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Review

Native or Exotic: A Bibliographical Review of the Debate on Ecological Science Methodologies: Valuable Lessons for Urban Green Space Design

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Abstract: Knowledge from ecological sciences is an important reference for landscape design as Urban Green Spaces (UGS) play a critical role in the ecological protection of cities. There is an ongoing debate among ecologists on the value of exotic vegetation to ecosystem resilience and integrity, with authors arguing that in order for ecosystems to survive in future climates, exotic species with similar conditions in their current range must be considered. Others deem biodiversity vital for ecosystem functions and services, stating that most biodiversity losses are man-induced and should be addressed through the enhancement of native communities. Through a literature review, we confronted the arguments used in this debate, with the aim of conducting a comprehensive analysis of the potential of exotic and native vegetation in different aspects of the vegetation's performance. The outcomes are important for the assessment of vegetation assemblages within UGS projects. Despite the strong arguments regarding their performative and adaptive capacity, we conclude that exotics pose significant ecological risks and have multiple negative impacts on ecosystem processes. Natives not only present high adaptive capacity, but also provide additional benefits for biodiversity, ecosystem integrity, and for people. In a broader framework, the literature demonstrates a preference for the use of native species in most situations.

Keywords: native vegetation; exotic vegetation; biodiversity; ecosystems; resilience; climate change; urban green spaces; landscape architecture

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1. Introduction

1.1. Context

Urban Green Spaces (UGS) are public open spaces within the city where vegetation is the predominant element. They represent nature in the cityscape and provide countless benefits for people. In contemporary cities, UGS play a multifunctional role, supporting ecological protection, production, recreation, and cultural expression. Their ecologic protective performance has become fundamental for urban resilience in the face of climate change [1,2]. With the spread of urban areas, cities are becoming increasingly disconnected from their natural surroundings. Thus, UGS, as a part of the urban green infrastructure, are the best option to improve cities' capacities for climate change adaptation as they provide multiple ecosystem services [3]. They are also the means to tackle biodiversity loss and the spread of invasive species [4], playing an important role in both climate change adaptation and biodiversity strategies [5].

Strengthening urban green and blue infrastructure is one of the strategies of urban mitigation, defined in the IPCC Report—Climate Change 2022 (IPCC AR6 WGIII). UGS can be used to restore modified ecosystems and to obtain ecological connectivity. The reconversion of land use in key urban areas and the requalification of urban ecosystems also converges with international biodiversity strategies, which identify ecological connectivity as a key element for biodiversity conservation. The EU Biodiversity Strategy for 2030 recognizes fragmentation as a major limitation to the successful implementation of the Natura 2000 Network. Urban and agricultural areas constitute the major drivers of fragmentation by their extension [6]. If based on the restoration of native communities, urban green infrastructures offer the opportunity to connect cities to rural and natural surrounding areas [7], while supporting the development of quality open spaces for the urban population.

Knowledge of the climatic effects of specific urban vegetation structures is fundamental to understanding the potential of using UGS for ecosystem service supplies, especially in regulating services, which are critical in the climate change adaptation of urban areas (IPCC AR5 WGII).

1.2. The Contribution of Ecological Sciences in UGS Design and Current Trends

The landscape architects' approach to UGS design can be considerably improved by incorporating the scientific knowledge of vegetation ecology, applied ecology, and ecological restoration. In particular, the research that relates vegetation type to ecosystem services and functions has a significant impact on landscape architecture practices. Several studies show a close relationship between vegetation structure and ecosystem services [1,8–10], especially in urban areas where the latter have an increased significance [11]. Vegetation structure is directly related to ecological function (e.g., root depth is related to the nutrient cycle, carbon fixation, and water capture) and any changes in the vegetation structure will directly influence the ecosystem services depending on those functions [5]. In this sense, restoration ecology provides an interesting framework for promoting the suitability of vegetation systems in UGS designs. Restoration processes are based on the articulation of three main ecosystem assessment factors (plant biology, abiotic elements, and the ecological interactions between them) and can be a valuable tool for enhancing urban ecosystems' capacities and establishing a sustainable ecological function through time [5]. With the arising of new concepts within the field of ecological restoration, namely Novel Ecosystems and Designed Ecosystems [12], the restoration methods can be an effective solution in UGS projects where the main purpose is not the restoration of a pre-existing system but the maximization of the vegetation's performative potential.

