sunlight, dry months without rain, and neglect through off-season abandonment all shape which ones survive [33]. As a result, an unusual group of cultivated plants has emerged over time. Studying it means looking beyond floristic aspects toward how these plants behave, interact, and persist. Islands face harsh summers, thin ground, and constant travelers; here, thoughtfully picked greenery does more than please the eyes, it helps land meet needs using fewer outside inputs [34]. Deeply connected to cultural traditions while continuously adapting to contemporary preferences, ornamental flora represents a dynamic link between historical practices and present-day societal needs. Through this interaction, these plants reflect the ongoing evolution of human–plant relationships across time. Current conditions on small Mediterranean islands reveal a complex interplay between ornamental green spaces and their surrounding environment [25]. Although often planted for aesthetic reasons, these cultivated patches may provide measurable ecosystem services, such as habitats for birds, erosion control, and support for pollinators, but they can also generate disservices, including allergenic or toxic effects [6,35]. This study sets out to analyze, on thirteen Sicilian circum-insular islands, the spatial configuration of ornamental green areas and its relationship with both services and disservices. Specifically, we examine the proportion of ornamental green cover relative to total island area, the degree of clustering or dispersion of patches (nearest neighbor ratio), patch size variability, and the strength of spatial clustering patterns. Using these landscape metrics together with a semi-quantitative assessment of plant-related services and disservices, we provide a first comparative overview across the island group. The aim of this contribution is not only to produce a comprehensive species checklist of ornamental cultivated plants, but also to identify which islands achieve a more favorable balance between benefits and risks, and how different spatial arrangements (aggregated versus dispersed green patches) influence that balance. These findings are intended as a support for local planners, landscape managers, and conservation practitioners who need evidence-based guidance on maintaining ornamental green spaces without amplifying disservices. In an era of rising temperatures, habitat fragmentation, and increasing tourism pressure on coastal and insular systems, understanding the functional role of ornamental vegetation becomes essential for designing resilient and healthy green infrastructure [36,37].

2. Materials and Methods

The study was carried out through field surveys followed by spatial and floristic analyses. The investigation targeted all major inhabited islands of the circum-Sicilian archipelagos (Figure 1 and Table 1). Uninhabited islets were excluded because of their small extent and poor plant assemblages. For each island, the area occupied by ornamental green spaces was obtained by photointerpretation of satellite images available on Google Earth (acquisition dates between 2019 and 2025), working at a scale of 1:2000 and mapping polygons with a minimum surface of 25 m². This minimum mapping unit ensures data consistency and avoids the “noise” introduction. Spatial analyses were performed using ArcGIS 10.5 with the Patch Analyst extension [38], and the results are summarized reporting class area (CA; total area of polygons in m²), number of patches (NumP), mean patch size (MPS), patch size standard deviation (PSSD; measuring size variability), nearest neighbor

ratio (NNR), standard deviations (Z score; how the spatial clustering deviates from a random pattern), and probability (p -value; likelihood that the observed pattern occurred by random chance).

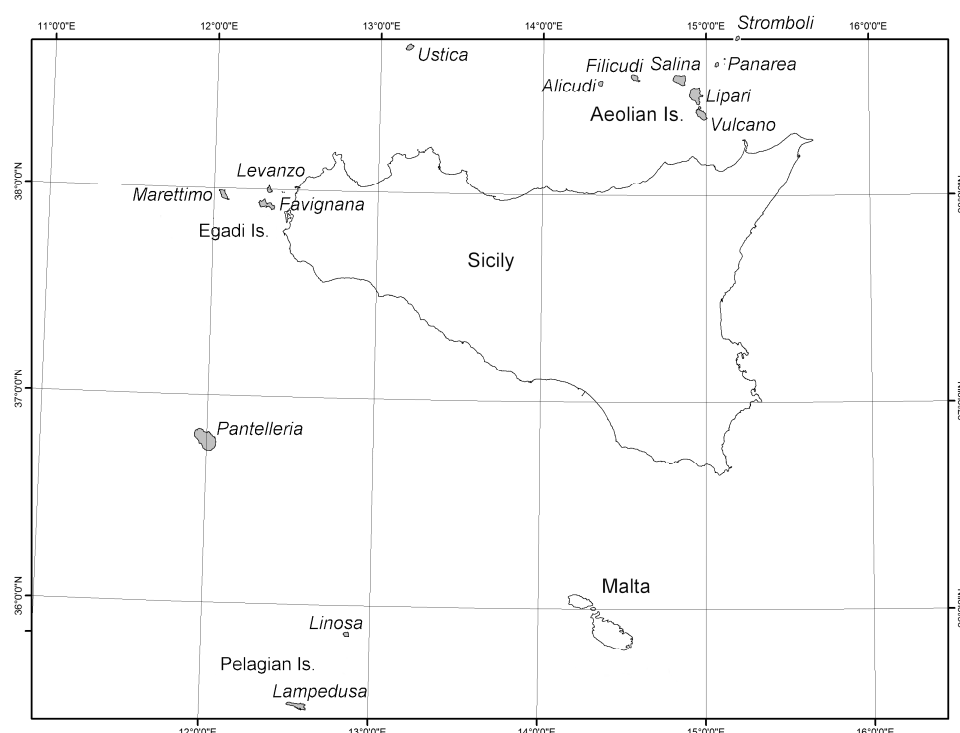


Figure 1. The circum-Sicilian archipelagos investigated.

