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Review

The Contribution of Ornamental Plants to Urban Ecosystem Services

Alessandra Francini [1], Daniela Romano [2,*], Stefania Toscano [2] and Antonio Ferrante [3]

[1] Institute of Life Sciences, Scuola Superiore Sant'Anna Pisa, 56127 Pisa, Italy
[2] Department of Agriculture, Food and Environment, Università degli Studi di Catania, 95131 Catania, Italy
[3] Department of Agricultural and Environmental Sciences—Production, Landscape, Agroenergy, Università degli Studi di Milano, 20133 Milan, Italy
* Correspondence: dromano@unict.it

Abstract: Urban areas can be differently anthropized; often, high-density populations lead to higher amounts of pollution. Nowadays, ornamental plants can represent important living components of urban areas, and if appropriate species are used, they can provide important ecosystem services. The relationships between green infrastructures and ecosystem services have been recognized for a long time, but the role of ornamental plant species has not been studied as much. In this frame, the different ecosystem services of ornamental plants, i.e., provisioning (e.g., food, air, and water cleaning), regulating (e.g., rain water, climate, nutrient recycling, pollination, and the formation of fertile soils), and cultural (e.g., recreation opportunities or the inspiration we draw from nature) will be critically analyzed to select the most suitable ornamental plant species able to assure the better performance. The action mechanisms will also be analyzed and discussed to individuate the best ideotypes of plant species able to better assure water purification, air quality, space for recreation, climate mitigation and adaptation, human wellbeing, and health. This information is suitable to ensure that the protection, restoration, creation, and enhancement of green infrastructure become integral parts of urban spatial planning and territorial development.

Keywords: green infrastructure; food production; water rain management; temperature regulation; nutrient recycling; pollution; biodiversity; human well-being

Citation: Francini, A.; Romano, D.; Toscano, S.; Ferrante, A. The Contribution of Ornamental Plants to Urban Ecosystem Services. *Earth* **2022**, *3*, 1258–1274. https://doi.org/10.3390/earth3040071

Academic Editor: Daniela Baldantoni

Received: 31 October 2022
Accepted: 29 November 2022
Published: 2 December 2022

1. Introduction

Urban areas can be differently anthropized; often, large cities are highly dense populations with higher amounts of pollution and limited spaces for growing plants.

Intense urbanization (in 2050, almost 70% of the world population is expected to reside in urban areas [1]); climate change, water scarcity, pollution, and a reduction of human well-being [2,3] will be problems that cities will have to find solutions to.

To overcome these problems, urban ecosystems will have to increase the environmental services provided via green urban infrastructure. Green Infrastructure (GI), defined by the European Biodiversity and GI Strategies as "*a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation*" [https://ec.europa.eu/environment/nature/ecosystems/index_en.htm (accessed on 6 September 2022)], is crucial to improve human wellbeing. Nowadays, however, ornamental plants are considered as important living components of urban areas; if appropriate species are used, they can provide important ecosystem services. Ecosystem services (ESs) are the benefits that humans can obtain from ecosystems [4]. The Common International Classification of Ecosystem Services (CICES) is widely used for mapping, ecosystem assessment, and natural capital ecosystem accounting [5]. The last revised version of CICES (V5.1) was released in January 2018 [5]; at the highest level, the services are grouped into three sections related to the contributions of supporting human

well-being: (a) the provisioning of material and energy needs, (b) regulation and maintenance of the environment for humans, and c) the nonmaterial characteristics of ecosystems that affect physical and mental states of people [6,7].

In industrialized countries with highly dense populations, large towns can suffer from air and soil pollution derived from human activities. Air can be polluted by indoor combustion of firewood, biomass fuels for heating, daily cooking at home or restaurants, and industrial activities that can generate high concentrations of particulate matter, sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and ozone in urban areas [8].

Particulate matter (PM), on the basis of the particle size, can be divided into fractions that contain larger particles with sizes ranging from 2.5 to 10 μm (PM10–PM2.5). Fine fractions contain particles with sizes up to 2.5 μm (PM2.5). PMs are typical air pollutants that can participate in atmospheric chemical reactions and influence environmental quality, climate, and public health. PM includes heavy metals that can deposit on the foliar or can enter inside leaves through the cuticle and stomatal pores [9]. Pollution is tightly correlated with heavy metals, which can limit the number of ornamental species that can be used. Moreover, the contaminated soil reduces the utilization of cultivation or utilization of different species as edible plants.

The maintenance and enhancement of GI, therefore, are key tools to support and promote sustainable development because they are recognized as having the ability to ensure a wide range of ecosystem services (ES) [10]. If the relationships between GI, plants, and life quality are supported by the numerous scientific evidence and literature studies, the role of ornamental plants is often not adequately considered [11], or negatively considered especially when the ornamental plant is alien [12].

Ornamental plants are grown for decoration and beautification of indoor and outdoor environments [13] and improving the aesthetic and/or visual quality of a built environment [14]. These plants are characterized by their leaves, especially flowers with brilliant color. Ornamental plants are used in different environments and situations, in landscaping, and in different green areas (roads, parks, and gardens), significantly improving life quality, whether in the countryside or in the city [15]. Despite ornamental plants being relevant elements of human environments, we know relatively little about them [16] and their contributions to life quality. Often in the analysis of plant components of urban or allotment gardens, the category of "ornamental" is considered different from, the others, forgetting that ornamental plants can ensure food (i.e., edible flowers [17] or edible ornamental plants [18]) or can be used for other purposes (i.e., phytoremediation [15]). In recent years, regarding the pressure of environmental problems and global change, ornamental plants have been considered for their aesthetic features and their capacity to improve the environment and the quality of our lives [19]. Thus, the use of ornamental plants was proposed to restore degraded landscapes, control erosion, reduce energy and water consumption, and improve the aesthetic quality of indoor and outdoor environments where people live [20]. The large number of plants potentially used as ornamental species enhances the possibility to individuate genotypes suitable for improving environmental benefits and human well-being (HWB).

Ornamental plants accompanied the history of men in different civilizations and continents [16]. Their uses were particularly intense in Greek and Roman civilizations, when numerous ornamental plants (hyacinth, ivy, narcissus) were linked to myths. As also demonstrated by the recent COVID-19 pandemic, ornamental plants are not just luxuries, they are also human necessities [21], because they allow humans to connect with nature [22] in increasingly urbanized environments.

Ornamental plants and relevant horticulture practices provide multiple environmental (e.g., climate regulation), economic (e.g., energy saving), social (e.g., improved privacy and security), and aesthetic (e.g., community and building beautification) benefits for HWB [23–26].

The objective of this work was to highlight the importance of the integration of green areas in highly anthropized areas. The selection of the correct plant species can provide

several direct and indirect benefits to urban environments and inhabitants. The elaboration of the state-of-the-art will help in the identification of critical issues related to the use of urban areas and potential solutions or research needs will be highlighted.

2. Methodology and Literature Research

According to the main objective of the review, i.e., to analyze the contribution of ornamental plants to ES, we used Scopus research and Google Scholar to individuate, in the last ten years, papers that (for ornamental plants) provided information about environmental (e.g., climate regulation), economic (e.g., energy saving), social (e.g., improved privacy and security), and aesthetic (e.g., community and building beautification) benefits. The main criterion was that, in the paper, the object of attention was the ornamental plant function. Of course, in consideration of multifunctional meanings of "ornamental" [19], many of the excluded papers could have dealt with plants of potential aesthetic value, but above all, we wanted to analyze those in which, for the authors, the ornamental function was very present.

3. Ecosystem Services

Ornamental plants (including woody, herbaceous, succulent plants, geophytes, etc.) ensure essential environmental services, including the reduction of heat islands in cities, the production of oxygen and carbon sequestration, the reduction of air and water pollution, the reduction of noise pollution, and an increase of biodiversity [24].

The benefits of ecosystem services depend on the urbanized areas and how the green areas are distributed in metropolitan areas. Accurate studies should be performed in cities for planning the distribution of ornamental plant species that can provide the desired ecosystem services [27]. Strengths and weaknesses must be considered before green area planning. The optimization of ornamental plant distribution should consider building densities in horizontal and vertical dimensions, green areas, and spaces for green planning enrichment. All of these factors should be geo-localized. The time dynamic evolution and non-stationarity of spatial urban compactness must be considered in long-term ecosystem services. An appropriate model should be developed for the optimization of urban planning. Urban areas and plants do not continuously grow or modify with positive or negative impacts on urban life (Figure 1).