It has always been considered that natural areas with unmodified native communities have higher resilience and capacity for ecosystem service supplies in the face of global changes and biodiversity alterations and that restoration interventions should mimic such reference systems. However, scientists have begun to debate whether biodiversity is the main element for ecosystem integrity when outlining ecological restoration projects. The need to assess future environmental conditions to ensure the ecosystems' climate change adaptive capacity has shifted the focus from native to adaptable species [13]. Some scientists point to functional diversity as the most important factor for ecosystem integrity. This concept favors plant traits over provenance or taxonomic composition [14–19]. From this perspective, exotic species should be evaluated by the ecosystem services they supply and not only by their negative impacts (disservices), which offers flexibility in the assessment of their ecological value [20–22]. Particularly in the restoration of urban or severely disturbed areas, some defend the presence of, and even an increase in, exotic species that can withstand the existing adverse conditions and replace natives with similar traits, resulting in lower diversity but maintaining ecosystem processes through a specific assemblage of plants that exhibit the essential functional traits [14].

On the other hand, some authors argue that the ecological functions of exotic species may have repercussions on the biodiversity and ecosystem processes, clashing with conservation goals [11]. They argue that a massive biodiversity loss is underway due to climate change, biological invasions, and human disturbance [23–25]. Thus, if species are selected for their good performance in disturbed environments, such as urban areas, and begin to be used in cities all over the world, this will aggravate the biological and landscape homogenization [26]. If there is not an attempt to reverse the species loss, repercussions will also be felt in the functional diversity [27].

Research relating vegetation type to ecosystem services and adaptive capacity is essential for UGS projects and the debate over the role of exotic and native vegetation calls for a special attention from landscape architects. The outcomes may shape future project methodologies seeking to ensure ecologically efficient vegetation assemblages for high-performing UGS. This debate has resulted in a consistent body of research that compares exotic and native vegetation in terms of ecological performance, impacts on ecosystem functions and processes, and the ability to provide different ecosystem services. However, these studies focus on individual features, lacking a wider analysis. An evaluation that considers all of the different aspects of vegetation performance is needed in order to weigh the advantages and disadvantages of exotic and native vegetation and to obtain more holistic conclusions in ecosystem-based adaptation strategies, particularly with nature-based solutions at the UGS level.

Thus, the aim of this paper is to examine and confront the arguments used to defend both perspectives in the ongoing debate over the use of exotic or native vegetation and answer critical questions regarding the role of landscape architects in climate change adaptation, such as the following:

- What ways forward do ecological sciences propose in order to maximize the vegetation's ecological potential when designing Urban Green Spaces?
- What are the arguments presented to support exotic species as the answer to climate change-adaptive and -resilient ecosystems? To what extent can these arguments justify the disturbance of the native biodiversity and the loss of landscape identity?
- Can native communities adapt to climate change and safeguard ecosystem function through time? Are they more resilient to climate change and more efficient at mitigating the subsequent effects?

Through a bibliographic review, this study compares the advantages and disadvantages highlighted in the examined papers regarding the use of exotic or native vegetation in several areas, namely the following: (i) biodiversity conservation; (ii) UGS performance in ecological protection, production, recreation, and ecosystem service supplies; (iii) ecosystem resilience and climate-adaptive capacity; (iv) people's connection to nature and to the surrounding landscape and their sense of belonging.

These aspects reflect the citizens' and urban environments' needs, as well as the urgency currently felt in safeguarding the environment, health, and general quality of life in the face of extreme climate events, which are becoming more frequent.

The results of this assessment will indicate the best solution for UGS vegetation systems.

2. Materials and Methods

We conducted a bibliographic review following the PRISMA method [28] (Figure 1) using Scopus and ScienceDirect as the main academic databases. We searched for papers that compare native and exotic vegetation, focusing on eco-physiological traits and phenotypic plasticity (which enables species to respond to climate change), ecosystem service supplies, and cultural and psychological aspects of citizens' perceptions of different vegetation systems.