Table 1. Key features of the study islands.

Island	Area (km ²)	No. of Inhabitants	Inhabitants per km ²	Distance from Mainland *	Substrate	Main Source of Water Supply
Ustica	8.12	1323	162.93	36	Volcanic	Desalination plant, Cisterns
Alicudi	5.06	105	20.75	52	Volcanic	Tankers, Cisterns
Filicudi	9.24	235	25.43	42	Volcanic	Tankers, Cisterns
Salina	26.06	2549	97.81	29	Volcanic	Tankers, Cisterns
Lipari	37.23	11,118	298.63	22	Volcanic	Desalination plant, Cisterns, Tankers
Vulcano	20.89	450	21.54	19	Volcanic	Desalination plant, Tankers, Cisterns
Panarea	3.37	241	71.51	30	Volcanic	Tankers, Cisterns
Stromboli	12.61	600	47.58	43	Volcanic	Tankers, Cisterns
Linosa	5.40	433	80.18	90	Volcanic	Desalination plants, Cisterns
Lampedusa	20.51	6052	295.08	115	Carbonate	Desalination plants, Wells, Cisterns
Pantelleria	83.71	7150	85.41	75	Volcanic	Desalination plants
Marettimo	12.16	680	55.92	24	Carbonate	Tankers
Favignana	19.92	3652	183.33	12	Carbonate	Tankers, Wells
Levanzo	5.81	208	35.80	9	Carbonate	Tankers

* Nautical miles from the main Sicilian port with which the island is connected.

Field surveys were conducted over the last twenty years. All cultivated ornamental plants, both exotic and native, grown in open ground or in outdoor pots were recorded to include common taxa, avoiding underestimating the overall biodiversity of the study area, while single individuals belonging to special public or private collections were excluded. Particular attention was paid to taxa traditionally associated with human activities as useful plants, and these include fruit trees, reforestation species, and plants providing fibers or other raw materials (e.g., *Arundo donax* L.), provided they also serve a significant ornamental purpose. Taxonomic identification followed the current standard floras for Italy [39] and for cultivated plants in Europe [40]. The nomenclature is based on POWO [41]. Critical cases were resolved by comparison with living collections at the Palermo Botanical

Garden and with exsiccata preserved at the Herbarium Mediterraneum Panormitanum (PAL) in Palermo. For each island, the classes (cultivated only, casual, naturalized, or invasive) follow [21] but the classification is based on island-specific observations.

For each recorded taxon we include the following information: area of origin [41], biological form [39,42], family [41], any relevant synonyms from local literature [30], and the period of introduction to Sicily, as derived from historical sources [43–47]. Toxicity and allergenicity, key ecosystem disservices, were assessed following [15,48,49], while the potential use as a source of medicinal substances was recorded from [50–52]. In addition, the following ecosystem services were evaluated directly in the field: provision of wildlife habitat, supply of fruits for wildlife, contribution to soil erosion control, feed for livestock, food for human consumption, beekeeping interest, suitability for green fences, and water requirement.

A synoptic table presents for each taxon its family, biological form, area of origin, current synonyms, and documented period of introduction to Sicily. Based on this dataset, comparative analyses were carried out to highlight similarities and differences among the islands and their ornamental floras.

Statistical analyses were performed using PAST version 4.14 [53]. Prior to analysis, the dataset was organized with islands as rows and the following variables as columns: island area (km²), population size, ornamental green cover (km²), total ornamental taxa, and the numbers of native, invasive, toxic, allergenic, habitat-providing, and low-water-requirement ornamental taxa.

Spearman's rank correlation coefficients (r_s) were computed to evaluate the pairwise relationships between the three predictors (island area, population size, and ornamental green cover) and the eight ornamental flora metrics (total taxa, native, invasive, toxic, allergenic, habitat-providing, and low-water-requirement taxa).

Generalized linear models (GLMs) with normal distribution and identity link were fitted to test the relationships between three predictors (island area, population size, and ornamental green cover) and each of the eight response variables (ornamental green cover when not used as a predictor, total ornamental taxa, native, invasive, toxic, allergenic, habitat-providing, and low-water-requirement taxa). Model significance was assessed using the G-test, with a significance threshold of $\alpha = 0.05$.

A principal component analysis (PCA) based on a correlation matrix was performed to explore the overall structure of the dataset and identify the main sources of variation among islands. The number of components to retain was evaluated based on eigenvalues and the proportion of explained variance.

All statistical tests were two-tailed, and results were considered statistically significant at $p < 0.05$.

3. Results

Based on the geographical dataset (Figure 2 and Table 2), several islands stand out for their ornamental green cover and spatial configuration. Favignana has the highest percentage of ornamental green relative to its total area, with approximately 11%, a value considerably larger than any other island in the survey. Despite this high coverage, its nearest neighbor ratio is close to 0.79, while the Z score is negative and significant, indicating a tendency toward clustering, although the clustering is only moderate in strength. In contrast, the island of Pantelleria shows a very strong clustering pattern with an extremely low nearest neighbor ratio, but the proportion of ornamental green area is just over 1%, suggesting that while the green spaces are highly concentrated, they occupy a very limited portion of the island.