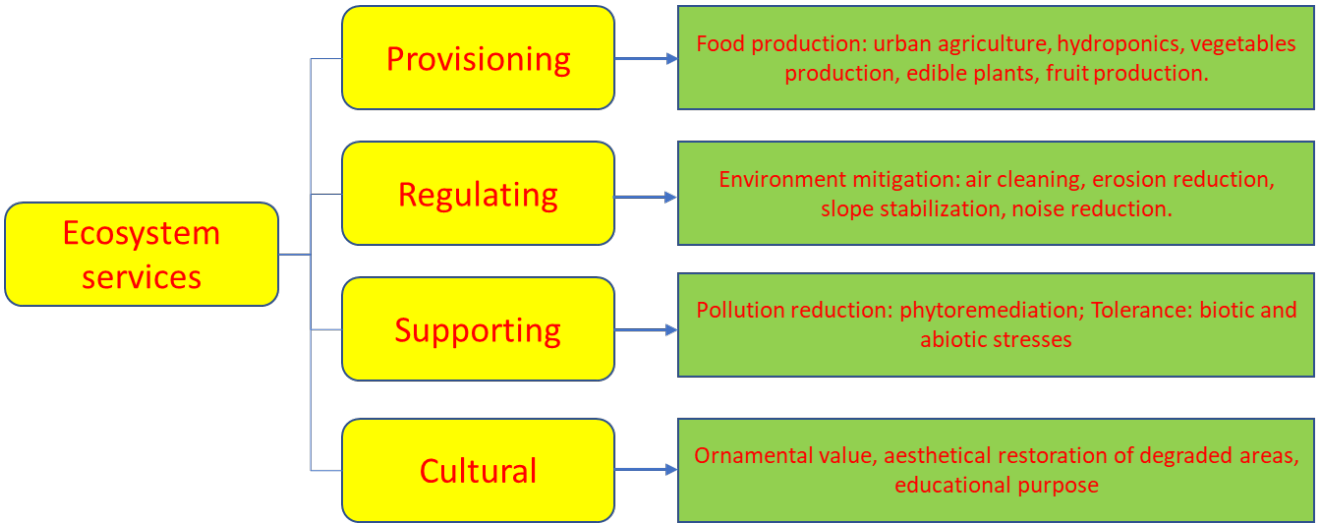

Figure 1. Ecosystem services and connections with benefits obtained from adequate green area planning and distribution in an urban or peri-urban area.

Urban complexity and urban greening can have effects at different scales that can include local areas up to small scales, such as urban vegetable cultivation that can provide

benefit to closer inhabitants, or larger scales, such as specific ornamental plants spread in a metropolitan area, which can benefit the entire urban city with specific actions, such as pollution removal, air cleaning, etc. [28]. The urban complexity has to consider soil quality [29], buildings, people density, climate, ornamental plants, and the potential expansion or reduction of green areas.

Urban planners have to consider social, ecological, and technological factors that interact each other and influence the ecosystem services in term of the quality, spatial, and temporal provision of benefits [30].

3.1. Provisioning of Material and Energy Needs

Food Production in an Urban Area

Crop cultivation around urban areas was a common practice in the past when fast transport systems and logistics were not available. In recent years, urban agriculture has been valorized as a strategy to supply food and security for the population inside highly urbanized areas, supporting low-carbon economy strategies. Shorter supply chains and the reduction of logistic networks can reduce the use of fossil fuels and increase the sustainability of food systems. It has been shown that long and complex distribution chains are vulnerable in sanitary emergency situations, such as COVID-19 [31]. Urban agriculture contributes toward increasing employment, reducing inequality, and helping with social inclusion. Unfortunately, urban and peri-urban soils are of low quality and the limited agronomic tools or their restricted usages may lead to low yield and quality of produce (Table 1). Alternative cultivation methods can be carried out using soilless or hydroponic systems, such as the cultivation on tanks containing substrates (pit, coconut fiber, etc.) or in floating or simplified NFT systems [32]. In urban areas without enough or adequate space, top roofs can be exploited for cultivation. Rooftop vegetable growing can be performed using soilless systems, such as aeroponics or floating systems, or other closed hydroponics systems. [33]. If there are no roofs available, the cultivation can be carried out in indoor conditions with artificial lighting using LED lamps. The indoor growing systems allow for the use of old buildings inside the towns. These cultivation techniques require specific training for the nutrient solution preparation or supply.

Table 1. Cultivation of plants in urban environments and the possible growing systems that can be adopted.

Cultivation Systems and Plant Species in Urban Areas	
Soil	All ornamental and vegetable species, including annual, shrubs, and trees.
Soilless systems	In areas without soil availability, the growing systems can be carried out in substrates, floating systems, aeroponics, and nutrient film techniques (NFT).
Rooftop	Ornamental and vegetable plants can be grown on the top of buildings.
Indoor	Indoor cultivation can be performed when there are no soil or roofs available. Indoor cultivation has the advantage of producing directly in the urban area and in contact with consumers.

Green urban areas can be composed of diverse plant species, including those that can provide food for inhabitants. Several plant species, including herbaceous, shrubs, or woody species, can be selected for their dual aims as ornamentals and for potential food production. Urban agriculture has been increasing in highly populated towns for several purposes. Large towns can represent real food production systems, but these areas can also offer from meeting points for the elders (often retired people), youngers, or simply give opportunities to people interested in gardening as a hobby. Crop cultivation can be directly carried out on soil, if not polluted and fertile. Unfortunately, often, urban soils

are highly heterogeneous with building residues that are not properly removed and with time integrated in the soil. The chemical and physical properties of the soil are not often adequate for growing edible plants and a top layer substitution may be required. The selection of crops should be carefully considered. The most productive crops used in agriculture are not more suitable, because in urban environments plant genotypes should have multiple tolerance traits that can allow growth (even in sub-optimal conditions). Urban green areas can increase plant biodiversity, and edible flowers, vegetables, and fruits can provide food for inhabitants and satisfy their nutritional needs. They are expected to have positive impacts on the preservation of local varieties and breeds, contributing to preserving genetic diversity. The strengthening of food production in urban areas is related to the production of products that can be harvested at the stage of ripening or maturity, reducing postharvest losses, leading to shorter distribution chains, and delivering fresh to consumers. Limitations are represented by the uptake or deposit of pollutants in the edible parts that can easily be eaten. Edible ornamentals represent fresh or raw vegetal food that can also improve the dish presentation and display [34,35]. Many edible ornamentals are rich in bioactive compounds and can be considered as functional or nutraceutical food [36]. Several studies have reported that phenolic compounds of edible flowers can have potential benefits on human health because these molecules have strong antioxidant activities and are able to scavenge reactive oxygen species (ROS) [37]. The Mediterranean area has many wild species that can be explored as ornamental or potential sources of food for the citizens [38]. Edible plants available in Sicily were classified; 467 belong to 304 genera and 119 botanical families. The most frequent families are Rosaceae, Asparagaceae, Malvaceae, Leguminosae, and Lamiaceae. Among these families, the most edible organs are represented by flowers (22%), leaves (20%), fruits (18%), and hypogeal organs (9%) [38]. However, it is well known that many wild plants have poison molecules [39]. Therefore, an accurate toxicological evaluation must be carried out if the species selected are not well characterized for their potential danger for human health [40].

Edible flowers can have a dual aim by improving the aesthetical qualities of urban areas and providing food for the inhabitants. Even with the potential usages of edible species, the real utilizations are limited. The low valorization of edible ornamentals in an urban area is associated with the lack of adequate cultivation systems, appropriate soil quality, and the lack of (or inadequate) agronomic management, such as fertilization, irrigation, and defense strategy. Moreover, specific protocols can be considered for the harvest of edible parts or plants from the urban environment (Table 2).

Ornamental plants include fruit trees, such as apples, pears, sweet cherries, etc. Fruit orchards can be part of the cultural landscape and heritage [41]. Fruit orchards in urban or peri-urban areas improve land use diversification and biodiversity among woody species; blooming in the spring–summer contributes to the aesthetical values of urban areas. Fruit orchards can also have educational functions, i.e., by showing students the fruit production seasons and linking the fruit to the tree.

It is important for the management of the fruit species to be carefully carried out. In particular, varieties or cultivars selected must be tolerant to the most common fungal diseases or pests. Since the protection chemical treatments should be avoided, the use of biological control agents or other organic products should be applied, if necessary. During the winter, pruning should be carefully carried out to guarantee an equilibrium of vegetation for supporting adequate productivity and providing a pleasant shape for ornamental purposes. It is common to find old apple varieties in big cities.