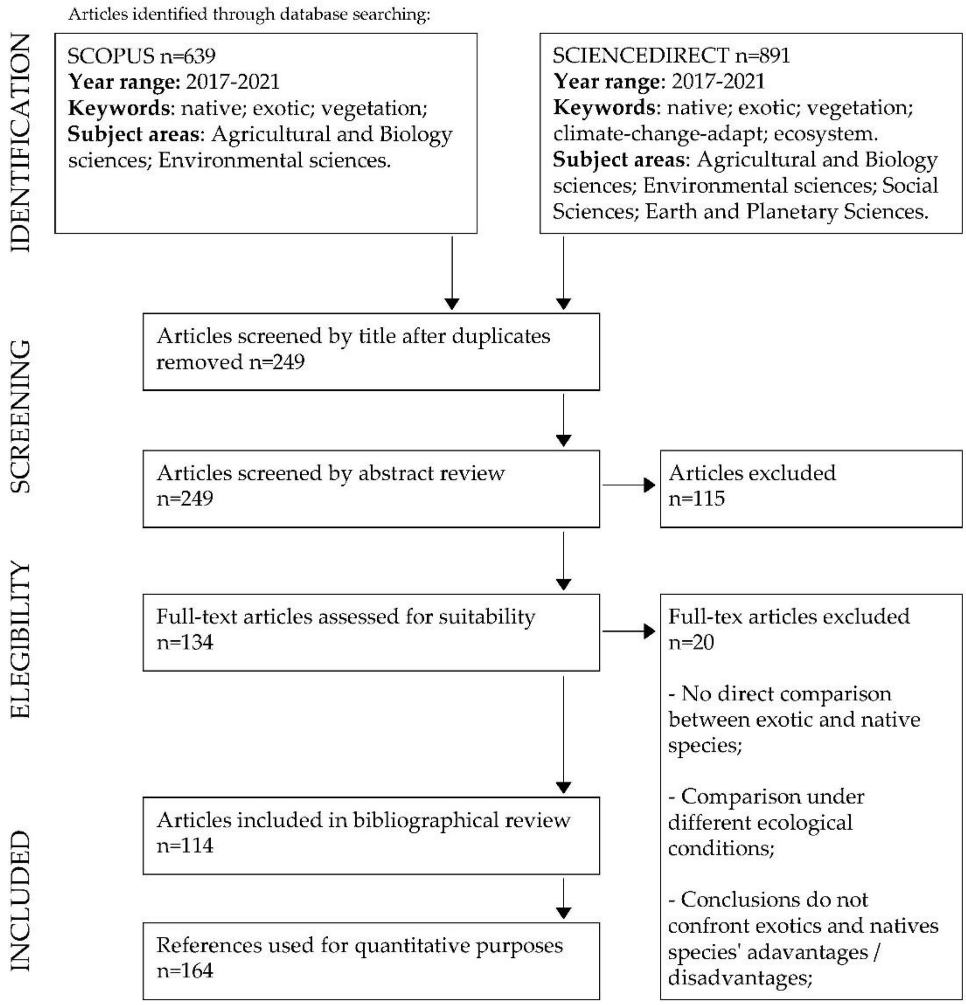

Figure 1. A flow of article selections through the different phases of the bibliographic review process. Adapted from PRISMA flow diagram [28].

For Scopus, we used a combination of the following keywords: native, exotic, and vegetation for a broader search range. For ScienceDirect, we used native, exotic, and vegetation, associated with ecosystem and climate-change-adapt for a more detailed search.

The time range was set between 2017 and 2021. Since this is a recent debate, these years represent a considerable sample of the research conducted on this subject.

The first search returned 639 articles on Scopus and 891 articles on ScienceDirect. After the removal of duplicates and the first phase of exclusion by title, 249 papers were selected for abstract reading and 134 articles were fully analyzed and assessed for suitability. In this phase, we excluded papers that could not be used for quantitative purposes, i.e., do not identify a clear advantage or disadvantage regarding the use of one type of vegetation against the other. For example, studies that compare native and exotic species in different ecological contexts (e.g., a native multi-stratal forest with exotic production forestry), conclusions that do not compare one's performance with the other, or papers that mention only one of the two types of vegetation. The comparison is only effective if the papers consider similar conditions for both types of vegetation, whether it is an urban area, a restoration site, or a fully functioning ecosystem. The selected studies could compare native and exotic vegetation either in a generic way or by focusing on certain species, but with the consideration of the identical ecological functions between them. The contexts in which such comparisons are made involve an active intervention for the improvement of existing vegetation communities or the establishment of new ones, e.g., restoration projects or the rehabilitation of degraded urban areas and former agricultural fields. For the analysis of the advantages and disadvantages, we also considered studies focusing on the impact of biological invasions as these are a major disadvantage related to the use of exotic species. Papers that did not meet the quantitative requirements but still added qualitative value to the debate were sometimes cited in the discussion of the results.

In total, 114 papers were included in this literature review for statistical purposes. For each article, we identified their results as relating either the advantages or disadvantages of the use of either exotic or native vegetation. The advantages were assessed by a comparison between the two types of vegetation, but the disadvantages refer to the measurable negative impacts of one of the vegetation types and not to a lower performance. As the articles may refer to more than one advantage or disadvantage, for the statistical analysis, each advantage and disadvantage was quantified as a "reference" to give a total of 164.

The selected papers were then divided into five major interconnected themes that reflect the aspects on which exotic and native plant species are compared: (i) Effects on Biodiversity Conservation; (ii) Ecological Performance; (iii) Ecosystem Resilience and Adaptive Capacity to Climate Change; (iv) Ecosystem Services; (v) Cultural Perception. Although this division might be subjective as there is a strong interinfluence and interdependence between them, it allows for a clearer view of the aspects according to which type of vegetation prevails over the other.