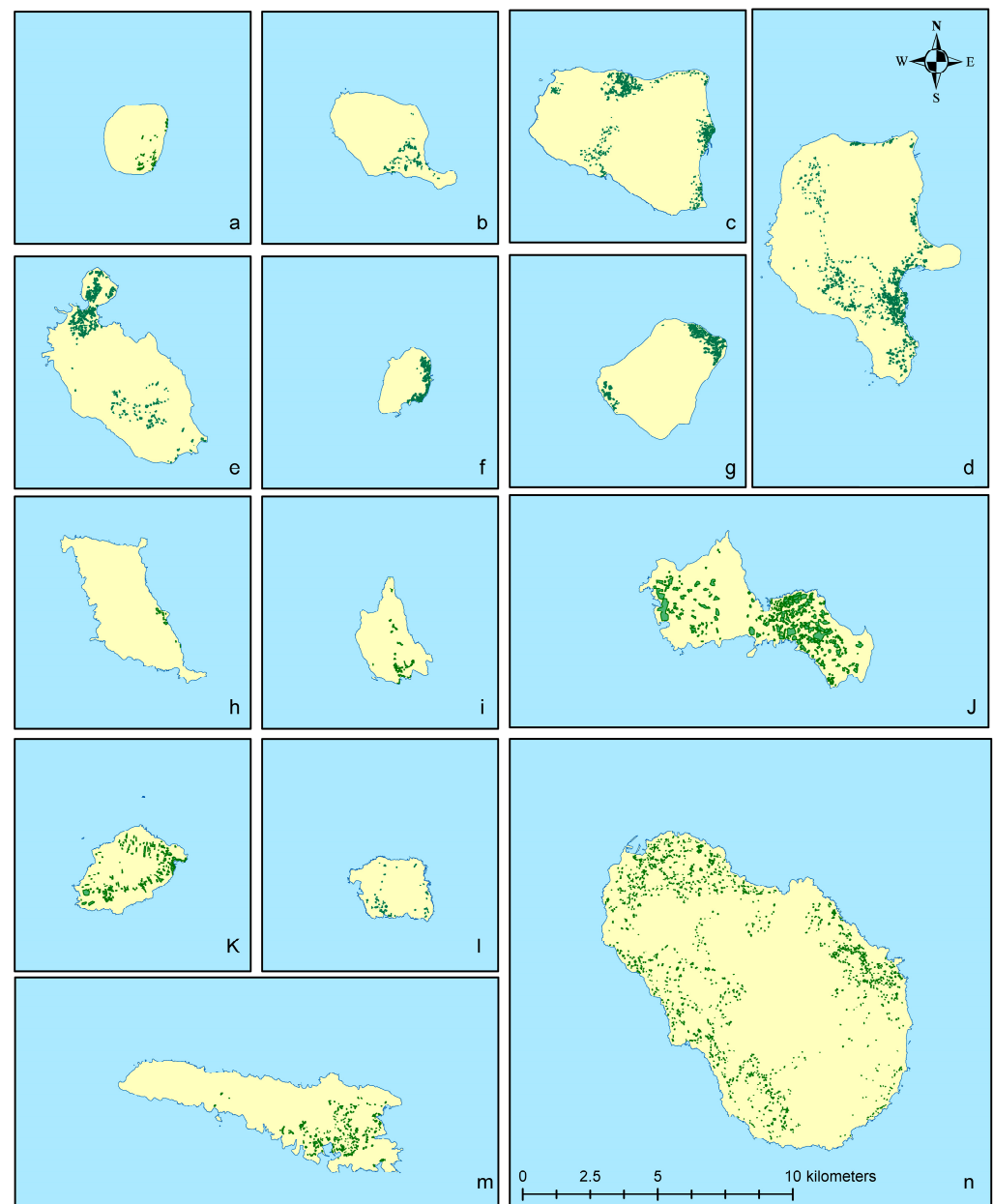


Figure 2. Ornamental green mapped via photointerpretation on each island: (a) Alicudi, (b) Filicudi, (c) Salina, (d) Lipari, (e) Vulcano, (f) Panarea, (g) Stromboli, (h) Marettimo, (i) Levanzo, (j) Favignana, (K) Ustica, (l) Linosa, (m) Lampedusa, and (n) Pantelleria.

Regarding fragmentation and patch characteristics, islands such as Lipari, Vulcano, and Stromboli display very strong clustering patterns with nearest neighbor ratios well below 0.5. These islands also have relatively small mean patch sizes and low standard deviations, implying that their ornamental green areas consist of numerous small, tightly grouped patches rather than large contiguous expanses. The island of Salina exhibits a similar trend, characterized by highly pronounced clustering and a mean patch size of approximately 0.06, indicating that green spaces are both aggregated and highly fragmented.

The islands of Ustica and Panarea show a different behavior: their nearest neighbor ratios are above 0.8, indicating a more dispersed or random distribution of green patches. Ustica has nearly 5% ornamental green cover, the second highest after Favignana, and its patches are larger on average compared to the strongly clustered islands, with a mean patch size of 0.22. The island of Panarea has a weak clustering pattern and a mean patch size of 0.12, suggesting a more even spread of green areas without strong aggregation.