Table 2. The main parameters and strategies that should be taken into consideration.

Environmental Evaluation	
Location	Adequate solar radiation and water availability.
Soil	Adequate organic matter (1.5–3%), pH (5.5–7.5), electric conductivity (<2.5), homogenous topsoil layer.
Management	Mineral nutrition should be carefully determined on the basis of soil availability and species requirements. Fertilizers should be slowly released and the supply should be performed by following the plant uptake dynamics.
Pollution	In case of soil pollution, such as heavy metals, cultivation can be carried out in hydroponic systems with nutrient solutions or substrates.
Ornamental species	
Annual	Edible flower species that can be grown in soil in urban areas with low traffic or in private gardens or balconies.
Shrubs and trees	These species have long permanence in the urban area; therefore, appropriate distribution and density must be considered. It is important to use varieties that have tolerance to diseases or pests.
Agronomic tools	
Irrigation	The water supply should be scheduled considering the plant growth and soil water retention.
Tillage tools	The soil can be prepared manually or with a small working machine.
Protection	Avoid chemical compounds, including pesticides and fungicides. In case of severe biotic stress conditions, biostimulants and biological control agents should be used.
Harvesting	In fruit plants, it is important to guarantee harvesting in the best ripening stage, avoiding overripening that can affect the quality of the production.

3.2. Regulation and Maintenance of the Environment for Humans

Green spaces, including parks, can provide moderate benefits related to carbon sequestration in urban areas, especially those with substantial tree cover and other woody vegetation [42]. Increasing urbanization, therefore, presents fundamental challenges but also unprecedented opportunities to enhance the resilience and ecological functioning of urban systems in global change [6]. Climate change must be considered as a danger for cities, with the same emphasis that has been adopted for COVID by territorial stakeholders and governments [43]

Green turfs can be open spaces where children can play and spend part of the day outside, e.g., during the summer. There are ornamental plants that have been used for volatile organic compounds (VOCs). This ability has been demonstrated and exploited for air cleaning in indoor environments [44], but this ability can also be used in open urban areas.

Plants can be sources of VOCs under stress conditions or pest attacks [45].

3.2.1. Water Rain Management and Mitigation

Green stormwater infrastructure can assure both runoff control and mitigation, along with water filtration [46].

Bioretention and rain garden systems are shallow planted areas designed to capture, retain, or detain stormwater to favorite the soil infiltration of water and avoid the runoff over the soil surface. Rain gardens assure many benefits to the environment: improved water quality, enhanced groundwater recharge, reduction of suspended particles, reduction of surface flows and associated erosion, and creation of new habitats for birds, butterflies, and other beneficial insects (Figure 2).

Figure 2. Ornamental plants and their potential positive effects on urban and peri-urban environments. A combination of species with vegetation from the ground can be used as noise barriers, and species with high density foliage can be used as shields for wind protection. Through their transpiration, they can reduce temperature, and with their canopy, they can created shadow areas for relaxing during the summer. Different species increase the biodiversity in urban and peri-urban areas.

Plants are key elements of rain gardens. Water cycles benefit plants through the transpiration process as well as the long-term maintenance of suitable soil structures (to increase the water infiltration) [47]. Plants also remove nutrient-based pollutants (mostly nitrogen and phosphorus) and, partially, non-biodegradable pollutants (i.e., heavy metals) in stormwater runoff [48]. The plants, also thanks to their ornamental features, enhance the aesthetic value of the landscape [49].

To provide a more suitable growing environment for common ornamental landscape plants, it is necessary to provide a soil blend meeting the engineering specifications and plant requirements, which can also improve the rain garden functionality and the aesthetic features of the plants [50].

Plant selections for rain gardens can be complicated, as cyclic flooding and the gradient moisture level are expected in the depression structure of a rain garden [51]. The rain garden is a green "sponge" used to intercept rainwater [52]. For the rain garden characteristics, the species selection has to be addressed to plants that are drought-tolerant and with well-developed roots. In a survey conducted in Shangai (China), Ma et al. [53] found that the main plant species adopted in rain gardens were trees (*Metasequoia glyptostroboides* Hu & W.C. Cheng, *Salix babylonica* L., *Paulownia tomentosa* Steud., *Acer palmatum* Thunb. 'Atropurpureum', shrub species (*Fatsia japonica* Decne. & Planch., *Aucuba japonica* Thunb. 'Variegata', *Loropetalum chinense* Oliv.), herbs (*Hemerocallis fulva* (L.) L., *Farfugium japonicum* (L.) Kitam., *Stipa tenuissima* Trin.), aquatic plants (*Phragmites australis* (Cav.) Steud., *Gladiolus* ×*gandavensis* Van Houtte, *Iris pseudacorus* L., *I. tectorum* Maxim., *Lythrum salicaria* L., *Cyperus alternifolius* L.). All of these species show interesting aesthetical features to emphasize the usefulness of choosing ornamental plants.

Further investigations should be carried out in different environmental contexts in order to broaden the knowledge of ornamental plants that could be used in rain gardens and in their performance.

3.2.2. Temperature Regulation

The urban heat island effect has become a matter of concern, particularly in regions with hot, humid climates. Plants have direct effects on the temperature, incident radiation, radiation absorption, surface roughness, wind velocity, relative humidity, and surface albedo. Trees, with their transpiration, contribute towards cooler summer temperatures [54]. Planting trees along paved roads reduces the temperature on the ground, helps to increase the longevity of the paving materials, and lengthens the asphalt's lifespan. In addition, planting trees around a building can significantly reduce the energy costs of heating and cooling [24]. The presence of urban trees strongly regulates the pedestrian's thermal comfort and surface energy balance via shading [55]. Diverse typologies of urban vegetation differently affect temperature. Among ornamentals, palm trees have important roles in regulating the levels of air humidity [56].

Gratani and Varone [57] investigated the contribution to the decreasing air temperature by *Quercus ilex* L. and *Q. pubescens* Willd., which are widely distributed in the city of Rome. The crown volume is the most significant variable explaining a variation of air temperature below the tree crown. *Q. pubescens* gave a higher contribution to the decreasing air temperature during the hottest months, due to its inherent larger crown volume when compared to *Q. ilex*.

If urban vegetation reduces air temperatures, the amount of this cooling effect is different between different types of vegetation. Richards et al. [58] compared the cooling effects of five vegetation types that are frequent in Singapore, a city with tropical climate: grass, shrub, managed trees, managed trees over shrubs, and secondary forest. Significant temperature reductions were linked to the increasing cover of managed trees, managed trees over shrubs below, and secondary forest vegetation; the latter vegetation type had the greatest effect, underlining the positive influences of the adoption of different plant species typologies. Temperature mitigation by green areas is the effect of the transpiration that allows the change of water in the vapor at the leaf level. This change of status requires heat with a cooling effect on the leaf and the environment. An adequate green area can reduce the cooling energy of the buildings around the shrubs and trees (Figure 2).

Plants of five ornamental shrubs [*Callistemon citrinus* (Curtis) Skeels, *Laurus nobilis* L., *Pittosporum tobira* (Thunb.) W.T. Aiton, *Thunbergia erecta* (Benth.) Anderson, and *Viburnum tinus* L. 'Lucidum'] were subjected to two consecutive cycles of suspension/rewatering and compared with plants that were watered daily. The transpiration behaviors showed the different responses of the plants to environmental conditions and to drought stresses, as well as the possibility, through the plant species choice, to maximize the reduction of temperature around the plants [59].

3.2.3. Nutrient Recycling

Urban and peri-urban environments suffer from lack in organic matter and plants can grow in limited nutrient availability. Nutrients in the soil must be recycled using appropriate plants that can uptake the mineral elements and avoid losses during the spring when a fast mineralization can occur. Turfgrass can be combined with shrubs and ornamental trees, representing a vegetation cover with the protection of soil forming heavy rains in urban environments. Mineral nutrients, such as nitrogen (N), phosphorous (P), and potassium (K) are essential elements required for the growth and color of leaf areas that contribute to the visual appearance and beauty of the landscape [60]. However, the higher availability due to the wrong fertilizer supply can lead to an excess of nutrients that can induce losses if nutrients are not absorbed by the plants. Good vegetation during all seasons can guarantee the nutrient recycling, preventing nutrient losses in urban environment. Root turnover can periodically provide organic matter and mineral elements to plants with the mineralization process. It is important to use plants that can have vegetative periods all year around. The same purpose is required in ornamental gardens, where, when using different species, an attempt is made to extend the period in which the plants are in vegetative activity to emphasize the aesthetic aspect of the green area.