Studies grouped under the first theme, Effects on Biodiversity Conservation, focus on the role that native and exotic species play in biodiversity conservation. Since the positive relation between biodiversity and ecosystem services is largely recognized, it is important to understand the advantages and disadvantages related to the use of both types of vegetation to assess their potential for use in UGS. An advantage, for the purpose of this paper, is defined as the capacity to promote the establishment of other plant species and to attract native animals and soil microorganisms. Contributing to maintaining the habitat structure is also considered an advantage in this theme as it is fundamental for the preservation of a species. A disadvantage is defined as a decrease in the number and diversity of plant species, an alteration in the habitat of native fauna, the facilitation of exotica fauna, and the negative impacts on soil biota.

In the category Ecological Performance, the papers compare the species' performance by evaluating the eco-physiological traits of native and exotic plants with similar ecological functions, their relationship with abiotic elements, their strategies of resource uptake, and their response in the face of stress or limited resource availability. The disadvantages in this case mean negative impacts on the interaction with ecosystem processes or functions, specifically those that concern abiotic features, such as soil stability, water, and nutrient cycle (the negative impacts on biotic elements fall within the biodiversity theme).

Ecosystem Resilience and Adaptive Capacity to Climate Change compiles the studies that assess the way exotic and native species contribute to the ecosystems' adaptive capacity to climate change, enhance communities' resilience in the face of disturbances related to extreme climatic events, and mitigate climate change effects in urban areas, providing ecological protection through UGS. On the other hand, the disadvantages include the deterioration of community structures or the intensification of climate change effects.

The Ecosystem Services are related to all other themes, mostly to the Biodiversity Conservation and Cultural Perception, which is determinant of the supply of cultural services. For that reason, the biodiversity conservation is not assessed as an ecosystem service in this study, nor are cultural services, which are analyzed in the Cultural Perception theme. For Ecosystem Services, we examine papers that compare exotic and native species in terms of the quantity and quality of Regulation and Supporting Services. Disservices are considered as disadvantages and range from the introduction of pathogens to reductions in agricultural productivity and soil fertility, phytotoxin presence, and the inducing of a higher fire risk.

The Cultural Perception addresses the different ways in which people value exotic and native species. Here, we grouped papers focusing on whether there is an actual difference perceived by common citizens between the two types of vegetation, assessing if people associate biodiversity with native vegetation and if they value one more than the other in terms of UGS use, aesthetics, and ecological significance. References to aesthetic experiences, nature enjoyment, cultural identification, and sense of belonging are also considered within this theme.

3. Results and Discussion

The bibliographic search, considering the criteria described in the Materials and Methods, resulted in 114 papers comparing exotic and native vegetation, which were both research and review papers. The focus is distributed equally across the five themes with some studies covering more than one theme (e.g., some studies that compare ecological performance conclude that exotics outperform natives, but they have a significant disadvantage in terms of biodiversity conservation due to their invasive behavior; others identify an advantage in Ecological Performance for natives, with additional advantages in Ecosystem Services).

The increase in the number of papers from 2017 to 2021 (Figure 2) may reveal the pertinence of this debate, with a growing body of research focusing on the comparison of benefits and impacts of the use of exotic and native vegetation. It can also reveal the effort made to tackle biodiversity loss by expanding the knowledge of the traits that make exotics outperform natives and exhibit an invasive behavior.

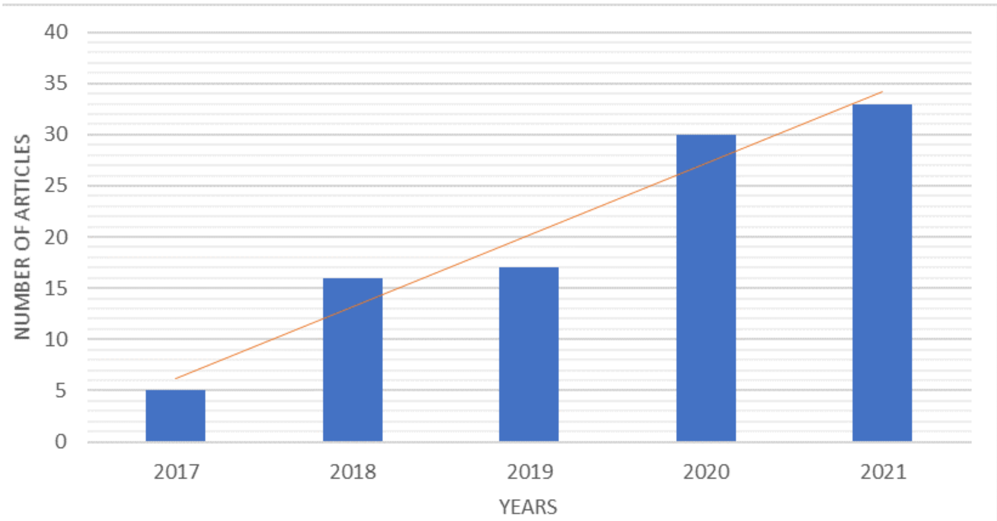

Figure 2. Selected articles within the search criteria by year of publication.