Table 2. Main features of the islands under study.

Island	Total Area	CA	Ornamental Green %	NumP	MPS	PSSD	NNR	Z Score	p-Value
Ustica	8.12	0.40	4.93	182	0.22	0.35	0.833	−4.31	0.000
Alicudi	5.06	0.04	0.78	54	0.07	0.08	0.721	−3.93	0.000
Filicudi	9.24	0.07	0.78	117	0.06	0.08	0.469	−10.99	0.000
Salina	26.06	0.34	1.30	582	0.06	0.06	0.397	−27.81	0.000
Lipari	37.23	0.65	1.75	846	0.08	0.11	0.471	−29.42	0.000
Vulcano	20.89	0.47	2.27	355	0.13	0.18	0.475	−18.94	0.000
Panarea	3.37	0.16	4.71	128	0.12	0.15	0.903	−2.09	0.037
Stromboli	12.61	0.25	1.99	329	0.08	0.09	0.438	−19.51	0.000
Linosa	5.40	0.05	0.88	60	0.08	0.11	0.662	−5.01	0.000
Lampedusa	20.51	0.26	1.25	291	0.09	0.14	0.563	−14.26	0.000
Pantelleria	83.71	0.92	1.10	1589	0.06	0.06	0.551	−34.21	0.000
Marettimo	12.16	0.03	0.26	21	0.15	0.22	0.788	−1.86	0.063
Favignana	19.92	2.20	11.05	300	0.73	1.50	0.794	−6.84	0.000
Levanzo	5.81	0.09	1.53	48	0.19	0.18	0.556	−5.88	0.000

Total area (total area of the island in km²), class area (CA; ornamental green area in km²), number of patches (NumP), mean patch size (MPS), patch size standard deviation (PSSD; measuring size variability), nearest neighbor ratio (NNR), standard deviations (Z score), and probability (p-value).

Among the smaller islands, Marettimo has the lowest ornamental green percentage, just 0.26%, with a moderate clustering pattern and a relatively high standard deviation in patch size, implying a few larger patches accompanied by several very small ones.

The islands of Alicudi and Filicudi also have very low percentages of ornamental green, below one percent, yet both show moderate to very strong clustering. In these cases, the green areas are few and concentrated around the villages rather than distributed across the island. The islands of Linosa and Levanzo, with strong clustering and low mean patch sizes, follow the pattern of aggregated but tiny ornamental green patches. Overall, Favignana is unique in combining high proportional cover with moderate clustering, whereas islands like Ustica and Panarea offer more dispersed green areas that might be less fragmented despite lower total cover percentages.

Looking at the total number of cultivated ornamental species per island (see the Supplementary Material, Table S1), Ustica is the richest with 217 species, followed by Lipari (213) and Salina (205). The poorest islands in terms of ornamental flora are Marettimo with only 95 species, Alicudi with 96, and Stromboli with 108. So, the smallest totals are found on the smaller Aeolian and Egadi islands, while Ustica and the larger Aeolian islands support a much wider range of ornamentals.

Regarding the use of native plants as ornamentals (Table 3), Stromboli exhibits the highest percentage (18.52%), indicating that approximately one in five ornamental species is native. Marettimo follows with 17.89%, and Filicudi ranks third with 15.65%. At the other end, Ustica has the lowest share of native ornamentals (9.22%), followed by Lampedusa and Salina.

For naturalized and invasive species combined (Table 3), Stromboli again leads with 15.74% (12.04% naturalized plus 3.70% invasive). Linosa is next at 14.13%, then Pantelleria at 12.88%. The lowest combined percentages are on Lampedusa (7.24%), Salina (7.32%), and Lipari (7.98%). Stromboli and Linosa are the islands where the most common ornamental plants are those that are no longer cultivated and become established in the wild.

The total number of taxa strongly correlated with allergenic ($\rho = 0.974$), toxic ($\rho = 0.960$), and habitat provider richness ($\rho = 0.982$, all $p < 0.001$; Table S2). Native richness showed similar patterns, while invasive richness was weakly and non-significantly associated with all variables. Geo-demographic metrics (area, population, and ornamental surface) had negligible correlations. Low water requirement correlated strongly with toxic, allergenic, and habitat provider richness ($\rho > 0.879$, $p < 0.001$), but not with invasives.

The GLM analyses (Table S3) revealed no statistically significant relationships between any of the predictors and the ornamental flora metrics examined (all $p > 0.05$; Table S2).

Table 3. Number and percentage of native, cultivated only, casual, naturalized, and invasive ornamental taxa recorded across the islands of the Sicilian archipelago.