The use of plants that belong to the Fabaceae family can provide nitrogen through N_2 fixation [61]. In urban planning, the Fabaceae should be combined with other ornamental species that require high nitrogen levels. In soil, the combination of ornamental species with different root growths and developments can colonize different soil layers (to 70–100 cm in depth). This root network avoids the loss of nutrients in the underground and avoids ground water pollution. Roots of ornamental plants aim to increase the stability of the soil, especially in slope conditions [62]. Plants with their root biomasses and architectures can significantly reduce the erosion and loss of nutrients on the surface in slope areas.

3.2.4. Pollution

The areas inside the towns and the peri-urban green areas can suffer from high pollution due to human activities. Most pollutants in urban areas are represented by heavy metals that can be distributed on the surface or in soils at different depths. The pollution can come from industrial activities or high vehicular traffic. Ornamental plants can be tools used to recover degraded areas and remove heavy metals from soil, storing them in different organs (roots, branches, or leaves). The selection of suitable ornamental species can rapidly change the visual appearance and restore (at least from the aesthetic point of view) the urban or peri-urban area. Heavy metals mainly derive from urban traffic (cars, motor vehicles, trucks, bus, etc.) along with road crossings, urban roads, and highways.

The benefit from using correct ornamental species is represented by the removal of heavy metals without showing phytotoxic symptoms. The optimal plant species should be able to uptake the heavy metals and these plants can be used for phytoremediation purposes, or they have to exclude the uptake or accumulate them under the phytotoxic threshold. It is well known that some elements or metals are essential for plant growth, development, and protection from stressful conditions, such as copper (Cu), zinc (Zn), and selenium (Se). Cu and Zn are important co-factors of antioxidant enzymes, such as superoxide dismutase (Zn/Cu SOD), which are involved in the control of the accumulation of reactive oxygen species accumulation (ROS) or reactive nitrogen species (RNS). Unfortunately, the required amounts of these metals are limited; in polluted soils, the concentrations overcome the needs, and many plants can suffer from heavy metals stress. The most common symptoms of heavy metal stress are represented by leaf yellowing, necrosis, abscission, etc. All of these symptoms compromise the ornamental value of plants and, therefore, sensitive ornamental species should be avoided in urban areas subjected to high heavy metal pollution. The most common (and potentially dangerous) heavy metals in urban areas are represented by aluminum (Al), lead (Pb), cadmium (Cd), Zn, mercury (Hg), Cu, and chromium (Cr). A large number of ornamental species can be selected for removing the heavy metals. The identification of most suitable species must be carefully done. The screening and selection of the species should be carried out at a nursery before transplanting. Specific studies can be planned for selecting the species that combines high phytoextraction capacity and tolerance to a large number of heavy metals. The restoration of a contaminated green area can be achieved using ornamental species that tolerate the concentration of heavy metals in the soil [63] and should not show any symptoms of phytotoxicity. The tolerance of the plants should be evaluated considering the interfering factors that can be represented by the soil's organic matter, pH, exposition, water availability, salinity, etc. Ornamental plants can also be selected as phytoremediation tools. The etymology of phytoremediation is obtained from the union of two words "*phyto*", which means plant, and "*remedium*", which means to remedy or restore. Plants can develop the ability to survive soil with high heavy metal concentrations. These species could be exploited to uptake and accumulate heavy metals, and remove them from polluted soils. Plants that accumulate high concentrations of heavy metals are usually named hyper-accumulators. Plants can uptake or stabilize heavy metals in a polluted site, e.g., phytostabilization, phytovolatilization, rhizofiltration, and phytoextraction. The rhizofiltration is a strategy where the roots of plants can uptake or precipitate the heavy metals. Ornamental aquatic plants

can remove heavy metals from urban rivers or water channels. Several aquatic species can be used for rhizofiltration; some of them are the water hyacinth [*Eichhornia crassipes* (Mart.) Solms], *Hydrocotyle umbellata* L., and *Lemna minor* L. Rhizofiltration, which can be used in urban areas that are crossed with rivers or in urban areas that are polluted from close industries. Phytostabilization, instead, is a stabilization process where the roots of plants avoiding heavy metals can go in the deeper layers of soils. Phytostabilization is an eco-friendly technique that also provides aesthetic improvement of urban areas. Therefore, an attempt is made to stabilize (inactivate) the metal in situ to reduce its polluting potential. The species that can be used for phytostabilization are *Agrostis capillaris* L. and *Festuca rubra* L., common turfgrass ornamental species. Phytovolatilization consists of the uptake of heavy metals and incorporates them in volatile organic compounds that can be easily released into the atmosphere in less toxic forms. Phytovolatilization has been used for mercury (Hg) and selenium (Se) [64,65]. In *Astragalus racemosus* Pursh plants, the conversion of Se into dimethyl diselenide [66] has been reported. The phytoextraction is represented by the removal of heavy metal using plants. Plant uptake of the heavy metals and transferring them to the areal part (leaves and branches) can be removed by pruning. This strategy is a slow process and takes several years to reach significant heavy metal reduction [67]. Ornamental plants that can be used for phytoextraction are oleander (*Nerium oleander* L.), Canna (*Canna* ×*generalis* L.H. Bailey), pelargonium (*Pelargonium* L'Hér. spp.), and four o'clock (*Mirabilis jalapa* L.). Among woody plants, *Robinia pseudoacacia* L. accumulates a high level of Al, while *Platanus orientalis* is suitable for Cr accumulation and monitoring. Among woody trees, the poplar (*Populus alba* L.) can be used as an ornamental plant and it is able to tolerate high concentrations of heavy metals [68]. Moreover, this tree has high phytostabilization ability [69], in particular, Villafranca clone is highly tolerant to Zn soil concentration [70].

Air pollutants also include aliphatic hydrocarbons and polycyclic aromatic hydrocarbons. They are considered dangerous to the environment and human health [71]. Hydrocarbons, commonly distinguished, such as aliphatic and aromatic compounds, belong to more than 20 n-alkanes that range from n-C8 to n-C33, and 2 isoprenoids, pristane and phytane. In a study performed in three France cities, Paris, Créteil, and Coulommiers, the amounts of total aliphatic hydrocarbons monitored were 33, 19, and 30 mg m^{-2} y^{-1}, respectively [72]. Predominance was represented by phenanthrene, fluoranthene, and pyrene. These compounds were associated with the mixture of petrogenic and pyrolytic contaminations.

The reduction of pollution can be achieved by traffic limitations. Inside urban traffic restrictions can significantly reduce these atmospheric pollutants. During the lockdown period, due to the sanitary emergency associated with COVID-19, air pollution was drastically reduced. The PM10 was reduced by 30–40% in the metropolitan city of Milan. This result was due to less vehicular traffic and industrial activities [73]. However, adequate plant species can help in the reduction of pollution. Ornamental plants that can be used in phytoremediation, for the removal of PAH degradation in contaminated soils, are represented by *Callistephus chinensis* (L.) Benth., *Echinacea purpurea* (L.) Moench, *Festuca arundinacea* Schreb., and *Medicago sativa* L.

Higher removal rates were 99.40% and 98.11%, respectively, of *F. arundinacea* and *M. sativa*, over the 150-day experiment. These plants are excellent species that can have great potential in removing polycyclic aromatic hydrocarbons in contaminated soils [74]. In urban environments, pharmaceuticals and personal care products (PPCPs) can be considered as pollutants, and conventional wastewater treatments do not sufficiently remove all of them [75,76]. Ornamental plants can uptake some of them and remove them from the environment. Poplar has a high accumulation of erythromycin in its roots and low translocation in its stem and leaves [77]. Therefore, this plant can be used for phytostabilization action in polluted environments.

3.2.5. Biodiversity

Urban environments are characterized by low levels of biodiversity [78]. Green spaces ensure important roles in conserving and improving biodiversity, favoring the resettlement of wild plants [79], and providing food sources and laces for nesting for many animal species [80]. Pollinating insects are part of endangered animal categories in cities because of the scarcity of nectar and pollen, primary sources for their sustenance [81]. The ornamental plants, chosen for their aesthetic features, are often characterized by showy flowers; they are allogamous species with entomophilous pollination.

Ornamental species are frequently used in green spaces to increase the plant diversity and cultural services (e.g., aesthetic, recreation, educational) of urban areas [82]. Despite the concerns about the ecological risks attributed to the introduced alien species [83], the process of species introduction in cities is increasing [84]. The introduction of ornamental plant species can enhance species diversity.