It should be highlighted that none of the analyzed studies pointed to disadvantages in the use of native vegetation (Figure 3). For example, regarding ecosystem adaptive capacity, some papers stated a clear advantage for exotics as they have better chances of coping with the adverse effects of climate change and considered natives less suitable [13,15–17], but there is no real negative impact related to the use of native plants—only a "less positive" one. On the contrary, in the case of exotic vegetation, most studies that found exotic species to be better performers also pointed to significant disadvantages related to their use, such as biodiversity loss due to invasive behavior [29–34] or negative interactions with abiotic elements [35–44]. In all five themes, the literature shows several negative ecological impacts, identified mostly through the first three themes, but also, in terms of Ecosystem Services, where negative impacts are classified as disservices, and in terms of Cultural Perception, throughpeople's awareness of the effects of biological invasions (Figure 3).

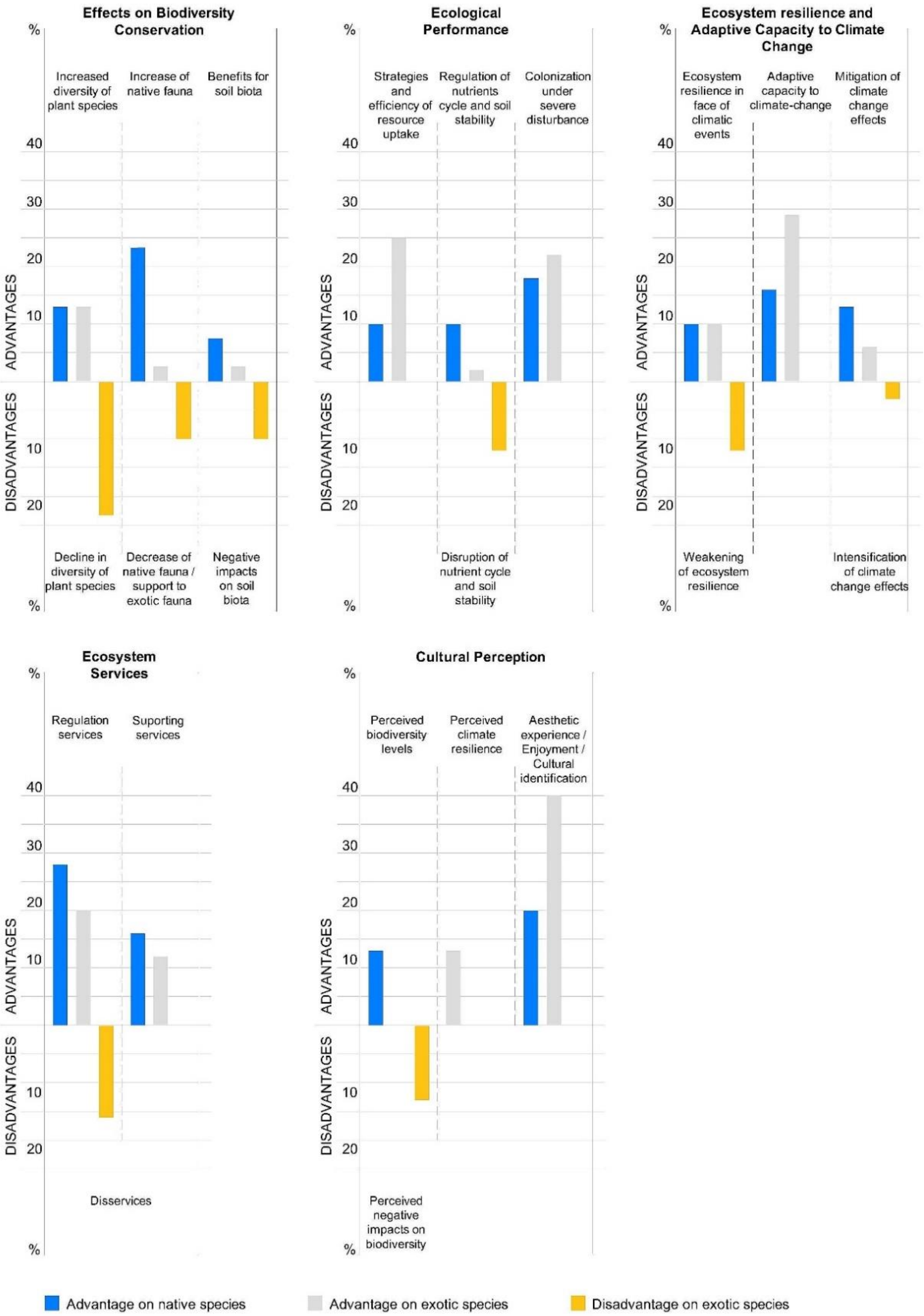

Figure 3. Results of the five themes in terms of percentage (%), considering the total number of references made by the analyzed articles to each theme; most papers refer to multiple advantages and