Island	Native		Cultivated Only		Casual		Naturalized		Invasive		TOTAL
	No.	%	No.	%	No.	%	No.	%	No.	%	
Ustica	20	9.22	158	72.81	15	6.91	21	9.68	3	1.38	217
Alicudi	14	14.58	65	67.71	8	8.33	7	7.29	2	2.08	96
Filicudi	18	15.65	85	73.91	1	0.87	8	6.96	3	2.61	115
Salina	24	11.71	161	78.54	5	2.44	11	5.37	4	1.95	205
Lipari	23	10.80	168	78.87	5	2.35	13	6.10	4	1.88	213
Vulcano	28	14.43	139	71.65	7	3.61	17	8.76	3	1.55	194
Panarea	19	13.01	109	74.66	6	4.11	8	5.48	4	2.74	146
Stromboli	20	18.52	68	62.96	3	2.78	13	12.04	4	3.70	108
Linosa	24	12.57	123	64.40	17	8.90	23	12.04	4	2.09	191
Lampedusa	18	11.84	119	78.29	4	2.63	9	5.92	2	1.32	152
Pantelleria	22	13.50	109	66.87	11	6.75	17	10.43	4	2.45	163
Marettimo	17	17.89	68	71.58	1	1.05	7	7.37	2	2.11	95
Favignana	20	15.04	98	73.68	1	0.75	11	8.27	3	2.26	133
Levanzo	17	14.66	83	71.55	3	2.59	10	8.62	3	2.59	116

The principal component analysis (Plot S1, Table S4) revealed that the first component (PC1) explained 99.96% of the total variance, overwhelmingly dominating the ordination structure. The PC1 scores were strongly correlated with population size ($r_s = 0.98$, $p < 0.001$), indicating that demographic pressure is the primary source of variation in the dataset. The second component (PC2), explaining only 0.033% of the variance, separated islands with higher proportions of native species and habitat-providing taxa (positive scores: Ustica, Vulcano, Salina, and Linosa) from those with higher proportions of invasive and toxic species (negative scores: Marettimo, Alicudi, Stromboli, and Favignana).

The cultivated ornamental green across the islands provides a range of ecosystem services but also generates some disservices. Among the services, the highest values for habitat provision are recorded on Lipari and Ustica, followed closely by Salina and Vulcano (Table 4). These same islands also score highly for fruit availability for birds and small mammals, with Lipari reaching 107, Ustica 112, and Salina 97, indicating that ornamental green supports local fauna. Erosion control is another notable service, with Lipari, Vulcano, and Salina showing strong values above 119, while Ustica and Linosa also contribute significantly. Pollination support, here labeled as bee-related value, is particularly high on Ustica, Lipari, and Salina, all exceeding 140 taxa, suggesting that ornamental plantings provide floral resources for pollinators. Food production for human use, though secondary, is present on most islands, with Ustica and Lipari again leading. Fences or live hedges as a service are strongest on Ustica and Salina, indicating that ornamental green can still play an important role as a vegetative barrier today.

Regarding disservices, the dataset includes categories for toxic or allergenic effects (Table 4). Ustica shows the highest toxic value at 98 and allergenic at 94 taxa, meaning that its ornamental green, despite offering many benefits, also introduces potentially harmful taxa. Lipari follows closely with 100 for toxic and 99 for allergenic, while Salina and Vulcano also have elevated values. The possible source of medicines column, which might be interpreted as a service, includes plants that could be toxic if misused, and here again Ustica, Lipari, Salina, and Linosa have high numbers, reflecting a double-edged character. Smaller islands, such as Marettimo and Stromboli, show lower disservice values, with Marettimo having the lowest toxic and allergenic scores overall, but their service provision is also reduced. Favignana presents moderate values for both services and disservices, while Levanzo and Alicudi remain relatively low across most categories. In summary, islands with the most abundant ornamental green, such as Ustica and Lipari, deliver the highest

levels of habitat, food for birds, erosion control, and pollination, but simultaneously pose greater risks from toxic and allergenic plants. Islands with a lower number of ornamental plants, like Marettimo and Stromboli, offer fewer services but also fewer disservices.

Table 4. Number of taxa with ecosystem services or disservices recorded across the islands of the Sicilian archipelago. To., toxic; Al., allergenic; Me., with known medicinal use; Ha., habitat provision; Wi., wildlife feed; Er., erosion control; Li., livestock feed; Fo., food for humans; Be., beekeeping interest; Fe., green fences.

Island	To.	Al.	Me.	Ha.	Wi.	Er.	Li.	Fo.	Be.	Fe.
Ustica	98	94	182	181	112	117	49	80	158	128
Alicudi	53	43	82	75	44	56	24	30	73	55
Filicudi	52	55	98	100	57	69	27	44	89	75
Salina	95	95	178	175	97	119	49	74	147	125
Lipari	100	99	178	183	107	126	49	77	151	125
Vulcano	85	86	169	170	97	124	51	77	144	122
Panarea	73	61	128	123	72	80	36	60	113	85
Stromboli	44	44	94	89	53	65	32	44	80	66
Linosa	90	76	164	155	98	103	49	69	140	107
Lampedusa	71	62	131	122	78	84	39	56	107	85
Pantelleria	67	66	134	130	78	94	40	62	120	89
Marettimo	40	39	84	79	54	54	25	45	71	56
Favignana	63	54	115	109	64	79	36	51	98	77
Levanzo	57	47	94	95	57	72	29	47	84	65

The analysis of water requirements for ornamental plants (Figure 3) reveals a consistent pattern across all islands. The proportion of species with low water needs ranges from 39% to 55%, those with medium requirements from 35% to 52%, and those with high requirements from 7% to 13%. Among the islands, the Egadi archipelago stands out, where over half of the ornamental plants fall into the low-water-demand category. In contrast, on Lipari and Salina, low-requirement species account for 39% and 40%, respectively, while medium-requirement species reach 52% on Lipari and 50% on Salina.