Plant diversity could contribute significantly to the enhancement of cultural services in urban areas [85]. Moreover, the introduction can be helpful for the ex situ conservation of some ornamental plant species. The conservation of genetic resources of ornamental plants is strategic. As underlined by Khoshbakth and Hammer [86], the percentage of ornamental-threatened plant species in relation to the total percentage of existing plants is higher (13.9% versus 13.5%).

A moderate introduction of ornamental species, if these species are not invasive, is good for biodiversity conservation. Currently, most of the plants in urban landscapes have been selected for their ornamental traits and their ability to grow in urban green spaces.

Global change and urban heat island effects determine the opportunity to adopt plant species that are resistant or tolerant to abiotic stresses [84]; most of them originate from warmer regions.

The genetic traits that plants need to provide services for a city's environment and population (e.g., pollution reduction, biodiversity conservation, soil stability, and food production) require suitable planning of genetic improvements [87] to increase the ES of ornamental plants.

3.3. Non-Material Characteristics of Ecosystems That Affect Physical and Mental States of People

The non-material benefits that the population obtains from ecosystems, through spiritual enrichment, cognitive development, reflection, and recreative/esthetic experiences, are important. Ornamental plants and gardens have always been sources of inspiration and bonds for cultures and civilizations all over the world, assuring aesthetic and recreational values, and are sources of inspiration for culture, arts, educational and spiritual values, and identity.

Human wellbeing (HWB) can be defined as "*the welfare, quality of life, living standard, utility, life satisfaction, human development, and capability expansion*" [88]. Ornamental plants, cultivated both in indoor and outdoor environments, can contribute to human health and wellbeing [56,89], reducing stress, and improving mind and life satisfaction [24]. Ornamental plants enhance individual moods, favor recovery from mental fatigue, reduce stress levels, and increase creative performances [90]. The presence of flowers and ornamentals in and around the home and workplaces can reduce stress and anxiety levels, and make people happier and more relaxed [24]. Flowers generate happiness; for example, roses, geraniums, and lilies surrounding one's home induce positive emotions [16].

The presence of ornamental plants increases productivity, reduces mental fatigue and physical discomfort symptoms, and enhances good mood [91]. Workers are more alert and productive thanks to the proximity of ornamental plants [24]. A child's learning and concentration skills improve if there are plants in the environment.

To evaluate the components of HWB, a 0–5 Likert scale was adopted. The findings indicate the significant role of ornamental plants for 'habitat formation' and 'wildlife attraction'. The most chosen components were 'habitats for pets' and 'aesthetic quality'.

The ornamental plant-based ESs contributed to the two components of HWB: 'security' (4.51 points) and 'contact with nature' (4.37 points) [11].

Cultural ecosystem services include recreational and tourism enjoyment, educational resources, physical and mental health enhancements, spiritual enlightenment, aesthetic appreciation and inspiration, non-market monetary value, etc. [92]. The valuations of the visual amenities of trees were conducted [93]. Densely arranged large flowers were preferred to small and sparse flowers [94]. Olfactory properties were also preferred [14], with a light scent more desired than a strong fragrance or odorless flowers [95].

The sense of being in contact with nature due to the presence of plants in the surrounding environment has several psychological effects on urban communities. For example, making people feel more relaxed and restored, enhancing social cohesion, improving fitness through the promotion of outdoor physical activities, and improving health through the reinforcement of the immunity system [96]. It is very difficult to define which of the plant traits are useful at providing specific psychosocial benefits to urban communities, but it is known that visual factors, such as flower color, morphology, and size, as well as the emission of scents, are not only appreciated for their beauty and decoration but also because of their contributions to the perceptions of higher psychological wellbeing. This concerns most flowering ornamental plants [87].

Healing Garden

The post-hospitalization course was also used as an indicator of the therapeutic effects linked to the presence of green areas near hospitals. The first studies by Ulrich [97] demonstrated that patients who enjoyed plant eyesight recovered much more quickly from surgeries, being less stressed and more psychologically charged. The ability of gardens and ornamental plants to increase the satisfaction of both patients and medical staff, as well as reduce stress, is attracting considerable attention from hospital administrators in the United States [98]. In countries with highly competitive markets for medical care, investing in gardens is seen as a valid tool for improving the economic or financial results of hospitals [99]. In the US, it has been estimated that building a hospital in a pleasant place surrounded by a garden can result in annual savings of approximately USD 15–20 million for a 300-bed facility [100].

Healing gardens are landscape-designed areas near hospitals and other healthcare structures, and are created using plants and other landscape elements to improve the health of those within that healthcare facility. Gardens containing different shrubs and flowers, able to stimulate the three major human senses, can contribute to the treatment of illnesses and medical disabilities [101].

Lu et al. [102] analyzed, through a model, the plant species selection in healing landscapes for the elderly. In this model, the importance order of the evaluation index was psychological healing, physiological healing, and plant scenery. Among the plant species that were more effective, including native, medicinal, and aromatic, the ornamentals played a relevant role [103].

4. Conclusions

Ornamental plants in urban and peri-urban areas can be used for the mitigation of the climate, reduction of air and soil pollution, providing food for habitants, and creating meeting points for elders and young people. Plants can belong to a wide range of species. A correct selection can ensure the improvement of the aesthetical appearance of urban areas and increase the biodiversity of plants. Ornamental plants can be selected considering their abiotic stress tolerances. Urban and peri-urban areas can be characterized by low water availability, salinity, and high or low temperatures, and in these conditions, the appropriate species must be used. Plants in urban areas can have different social importance characteristics. Ornamental plants have a direct positive effect on patients in hospitals or in private houses with people having different health problems. Plants around schools

can help with learning, i.e., regarding the importance of plants for humans, and they can represent live learning tools for teaching activities.

The information available in the literature is only partially able to support the role that ornamental plants have in improving the environmental characteristics and HWB of cities, despite the fact that these are the places where the majority of populations live, and above all, where the most ornamental plants are present. Research activities in ornamental plants and their applications are rarely funded, and scientific validation is missed for target urban environments. Urban green area management costs are usually underestimated with negative effects on the ecosystem service benefits.

Further investigations should be performed for providing additional knowledge related to:

- The importance of the urban ecosystem services of green areas at a local level, involving stakeholders, politicians, and citizens urban;
- Detailed analysis of the contribution that ornamental species can offer, in consideration of the very broad genetic bases on which they can be counted;
- Identification of easy to use parameters that are able to define the performances of the different species to help in the choices of the most suitable genotypes.

Author Contributions: Conceptualization, A.F. (Antonio Ferrante) and D.R.; methodology, A.F. (Alessandra Francini), S.T., D.R. and A.F. (Antonio Ferrante); formal analysis, A.F. (Alessandra Francini), S.T., D.R. and A.F. (Antonio Ferrante); writing—original draft preparation, A.F. (Alessandra Francini), S.T., D.R. and A.F. (Antonio Ferrante); writing—review and editing, A.F. (Alessandra Francini), S.T., D.R. and A.F. (Antonio Ferrante); supervision, D.R. and A.F. (Antonio Ferrante). All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. UN (United Nations). *World Urbanization Prospects: The 2018 Revision*; United Nations, Department of Economic and Social Affairs, Population Division: New York, NY, USA, 2018; pp. 1–126.
2. IPCC (Intergovernmental Panel on Climate Change). *Urban Areas Climate Change 2014—Impacts, Adaptation and Vulnerability: Part A: Global and Sectoral Aspects: Working Group II Contribution to the IPCC Fifth Assessment Report*; Cambridge University Press: Cambridge, UK, 2014; pp. 535–612. [CrossRef]
3. WHO (World Health Organization); UN-Habitat. *Global Report on urban Health: Equitable Healthier Cities for Sustainable Development*; World Health Organization: Geneva, Switzerland, 2016; pp. 1–239. Available online: https://apps.who.int/iris/handle/10665/204715 (accessed on 4 October 2022).
4. Millennium Ecosystem Assessment, M.A. *Ecosystems and Human Well-Being: A Framework for Assessment*; Report of the Conceptual Framework Working Group of the Millennium Ecosystem Assessment; Island Press: Washington, DC, USA, 2003; p. 266. Available online: http://pdf.wri.org/ecosystems_human_wellbeing.pdf (accessed on 13 September 2022).
5. Haines-Young, R.; Potschin-Young, M. Revision of the common international classification for ecosystem services (CICES V5. 1): A policy brief. *One Ecosyst.* **2018**, *3*, e27108. [CrossRef]
6. Elmqvist, T.; Setälä, H.; Handel, S.N.; Van Der Ploeg, S.; Aronson, J.; Blignaut, J.N.; Gomez-Baggethun, E.; Nowak, D.J.; Kronenberg, J.; De Groot, R. Benefits of restoring ecosystem services in urban areas. *Curr. Opin. Environ. Sustain.* **2015**, *14*, 101–108. [CrossRef]
7. Nawrath, M.; Elsey, H.; Dallimer, M. Why cultural ecosystem services matter most: Exploring the pathways linking greenspaces and mental health in a low-income country. *Sci. Total Environ.* **2022**, *806*, 150551. [CrossRef] [PubMed]
8. Schwela, D. Air pollution and health in urban areas. *Rev. Environ. Health* **2000**, *15*, 13–42. [CrossRef]
9. Li, C.; Du, D.; Gan, Y.; Ji, S.; Wang, L.; Chang, M.; Liu, J. Foliar dust as a reliable environmental monitor of heavy metal pollution in comparison to plant leaves and soil in urban areas. *Chemosphere* **2022**, *287*, 132341. [CrossRef]
10. Capotorti, G.; Ortí, M.M.A.; Copiz, R.; Fusaro, L.; Mollo, B.; Salvatori, E.; Zavattero, L. Biodiversity and ecosystem services in urban green infrastructure planning: A case study from the metropolitan area of Rome (Italy). *Urban For. Urban Green.* **2019**, *37*, 87–96. [CrossRef]
11. Ciftcioglu, G.C.; Ebedi, S.; Abak, K. Evaluation of the relationship between ornamental plants–based ecosystem services and human wellbeing: A case study from Lefke Region of North Cyprus. *Ecol. Indic.* **2019**, *102*, 278–288. [CrossRef]