disadvantages in more than one theme and one reference represents one identified advantage or disadvantage. The five themes were divided into subcategories, which represent the most studied aspects of each theme. The results in every subcategory are the percentage of references to an advantage of native species, an advantage of exotic species, or a disadvantage of exotic species within the total attributed to that theme (for example, in the case of 49 references made to Ecological Performance, 12% were to the disadvantages of exotic species for nutrient cycle and soil stability).

There may also be some reluctance to clearly state an advantage of exotics or a disadvantage of natives because the analysis of the results must contemplate several aspects beyond the ones compared in each case study. Broader assessments frequently show that the use of native vegetation is preferable in most situations [5,11,13,19,45].

3.1. Effects on Biodiversity Conservation

The reviewed bibliography reveals an effort to understand how biodiversity influences ecosystem services and functions and how this can be transferred to conservation and restoration guidelines [46]. The scientific evidence shows a positive relationship between biodiversity and ecosystem services and links biodiversity loss to a diminished capacity for service supplies [47,48]. Biodiversity is identified as the ecosystem component that supports the provision of multiple human-essential services, such as food and water security, heath, climate change adaptation, and cultural benefits [49]. The way native and exotic vegetation contribute to biodiversity is not universally agreed upon.

Through several papers, we analyzed the perceived importance of native vegetation as the sole guarantee of biodiversity conservation and to what extent exotics are believed to contribute to biodiversity, especially in urban areas or degraded ecosystems, even considering the ecological risk they represent. Studies related to this theme address the effects that plant species have on biodiversity through their influence on the establishment of other plant species and their interaction with soil bacterial and fungal communities, arthropods, and other native fauna, and consequently, with ecosystem functioning.

Most of the analyzed papers demonstrate that native species largely outperform exotics (Figure 3) in the enhancement of native animal species, in the interaction with soil biota, and in the establishment of other plant species [19,32,50–65]. In contrast, the research reveals a clear disadvantage of exotic species when it comes to the effects on biodiversity due to existing or potential invasiveness [13,24,29–31,33,34,60,61,66] via their interference in the abiotic environment, which inhibits the thriving of other species [20,37,38,67].

However, when it comes to cities, these assumptions are challenged by some authors, who consider cities to be distinct socio-ecological systems with unusual plant assemblies that influence ecosystem functioning and stability in distinct ways [46]. The same happens when it comes to severely degraded areas, such as eroded areas, former mining sites, or landfills. Despite the known ecological risks and the disadvantages described in a considerable number of studies, some of the examined papers argue that, in these particular situations, exotic pioneer species have an advantage as they can colonize under severe conditions and enhance native plant communities by providing habitats and shelter for native species to thrive [68–71]. In the same way, exotics are considered to act as a replacement for lost native species in UGS, helping to maintain the necessary levels of functional diversity [72].

3.2. Ecological Performance

Papers analyzed within this theme assess the eco-physiological traits of ecologically similar exotic and native species, comparing their capacities and strategies for resource use and their interactions with the abiotic features of the ecosystem.

A significant part of the research compares the species' strategies for the efficient capture and use of resources; here, in most cases, exotics outperform natives, particularly in scarcity contexts, which is frequently associated with their invasive behavior [25,29–31,33,34,66,73]. There is also a high number of studies focusing on the interaction with abiotic elements, such as soil nutrients and water, with exotic species showing significant disadvantages given their negative impacts on the nutrients cycle, resource consumption, and levels of soil pH [20,35–44]. On the other hand, when compared to exotics, native species present clear benefits in their interaction with the soil nutrient cycle and stability [7,50,58,74–77].

In other cases, exotics are indicated as viable solutions in contexts of low resource availability or significant disturbance [78–81], which are expected to increase with climate change [30]. Particularly in urban environments, exotics are presented as viable substitutes for natives that cannot cope with stressors or as complementary elements in mixed communities [21,45,82,83].