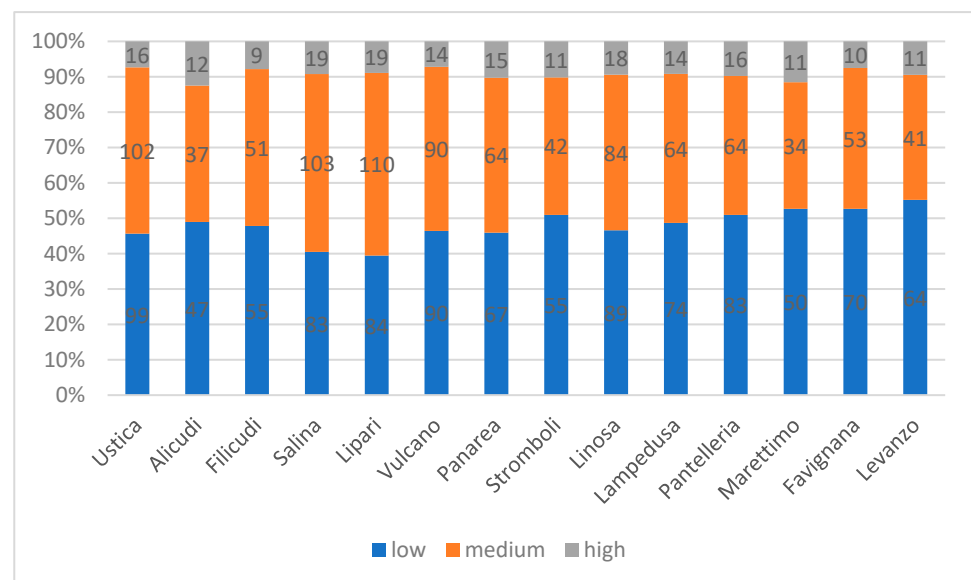


Figure 3. Water requirements of the ornamental flora across the islands of the Sicilian archipelago. Numbers in the middle of the bar represent the absolute counts of the detected taxa.

4. Discussion

On small islands like Marettimo and Alicudi where decorative green is limited, the selection of cultivated plants has turned to local native species instead of a diverse group of non-native plants. On the other hand, larger islands, such as Ustica or Lipari, which feature

extensive gardens and public green spaces, resulted to support numerous introduced non-native plants.

The disturbance (bare ground and ash fall) in Stromboli creates open habitats where cultivated species can easily establish themselves. This island, despite having a low total species count, has the highest native percentage and the highest combined naturalized plus invasive share. Ornamental plants that manage to survive there may spread rapidly because competition from a closed vegetation cover is weak. Stromboli shows that even with a modest planting area, high invasive potential can occur, and disturbances outweigh the effects of the area. The ornamental green patches display a clear spatial dichotomy across the islands. Pantelleria, Lipari, Vulcano, Stromboli, and Salina show very strong clustering, indicating that green areas are tightly packed into restricted zones around settlements. Also, among the smaller islands (Marettimo, Alicudi, Filicudi, Linosa, and Levanzo), clustering tends to be moderate to strong, with ornamental vegetation largely confined to village cores. A different behavior emerges on Ustica and Panarea, where the distribution approaches a dispersed pattern with a more uniform spatial footprint. Favignana occupies an intermediate position, showing a weak but statistically detectable tendency toward clustering, without falling into either extreme. Overall, the islands divide into two main groups—strongly aggregated versus more dispersed—with only Favignana lying between them as a transitional case. This variation points to different local drivers, such as topography or settlement history, shaping ornamental green spaces.

It is important to emphasize that the natural and semi-natural vegetation present on most islands (particularly Marettimo, Alicudi, and Stromboli) already provides substantial habitat and connectivity functions. Ornamental patches should, therefore, be viewed as complementary elements within a broader landscape mosaic, rather than as primary habitat providers. On islands where natural vegetation is extensive, like Marettimo, increasing ornamental cover would not necessarily improve overall connectivity and could inadvertently facilitate invasions, especially where disturbance creates open niches. Thus, management recommendations should be tailored to each island's existing vegetation cover, disturbance regime, and invasion history.

Favignana, on the other hand, has the largest area devoted to ornamental, more than twice that of Pantelleria, which ranks second. Although part of its water supply is obtained from groundwater wells, the island's freshwater resources are intrinsically limited, and approximately 70% of its groundwater is highly saline because of seawater intrusion into the aquifer. Nevertheless, its total ornamental flora is intermediate among the studied islands, while its combined proportion of naturalized and invasive species (10.53%) remains relatively low compared with Stromboli (15.74%) or Linosa (14.13%). This suggests that, despite severe water constraints, appropriate species selection has limited both irrigation demand and the establishment of invasive ornamentals.

The absence of significant relationships between the tested predictors and ornamental flora metrics suggests that ornamental plant diversity on these islands is shaped by local cultural and historical factors rather than by simple biogeographic or demographic rules. The overwhelming dominance of PC1 (99.96% of variance) confirms that population size is the main driver of ornamental flora quantity across the circum-Sicilian islands, as it determines the overall number of species, including toxic, allergenic, and habitat-providing taxa. However, as shown by the non-significant GLM results, population size does not explain the functional composition of the ornamental flora. The association between the number of drought-tolerant taxa and allergenic/toxic traits reveals a trade-off between water-efficient landscaping and public health safety, calling for cautious plant selection in urban green spaces.