12. Wang, H.F.; Qureshi, S.; Knapp, S.; Friedman, C.R.; Hubacek, K. A basic assessment of residential plant diversity and its ecosystem services and disservices in Beijing, China. *Appl. Geogr.* **2015**, *64*, 121–131. [CrossRef]
13. Hernández, M.; Morales, A.; Saurí, D. Ornamental plants and the production of nature (s) in the Spanish real estate boom and bust: The case of Alicante. *Urban Geogr.* **2014**, *35*, 71–85. [CrossRef]
14. Kendal, D.; Williams, N.S.; Williams, K.J. A cultivated environment: Exploring the global distribution of plants in gardens, parks and streetscapes. *Urban Ecosyst.* **2012**, *15*, 637–652. [CrossRef]
15. Rocha, C.S.; Rocha, D.C.; Kochi, L.Y.; Carneiro, D.N.M.; Dos Reis, M.V.; Gomes, M.P. Phytoremediation by ornamental plants: A beautiful and ecological alternative. *Environ. Sci. Pollut. Res.* **2022**, *29*, 3336–3354. [CrossRef] [PubMed]
16. Wilson, A.; Kendal, D.; Moore, J.L. Humans and ornamental plants: A mutualism? *Ecopsychology* **2016**, *8*, 257–263. [CrossRef]
17. Benvenuti, S.; Mazzoncini, M. The biodiversity of edible flowers: Discovering new tastes and new health benefits. *Front. Plant Sci.* **2021**, *11*, 569499. [CrossRef]
18. Fetouh, M.I. Edible Landscaping in Urban Horticulture. In *Urban Horticulture. Sustainable Development and Biodiversity*; Nandwani, D., Ed.; Springer: Cham, Switzerland, 2018; Volume 18, pp. 141–173. [CrossRef]
19. Savé, R. What is stress and how to deal with it in ornamental plants? *Acta Hortic.* **2009**, *813*, 241–254. [CrossRef]
20. Toscano, S.; Ferrante, A.; Romano, D. Response of Mediterranean ornamental plants to drought stress. *Horticulturae* **2019**, *5*, 6. [CrossRef]
21. Gopal, D.; Nagendra, H. Vegetation in Bangalore's slums: Boosting livelihoods, well-being and social capital. *Sustainability* **2014**, *6*, 2459–2473. [CrossRef]
22. Maller, C.; Townsend, M.; St Leger, L.; Henderson-Wilson, C.; Pryor, A.; Prosser, L.; Moore, M. Healthy parks, healthy people: The health benefits of contact with nature in a park context. *Georg. Wright Forum* **2009**, *26*, 51–83.
23. Baiyewu, R.A.; Amusa, N.A.; Olayiwola, O. Survey on the use of ornamental plants for environmental management in south-western Nigeria. *RJABS* **2005**, *1*, 237–240. Available online: http://www.aensiweb.net/AENSIWEB/rjabs/rjabs/237-240.pdf (accessed on 20 September 2022).
24. Hall, C.R.; Hodges, A.W. Economic, environmental and well-being benefits of lifestyle horticulture. *Chron. Horticult.* **2011**, *51*, 5–8.
25. Summers, J.K.; Smith, L.M.; Case, J.L.; Linthurst, R.A. A review of the elements of human well-being with an emphasis on the contribution of ecosystem services. *AMBIO* **2012**, *41*, 327–340. [CrossRef]
26. Ciftcioglu, G.C. Assessment of the relationship between ecosystem services and human wellbeing in the social-ecological landscapes of Lefke Region in North Cyprus. *Landsc. Ecol.* **2017**, *32*, 897–913. [CrossRef]
27. Yu, P.; Zhang, S.; Yung, E.H.; Chan, E.H.; Luan, B.; Chen, Y. On the urban compactness to ecosystem services in a rapidly urbanising metropolitan area: Highlighting scale effects and spatial non–stationary. *Environ. Impact Assess. Rev.* **2023**, *98*, 106975. [CrossRef]
28. Evans, D.L.; Falagán, N.; Hardman, C.A.; Kourmpetli, S.; Liu, L.; Mead, B.R.; Davies, J.A.C. Ecosystem service delivery by urban agriculture and green infrastructure–a systematic review. *Ecosyst. Serv.* **2022**, *54*, 101405. [CrossRef]
29. Ungaro, F.; Maienza, A.; Ugolini, F.; Lanini, G.M.; Baronti, S.; Calzolari, C. Assessment of joint soil ecosystem services supply in urban green spaces: A case study in Northern Italy. *Urban For. Urban Green.* **2022**, *67*, 127455. [CrossRef]
30. McPhearson, T.; Cook, E.M.; Berbés-Blázquez, M.; Cheng, C.; Grimm, N.B.; Andersson, E.; Barbosa, O.; Chandler, D.G.; Chang, H.; Chester, M.V.; et al. A social-ecological-technological systems framework for urban ecosystem services. *One Earth* **2022**, *5*, 505–518. [CrossRef]
31. Bulgari, R.; Petrini, A.; Cocetta, G.; Nicoletto, C.; Ertani, A.; Sambo, P.; Ferrante, A.; Nicola, S. The impact of COVID-19 on horticulture: Critical issues and opportunities derived from an unexpected occurrence. *Horticulturae* **2021**, *7*, 124. [CrossRef]
32. Giro, A.; Ciappellano, S.; Ferrante, A. Vegetable production using a simplified hydroponics system inside City of Dead (Cairo). *Adv. Hortic. Sci.* **2016**, *30*, 23–29. [CrossRef]
33. Appolloni, E.; Orsini, F.; Specht, K.; Thomaier, S.; Sanye-Mengual, E.; Pennisi, G.; Gianquinto, G. The global rise of urban rooftop agriculture: A review of worldwide cases. *J. Clean. Prod.* **2021**, *296*, 126556. [CrossRef]
34. Demasi, S.; Caser, M.; Donno, D.; Enri, S.; Lonati, M.; Scariot, V. Exploring wild edible flowers as a source of bioactive compounds: New perspectives in horticulture. *Folia Horticult.* **2021**, *33*, 27–48. [CrossRef]
35. Scariot, V.; Ferrante, A.; Romano, D. Edible flowers: Understanding the effect of genotype, preharvest, and postharvest on quality, safety, and consumption. *Front. Plant Sci.* **2022**, *13*, 1025196. [CrossRef]
36. Falla, N.M.; Contu, S.; Demasi, S.; Caser, M.; Scariot, V. Environmental Impact of Edible flower production: A case study. *Agronomy* **2020**, *10*, 579. [CrossRef]
37. Durazzo, A.; Lucarini, M.; Novellino, E.; Daliu, P.; Santini, A. Fruit-based juices: Focus on antioxidant properties—Study approach and update. *Phytother. Res.* **2019**, *33*, 1754–1769. [CrossRef] [PubMed]
38. Romano, D.; La Fornara, G.; Toscano, S. The edible ornamental plants: A resource for urban Mediterranean horticulture. *Acta Hortic.* **2022**, *1345*, 57–64. [CrossRef]
39. Davanzo, F.; Miaglia, S.; Perego, S.; Assisi, F.; Bissoli, M.; Borghini, R.; Cassetti, F.; Della Puppa, T.; Dimasi, V.; Falciola, C.; et al. Plant poisoning: Increasing relevance, a problem of public health and education. North-western Italy, Piedmont region. *J. Pharm. Sci. Res.* **2011**, *3*, 1338.
40. Bowerbank, S.L.; Gallidabino, M.D.; Dean, J.R. Plant poisons in the garden: A human risk assessment. *Separations* **2022**, *9*, 308. [CrossRef]