However, a consistent body of research points to native vegetation as having better ecological performance [41,75,84–87]. Specifically in arid and semi-arid environments, native species possess high plasticity and adaptive traits that help them cope with the environmental stress related with the harsh environments they live in [74,84,88]. Studies demonstrate an advantage of the native species regarding the restoration of areas disturbed by biological invasions or human activities, such as agricultural production, the mining industry, or landfills [41,50,75,78,87,89]. Furthermore, in UGS exposed to additional stresses, natives can be particularly important as they also provide many regulating ecosystem services [15,58,90].

It is stated that natives are a better solution as they not only match exotics in performance, but also provide additional benefits, such as ecological integrity, connectivity, and the ability to increase native plant and animal species and soil biological activity [50,58,74,75]. Exotic species, although showing a better ecological performance in some situations, have several negative impacts and pose an ecological risk that raises reservations in regard to their use [24,25,33].

3.3. Ecosystem Resilience and Adaptive Capacity to Climate Change

Another central topic within this debate is the extent to which native species can adapt to future climate conditions. Whether they will migrate to more favorable conditions, go extinct, or be replaced by more suitable exotics are questions the research is trying to answer. Some researchers propose that, as this is the most likely scenario, projects within ecological restoration, UGS, and forestry should consider future climate conditions and introduce species that are more suitable to those conditions [13,15,17,91]. It is also argued that ecosystems will be as resilient as they are functionally rich and that plant functional traits are more important than the diversity or origin of the species. The argument that the resources provided by plants are more important than their provenance reveals the researchers' flexibility when exploring strategic responses to climate change [14,19,92]. Many of the reviewed papers state that exotic species play an important role in ecosystem adaptive capacity, showing a greater capacity for colonization in places where natives cannot subsist and for adjustment to changing conditions, such as hydrologic alterations due to rising sea levels, extended drought periods, or higher temperatures, which are expected to worsen with climate change [79,93].

On the other hand, there are concerns that if taxon replacement is a viable solution for a native species vulnerable to climate change, this option also involves many uncertainties, with the possibility of inexplicable maladaptation, underestimation of climate variability, and other unpredictable problems connected with invasiveness [13,91], including crypticity [24]. Besides the negative effects related to the interaction with abiotic components discussed in the Ecological Performance section, many of the examined studies point out the disadvantages of the presence of exotics in terms of ecosystem resilience, such as higher flammability, alterations in communities' phenology, and the weakening of ecosystems' structures, making them more vulnerable to extreme weather events [94–97].

Research approaching this perspective focuses on the native species' capacity to adapt through plasticity, selection, or gene flow [98,99], expanding the available knowledge on plant eco-physiological traits and adaptive capacity [100–102]. The increase in habitat diversity to improve integrity and connectivity [103] and the development of strategies to assist the native communities' adaptation [104,105] are suggested as solutions for achieving resilient ecosystems and halting biodiversity losses under the conditions of climate change. Thus, despite the adaptive potential shown by exotic species, a consistent body of research points to natives as a viable option and states that projects should favor the evolutionary development of native communities [99]. Several papers included in this review discuss different strategies to enhance the resilience and adaptive ability of native species and communities. The increase in genetic diversity within the same species (e.g., by using seeds from different ends of the species distribution range) and between species can improve the resilience of a native community [99]. Additionally, the use of rare, specialist native plants in their ecological optimum slows biodiversity loss and positively impacts ecosystem stability and structural complexity, enhancing resilience and ecosystem service supplies [106]. The increment in the number of species and the expansion of habitat areas both strengthen ecosystem integrity and ecological connectivity, improving the ecosystem's ability to retain biological diversity in the face of climate change [103,105]. Intervention strategies both at the community and the landscape level (e.g., genetic strategies, such as assisted migration, or silvicultural interventions, such as density management, to reduce resource competition, fire risk, or disease spreading) support ecosystems' adaptive capacity [104,107]. Beyond the development of strategies to enhance the natives' adaptive capacity, several studies have demonstrated that well-structured native communities are better prepared to cope with adverse events due to climate change, such as storms and floods, long periods of drought, increasing temperatures, and recurrent fires, while the presence of exotic species, particularly invasive ones, progressively deteriorates the system [86,96,108,109].

3.4. Ecosystem Services

In terms of ecosystem services, native species are more favorable. Since biodiversity supports most ecosystem functions and services [49], many studies show the direct detrimental effects of biodiversity losses on ecosystem services [25,108,110]. As biological invasions are among the main drivers of biodiversity loss [22–24,110], it is reasonable that most papers addressing this theme identify a greater capacity to deliver ecosystem services in native species. The benefits they represent to biodiversity, namely the increase in the number and variety of insects, animals, and soil microbial communities, are essential to several ecosystem services, such as water and nutrient cycle regulation and soil formation [5,32,50,51,54,61,62]. Beyond establishing a positive relation between biodiversity levels and ecosystem services [47,111], some papers conclude that natives are more efficient in the supply ofregulating ecosystem services because they possess functions and structures adapted to the use of local resources, thus, they dispense less energy and respond more efficiently to the local climate [90,108].