Maintaining ornamental plants on Mediterranean islands requires greater care than on the mainland, involving both the selection of species with moderate or low water requirements and appropriate long-term management. Climate change is expected to intensify water scarcity throughout the Mediterranean basin by increasing temperatures, prolonging drought periods, and reducing groundwater recharge. These effects are likely to be particularly severe on small islands, where freshwater resources are naturally scarce and often threatened by seawater intrusion. Under these conditions, ornamental planting should increasingly favor native species and long-established drought-tolerant taxa that are naturally adapted to local environmental conditions. Besides reducing irrigation requirements, these species generally require less maintenance, better withstand saline winds and prolonged summer drought, and often present a lower risk of naturalization and invasion than recently introduced exotic ornamentals. Examination of the introduction dates (Table S1) shows that a large proportion of the ornamental flora has been cultivated in Sicily or Italy for centuries. This finding highlights the islands' reliance on plant species that are already well adapted to the Sicilian climate and capable of surviving with limited external inputs.

It is notable that on Favignana several abandoned calcarenite quarries have been successfully transformed into gardens [54]. Similarly, on Pantelleria, traditional circular dry-stone enclosures built from lava blocks create sheltered and humid microclimates that protect ornamental and cultivated plants from strong winds while reducing water loss [55]. These examples illustrate how traditional landscape practices can complement species selection in improving the resilience of ornamental green spaces under increasingly water-limited conditions.

The increasing interest in ornamental greening has drawn attention to the multiple functions of ornamental vegetation, but also to its potential trade-offs. This examination of thirteen Mediterranean islands provides a comprehensive overview of how cultivated green spaces contribute simultaneously to ecosystem services and ecosystem disservices, and how their spatial distribution influences their ecological performance. Furthermore, ornamental green spaces increasingly provide ecosystem functions that were formerly supplied by agricultural land, which has steadily declined on the circum-Sicilian islands since the end of the Second World War. A first key finding is the consistent association between total ornamental green cover and the provision of multiple services. Islands such as Ustica and Lipari, which rank highest in ornamental green percentage and in the number of plant taxa providing habitat, fruit for birds and small mammals, erosion control, bee forage, and live hedges, also exhibit the highest values of allergenic and toxic plants. In other words, greener, and especially a richer plant diversity, brings more benefits, but also increases the risk of negative effects. This pattern mirrors a general trade-off widely discussed in urban ecosystem literature: a larger and more diverse plant community tends to produce both more services and more disservices [14,56]. In small island settings, where spatial constraints are pronounced and isolation from mainland contexts is marked, these effects may be considerably exacerbated.

The spatial configuration of ornamental patches adds another layer of variability. Islands with very strong clustering patterns (Lipari, Vulcano, Stromboli, and Salina) have ornamental green areas composed of numerous small patches aggregated in few locations, often near residential centers. This configuration maximizes some local services, such as shading or aesthetic enjoyment, but likely reduces landscape connectivity and habitat for wide-ranging species. Conversely, Ustica and Panarea show a more dispersed distribution of patches, with larger mean patch sizes and a weaker clustering pattern. Dispersed ornamental green, even when covering a smaller total area, may better support pollinators and other animals by increasing habitat accessibility across the island. This observation is

consistent with the island biogeography theory as applied to urban green spaces: larger and more interconnected patches support greater biodiversity and lower extinction rates [57]. In an island setting, this framework is particularly relevant because every patch of ornamental vegetation functions as a “habitat island” embedded in a matrix of other land uses.

The results also reveal that high cultivated ornamental plant diversity does not necessarily imply high fragmentation. Favignana has the highest proportional cover of ornamental green (about 11% of the island) and a moderate clustering pattern, which suggests that a high cover can be achieved without excessive fragmentation. This is an encouraging case: it demonstrates that a relatively large and moderately aggregated green area can deliver a balanced set of services without the high disservice levels observed on Ustica and Lipari.

When comparing these results with other Mediterranean studies, several convergences emerge. Domina et al. [14] surveyed 100 sites across Sicily and found that 137 poisonous and allergenic taxa are commonly planted in gardens and parks, 21 of which are deadly. Their recommendations include careful plant selection and environmental education, which are directly applicable to ornamental green management on islands. Similarly, assessments on the Ionian Islands [58] identified seven ecosystem service bundles and highlighted that the degree of mixing between natural vegetation and olive orchards determines different ecosystem service patterns across islands. That study also stressed the importance of compact ecosystem service zones where demand and supply are balanced. In the Aegean, research on Paros [59] emphasized xeriscaping and stormwater management as key strategies for sustainable ornamental landscaping in water-stressed insular environments. Our study highlighted the high incidence and ecological importance in circum-Sicilian islands of aridity-tolerant plant species, including many native taxa.