41. Janeček, V.; Rada, P.; Rom, J.; Horák, J. Rural agroforestry artifacts in a city: Determinants of spatiotemporally continuous fruit orchards in an urban area. *Urban For. Urban Green.* **2019**, *41*, 33–38. [CrossRef]
42. Scholz, T.; Hof, A.; Schmitt, T. Cooling effects and regulating ecosystem services provided by urban trees—novel analysis approaches using urban tree cadastre data. *Sustainability* **2018**, *10*, 712. [CrossRef]
43. Lopes, H.S.; Remoaldo, P.C.; Ribeiro, V.; Martín-Vide, J. Pathways for adapting tourism to climate change in an urban destination–Evidences based on thermal conditions for the Porto Metropolitan Area (Portugal). *J. Environ. Manag.* **2022**, *315*, 115161. [CrossRef]
44. Dela Cruz, M.; Christensen, J.H.; Thomsen, J.D.; Müller, R. Can ornamental potted plants remove volatile organic compounds from indoor air?—A review. *Environ. Sci. Pollut. Res.* **2014**, *21*, 13909–13928. [CrossRef]
45. Pellegrini, E.; Cioni, P.L.; Francini, A.; Lorenzini, G.; Nali, C.; Flamini, G. Volatiles emission patterns in poplar clones varying in response to ozone. *J. Chem. Ecol.* **2012**, *38*, 924–932. [CrossRef]
46. Calderón-Contreras, R.; Quiroz-Rosas, L.E. Analysing scale, quality and diversity of green infrastructure and the provision of Urban Ecosystem Services: A case from Mexico City. *Ecosyst. Serv.* **2017**, *23*, 127–137. [CrossRef]
47. Hunt, W.F.; Lord, B.; Loh, B.; Sia, A. *Plant Selection for Bioretention Systems and Stormwater Treatment Practices*; Springer Nature: Singapore, 2015; p. 59. [CrossRef]
48. Takaijudin, H.; Ghani, A.; Zakaria, N.A. Challenges and developments of bioretention facilities in treating urban stormwater runoff; A review. *Pollution* **2016**, *2*, 489–508. [CrossRef]
49. Bortolini, L.; Zanin, G. Reprint of: Hydrological behaviour of rain gardens and plant suitability: A study in the Veneto plain (north-eastern Italy) conditions. *Urban For. Urban Green.* **2019**, *37*, 74–86. [CrossRef]
50. Funai, J.T.; Kupec, P. Evaluation of three soil blends to improve ornamental plant performance and maintain engineering metrics in bioremediating rain gardens. *Water Air Soil Pollut.* **2019**, *230*, 3. [CrossRef]
51. Yuan, J.; Dunnett, N. Plant selection for rain gardens: Response to simulated cyclical flooding of 15 perennial species. *Urban For. Urban Green.* **2018**, *35*, 57–65. [CrossRef]
52. Bolques, A.; Cherrier, J.; Abazinge, M.; Matungwa, G. Installation of a bioretention/rain garden to mitigate agricultural irrigation runoff from a container plant nursery. *Proc. Fla. State Hort. Soc.* **2010**, *123*, 326–329.
53. Ma, X.; Shu, Y.; Shi, Y.; Bao, Z. Analysis of plant selection and landscaping design for rain garden: A case study of Gongkang Rainwater Garden in Shanghai. *Acta Agric. Zhejiangensis* **2018**, *30*, 1526–1533.
54. Kapoor, M. Managing ambient air quality using ornamental plants-an alternative approach. *Univers. J. Plant Sci.* **2017**, *5*, 1–9. [CrossRef]
55. Wang, C.; Wang, Z.H.; Yang, J. Cooling effect of urban trees on the built environment of contiguous United States. *Earth's Future* **2018**, *6*, 1066–1081. [CrossRef]
56. Buta, E.; Cantor, M.; Singureanu, V.; Husti, A.; Hort, D.; Buta, M. Ornamental plants used for improvement of living, working and studying spaces microclimate. *ProEnviron. Promediu* **2013**, *6*, 562–565.
57. Gratani, L.; Varone, L. Carbon sequestration by *Quercus ilex* L. and *Quercus pubescens* Willd. and their contribution to decreasing air temperature in Rome. *Urban Ecosyst.* **2006**, *9*, 27–37. [CrossRef]
58. Richards, D.R.; Fung, T.K.; Belcher, R.N.; Edwards, P.J. Differential air temperature cooling performance of urban vegetation types in the tropics. *Urban For. Urban Green.* **2020**, *50*, 126651. [CrossRef]
59. Toscano, S.; Scuderi, D.; Giuffrida, F.; Romano, D. Responses of Mediterranean ornamental shrubs to drought stress and recovery. *Sci. Hortic.* **2014**, *178*, 145–153. [CrossRef]
60. Carey, R.O.; Hochmuth, G.J.; Martinez, C.J.; Boyer, T.H.; Nair, V.D.; Dukes, M.D.; Toor, G.S.; Shober, A.; Cisar, J.L.; Trenholm, L.E.; et al. A review of turfgrass fertilizer management practices: Implications for urban water quality. *HortTechnology* **2012**, *22*, 280–291. [CrossRef]
61. Perrone, S.; Grossman, J.; Liebman, A.; Sooksa-nguan, T.; Gutknecht, J. Nitrogen fixation and productivity of winter annual legume cover crops in Upper Midwest organic cropping systems. *Nutr. Cycl. Agroecosys.* **2020**, *117*, 61–76. [CrossRef]
62. Francini, A.; Toscano, S.; Romano, D.; Ferrini, F.; Ferrante, A. Biological contribution of ornamental plants for improving slope stability along urban and suburban areas. *Horticulturae* **2021**, *7*, 310. [CrossRef]
63. Khan, A.H.A.; Kiyani, A.; Mirza, C.R.; Butt, T.A.; Barros, R.; Ali, B.; Iqbal, M.; Yousaf, S. Ornamental plants for the phytoremediation of heavy metals: Present knowledge and future perspectives. *Environ. Res.* **2021**, *195*, 110780. [CrossRef]
64. Liu, Z.; Chen, B.; Wang, L.A.; Urbanovich, O.; Nagorskaya, L.; Li, X.; Tang, L. A review on phytoremediation of mercury contaminated soils. *J. Hazard. Mater.* **2020**, *400*, 123138. [CrossRef]
65. Bortoloti, G.A.; Baron, D. Phytoremediation of toxic heavy metals by brassica plants: A biochemical and physiological approach. *Environ. Adv.* **2022**, *8*, 100204. [CrossRef]
66. Evans, C.S.; Asher, C.J.; Johnson, C.M. Isolation of dimethyl diselenide and other volatile selenium compounds from *Astragalus racemosus* (Pursh.). *Aust. J. Biol. Sci.* **1968**, *21*, 13–20. [CrossRef]
67. Khandare, R.V.; Desai, S.B.; Bhujbal, S.S.; Watharkar, A.D.; Biradar, S.P.; Pawar, P.K.; Govindwar, S.P. Phytoremediation of fluoride with garden ornamentals *Nerium oleander*, *Portulaca oleracea*, and *Pogonatherum crinitum*. *Environ. Sci. Pollut. Res.* **2017**, *24*, 6833–6839. [CrossRef] [PubMed]
68. Pierattini, E.C.; Francini, A.; Raffaelli, A.; Sebastiani, L. Surfactant and heavy metal interaction in poplar: A focus on SDS and Zn uptake. *Tree Physiol.* **2018**, *38*, 109–118. [CrossRef] [PubMed]