Other studies find exotic vegetation to be equally as important for several ecosystem services [53], mainly in UGS, where they represent a significant percentage of the existing vegetation. Furthermore, exotic species are sometimes considered to surpass the native vegetation as they offer a denser canopy, have higher foliar biomass, and contribute significantly to the species' diversity [21].

One significant turning point in the ecological relevance exotics have among scientists is their approach to invasive species, not only for the negative impacts they represent, but also for the services they provide [20,22]. Some papers state that the benefits balance the disadvantages of invasion [112]. However, most ecologists defend the negative impacts as being too significant to be compensated for by any services that invasive species may provide [23,110].

3.5. Cultural Perception

People's perception of biodiversity and the value they assign to native species depend on many factors, such as socio-economic and cultural contexts. Education level, age, and access to information influence people's attitudes to UGS and biodiversity [113–115]. The landscape context also changes the relevance attributed to ecosystem functioning, with urban citizens displaying a more alienated attitude. Rural citizens have a higher sensibility to vegetation since they are also more directly exposed to the effects of ecosystem changes.

The papers analyzed here explore the way people evaluate exotic and native vegetation, as well as their perception of natural spaces with native vegetation compared to traditional green spaces, particularly in urban areas where this perception is more likely distorted. Most studies were conducted by gathering empirical data through public consultations and behavioral observations related to several vegetation features.

Exotic species prevail; they are clearly preferred in domestic gardens or public spaces and are associated with cultural landscapes by people [116–118]. Most studies reveal that common citizens do not distinguish exotic species from native ones, especially if they have been introduced for a long time [119]. Empirical evidence shows that in UGS, exotic species are equally important for cultural ecosystem services, holding heritage significance in many public gardens and parks [120,121]. Additionally, in urban areas, people link exotic plants to a greater resilience and adaptive capacity to climate change [117,118]. This is not surprising as a significant portion of the urban vegetation is composed of exotic species and this is most of the "nature" that many city dwellers have contact with.

On the other hand, in recent years, due to the spread of information regarding climate change and biodiversity loss effects, several studies show that urban citizens have become more aware of the relevance of natural and biodiverse spaces, associating them with a positive aesthetic experience and more benefits to mental health [122–124]. An increasing part of the urban population recognizes the importance of promoting biodiversity within UGS through native species and acknowledges the possibility of conciliation between high biodiversity and recreational and cultural functions [114,125,126]. There is also evidence of an increasing awareness regarding the negative effects of biological invasions and the dangers of triggering one by introducing an exotic plant. Some authors defend these trends as a perfect opportunity for environmental education [119], thereby increasing the value of native species in the UGS. As they are the only daily contact with nature for many urban dwellers, UGS are also considered educational spaces [5,123]. In these situations, it is argued that the presence of native communities within UGS increases the public's recognition of the many ecosystem services they provide [10], especially concerning regulating services that are not tangible at a local scale [127], wherein natives perform better [90,108].

4. Conclusions

Our bibliographical review of studies comparing the use of exotic and native species, with the purpose of achieving more resilient and climate-adaptive ecosystems, revealed the significant role that exotic species play, especially in urban spaces. They often show a greater capacity to survive in resource scarcity and stress conditions and they are more likely to successfully adapt to climate change. However, most studies that identify these advantages also highlight the negative impacts of the use of exotic species. Beyond the ecological risks, they have different resource use strategies and a distinct phenology from the native vegetation, which disturbs ecosystem functioning by altering the nutrient and water cycles, soil pH, and soil biota, thus, compromising ecological integrity. Additionally, it is widely acknowledged that the systematic replacement of native species with exotic ones with similar ecological traits increases the ongoing biotic homogenization and biodiversity loss, while weakening the landscape identity.

On the other hand, the examined literature has demonstrated the significant adaptive capacity of native species as an ecological feature that can equal that of exotic species. Furthermore, as opposed to exotics, native species not only present no disadvantages, but they also provide additional benefits for biodiversity and ecosystem services, delivering strong ecological protection. In UGS, the native vegetation also contributes to spaces of high landscape diversity that host multiple functions (recreation, contemplation, sport, and nature enjoyment) and they promote identity as they resemble local and regional landscapes [122,123].

Although exotic species present some advantages over native species in terms of ecological performance and adaptive capacity, concerns regarding their negative impacts and the important benefits of using native species illustrate why, even in UGS, most scientists prefer the use of native over exotic vegetation.

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