Regarding the care and maintenance of ornamental plants on Mediterranean islands, the current findings indicate several practical suggestions. First, plant selection should prioritize native or well-adapted non-invasive species that provide ecosystem services without high allergenic or toxic potential [60,61]. Where high diversity is desired, a careful mix of service-providing and low-risk species can be designed, avoiding the dominance of highly allergenic trees (e.g., many Cupressaceae or Oleaceae) or toxic ornamentals (e.g., *Nerium oleander* or *Ricinus communis*). Second, the spatial configuration matters: rather than concentrating all ornamental green space in a few dense clusters, a pattern of medium-sized patches connected by green corridors (even if narrow) would likely enhance connectivity for pollinators and birds without excessively increasing maintenance costs. This approach is in line with the island biogeography principle that connectivity reduces extinction rates and supports biodiversity [57]. Third, on islands with water scarcity, such as Ustica or Lampedusa, xeriscaping and use of drought-tolerant native species should be integrated with ornamental design to reduce irrigation demand and avoid the introduction of water-intensive exotic plants [59].

Conversely, certain practices should be avoided. The indiscriminate planting of highly allergenic or toxic species, especially in public gardens or near schools and health facilities, is clearly inadvisable. Domina et al. [14] explicitly warn against 21 deadly poisonous plants commonly found in Sicilian gardens. Also, extreme fragmentation (many tiny, isolated patches) should be avoided, as it limits the capacity to support viable populations of pollinators and birds [62,63], while still requiring maintenance. Moreover, a complete removal of ornamental green, as might be implied by the low service/low disservice islands like Marettimo, would not be a desirable solution, because it would deprive islands of essential services. Rather, an adaptive management that balances services and disservices through informed species selection and spatial design is the recommended path.

The study has some limitations worth noting. First, while the checklist recorded ornamental plants grown in outdoor pots, the spatial analysis of green areas was based

on satellite mapping of polygons with a minimum size of 25 m². This minimum mapping unit was adopted to ensure data consistency and mitigate the noise that would result from mapping numerous tiny, fragmented features. The species cultivated in small pots, balcony plantings, and isolated container specimens, despite occupying negligible surface area, often harbor a surprisingly rich and diverse flora. The assessment of ecosystem services and disservices relies entirely on a presence–absence checklist of taxa, without considering species abundance, frequency, or actual distribution across each island. Third, the study does not account for seasonal dynamics or management intensity, both of which strongly influence the actual provision of services, such as erosion control or wildlife habitat.

Despite these limitations, this paper delivers valuable data for understanding and managing ornamental heritage on circum-Sicilian islands. The comparative framework, linking spatial configuration (clustered versus dispersed patches) to service and disservice patterns, offers practical insights. For instance, the observation that Favignana achieves high cover with moderate clustering and relatively low naturalization risk, while Stromboli shows high invasion potential despite limited planted area, gives local managers concrete evidence to adjust planting strategies. The study also clearly demonstrates the trade-off whereby species-rich ornamental floras (Ustica and Lipari) deliver many services but also higher toxicity and allergenicity risks. Such findings can inform species selection and spatial planning, even without detailed abundance data. In essence, the work opens a necessary discussion on functional ornamental green in insular environments and provides a replicable methodological framework that future studies can refine by incorporating abundance, distribution, and temporal monitoring.

5. Conclusions

This study shows that ornamental green spaces on Mediterranean islands are not a uniform asset: their ecological role depends strongly on both species composition and spatial arrangement. The survey of 402 cultivated taxa across the circum-Sicilian islands revealed marked differences among islands in both floristic richness and ecosystem functions. Ustica and Lipari hosted the highest numbers of ornamental taxa and provided the greatest levels of ecosystem services, including habitat provision, pollinator support, erosion control, and food resources for wildlife, but they also showed the highest occurrence of toxic and allergenic species. In contrast, Favignana combined the largest proportional ornamental green cover (approximately 11% of the island area) with only moderate spatial clustering and relatively limited naturalization risk, suggesting that extensive ornamental green can be compatible with a balanced provision of ecosystem services when supported by appropriate species selection and landscape configuration.

These findings demonstrate that ornamental vegetation on Mediterranean islands should be planned not only according to aesthetic criteria but also considering ecosystem services, potential disservices, and spatial configuration. The results also indicate that the island biogeography framework provides a useful approach for understanding and designing functional ornamental green networks. Future research should extend this methodology to other island systems and urban environments, while incorporating species abundance, temporal dynamics, and management intensity to better quantify ecosystem service delivery.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land15071252/s1>. Table S1: Summary of taxonomic, ecological, and phytogeographic characteristics of the studied flora, with distribution across the major islands of the Sicilian archipelagos; Table S2: Spearman's correlation coefficients for all variables (Area, Population, Ornamental surface, No. of taxa, Native no., Invasive no., Toxic no., Allergenic no., Habitat providers no., Low-water-requirement ornamental taxa no.; Tables S3: Generalized Linear

Model (GLM) results testing the effects of island area, population size, and ornamental green cover on eight ornamental flora metrics; Plot S4: Principal component analysis based on the 7 continuous variables (island area (km²), population size, ornamental green cover (km²), total ornamental taxa, and the numbers of native, invasive, toxic, allergenic, habitat-providing, and low-water-requirement ornamental taxa; Table S4: PCA scores of the circum-Sicilian islands along the first seven principal components.

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