69. Sebastiani, L.; Francini, A.; Romeo, S.; Ariani, A.; Minnocci, A. Heavy metals stress on poplar: Molecular and anatomical modifications. In *Approaches to Plant Stress and Their Management*; Springer: New Delhi, India, 2014; pp. 267–279.
70. Romeo, S.; Francini, A.; Sebastiani, L.; Morabito, D. High Zn concentration does not impair biomass, cutting radial growth, and photosynthetic activity traits in *Populus alba* L. *J. Soils Sedim.* **2017**, *17*, 1394–1402. [CrossRef]
71. Agudelo-Castañeda, D.M.; Teixeira, E.C.; Schneider, I.L.; Lara, S.R.; Silva, L.F. Exposure to polycyclic aromatic hydrocarbons in atmospheric PM1. 0 of urban environments: Carcinogenic and mutagenic respiratory health risk by age groups. *Environ. Pollut.* **2017**, *224*, 158–170. [CrossRef]
72. Azimi, S.; Rocher, V.; Muller, M.; Moilleron, R.; Thevenot, D.R. Sources, distribution and variability of hydrocarbons and metals in atmospheric deposition in an urban area (Paris, France). *Sci. Total Environ.* **2005**, *337*, 223–239. [CrossRef]
73. Collivignarelli, M.C.; Abbà, A.; Bertanza, G.; Pedrazzani, R.; Ricciardi, P.; Miino, M.C. Lockdown for COVID-2019 in Milan: What are the effects on air quality? *Sci. Total Environ.* **2020**, *732*, 139280. [CrossRef]
74. Xiao, N.; Liu, R.; Jin, C.; Dai, Y. Efficiency of five ornamental plant species in the phytoremediation of polycyclic aromatic hydrocarbon (PAH)-contaminated soil. *Ecol. Eng.* **2015**, *75*, 384–391. [CrossRef]
75. McArdell, C.S.; Molnar, E.; Suter, M.J.F.; Giger, W. Occurrence and fate of macrolide antibiotics in wastewater treatment plants and in the Glatt Valley Watershed, Switzerland. *Environ. Sci. Technol.* **2003**, *37*, 5479–5486. [CrossRef]
76. Luo, Y.; Guo, W.; Ngo, H.H.; Nghiem, L.D.; Hai, F.I.; Zhang, J.; Liang, S.; Wang, X.C. A review on the occurrence of micropollutants in the aquatic environment and their fate and removal during wastewater treatment. *Sci. Total Environ.* **2014**, *473*, 619–641. [CrossRef]
77. Pierattini, E.C.; Francini, A.; Raffaelli, A.; Sebastiani, L. Morpho-physiological response of Populus alba to erythromycin: A timeline of the health status of the plant. *Sci. Total Environ.* **2016**, *569*, 540–547. [CrossRef]
78. Goddard, M.A.; Dougill, A.J.; Benton, T.G. Scaling up from gardens: Biodiversity conservation in urban environments. *Trends Ecol. Evol.* **2010**, *25*, 90–98. [CrossRef] [PubMed]
79. Spotswood, E.N.; Beller, E.E.; Grossinger, R.; Grenier, J.L.; Heller, N.E.; Aronson, M.F.J. The biological deserts fallacy: Cities in their landscapes contribute more than we think to regional biodiversity. *BioScience* **2021**, *71*, 148–160. [CrossRef] [PubMed]
80. Hausmann, S.L.; Petermann, J.S.; Rolff, J. Wild bees as pollinators of city trees. *Insect Conserv. Divers.* **2016**, *9*, 97–107. [CrossRef]
81. Wenzel, A.; Grass, I.; Belavadi, V.V.; Tscharntke, T. How urbanization is driving pollinator diversity and pollination—A systematic review. *Biol. Conserv.* **2020**, *241*, 108321. [CrossRef]
82. Noe, S.M.; Penuelas, J.; Niinemets, Ü. Monoterpene emissions from ornamental trees in urban areas: A case study of Barcelona, Spain. *Plant Biol.* **2008**, *10*, 163–169. [CrossRef]
83. Qian, S.; Qi, M.; Huang, L.; Zhao, L.; Lin, D.; Yang, Y. Biotic homogenization of China's urban greening: A meta-analysis on woody species. *Urban For. Urban Green.* **2016**, *18*, 25–33. [CrossRef]
84. Niinemets, Ü.; Peñuelas, J. Gardening and urban landscaping: Significant players in global change. *Trends Plant Sci.* **2008**, *13*, 60–65. [CrossRef]
85. Graves, R.A.; Pearson, S.M.; Turner, M.G. Species richness alone does not predict cultural ecosystem service value. *Proc. Natl. Acad. Sci. USA* **2017**, *114*, 3774–3779. [CrossRef]
86. Khoshbakht, K.; Hammer, K. Threatened and rare ornamental plants. *J. Agric. Rural Dev. Trop. Subtrop.* **2007**, *108*, 19–39. Available online: https://www.jarts.info/index.php/jarts/article/view/106/97 (accessed on 13 September 2022).
87. Farinati, S.; Betto, A.; Palumbo, F.; Scariolo, F.; Vannozzi, A.; Barcaccia, G. The new green challenge in urban planning: The right genetics in the right place. *Horticulturae* **2022**, *8*, 761. [CrossRef]
88. Blundo Canto, G.M. Exploring the Links Between Agricultural Biodiversity, Ecosystem Services and Human Well-Being: Evidence from the Yucatan, Mexico. Ph.D. Thesis, Università Degli Studi Roma, Roma, Italy, 2014. Available online: https://hdl.handle.net/2307/4487 (accessed on 20 September 2022).
89. Husti, A.M.; Conţiu, I.; Radu, M.; Neacşu, I.; Cantor, M. Psychological benefits of ornamental plants used in office environments. *Bull. UASVM Hortic.* **2015**, *72*, 101–107. [CrossRef] [PubMed]
90. Dijkstra, K.; Pieterse, M.E.; Pruyn, A. Stress-reducing effects of indoor plants in the built healthcare environment: The mediating role of perceived attractiveness. *Prev. Med.* **2008**, *47*, 279–283. [CrossRef] [PubMed]
91. Thomsen, J.D.; Sønderstrup-Andersen, H.K.; Müller, R. People–plant relationships in an office workplace: Perceived benefits for the workplace and employees. *HortScience* **2011**, *46*, 744–752. [CrossRef]
92. La Rosa, D.; Spyra, M.; Inostroza, L. Indicators of Cultural Ecosystem Services for urban planning: A review. *Ecol. Indic.* **2016**, *61*, 74–89. [CrossRef]
93. Helliwell, R. Putting a value on visual amenity. *Arboric. J.* **2014**, *36*, 129–139. [CrossRef]
94. Lindemann-Matthies, P.; Bose, E. Species richness, structural diversity and species composition in meadows created by visitors of a botanical garden in Switzerland. *Landsc. Urban Plan.* **2007**, *79*, 298–307. [CrossRef]
95. Qin, J.; Sun, C.; Zhou, X.; Leng, H.; Lian, Z. The effect of indoor plants on human comfort. *Indoor Built Environ.* **2014**, *23*, 709–723. [CrossRef]
96. WHO. *Urban Green Spaces and Health*; World Health Organization, Regional Office for Europe: Copenhagen, Denmark, 2016; pp. 1–80.
97. Ulrich, R.S. View through a window may influence recovery from surgery. *Science* **1984**, *224*, 420–421. [CrossRef]

98. Ulrich, R.S. Health benefits of gardens in hospitals. In Paper for Conference, Plants for People. In Proceedings of the International Exhibition Floriade, Haarlemmermeer, The Netherlands, 6–20 October 2002.
99. Sadler, B. Design to compete in managed healthcare. *Facil. Des. Manag.* **2001**, *20*, 38–41.
100. Coile, R.C. *Paperless Hospital: Healthcare in a Digital Age*; Health Administration Press: Chicago, IL, USA, 2002; p. 320.
101. Paraskevopoulou, A.T.; Kamperi, E. Design of hospital healing gardens linked to pre-or post-occupancy research findings. *Front. Archit. Res.* **2018**, *7*, 395–414. [CrossRef]
102. Lu, S.; Wu, F.; Wang, Z.; Cui, Y.; Chen, C.; Wei, Y. Evaluation system and application of plants in healing landscape for the elderly. *Urban For. Urban Green.* **2021**, *58*, 126969. [CrossRef]
103. Amingad, V.; Lakshmipathy, M. Ornamental plants and their role in human psychology. In Proceedings of the 2nd International Conference on Agricultural & Horticultural Sciences, Hyderabad, India, 27–29 October 2014.