land

MDPI

Review

Alien Plant Invasion: Are They Strictly Nature's Enemy and How Can We Use Their Supremacy?

Lenka Bobuľská [1,*], Lenka Demková [1], Gabriela Pinčáková [1] and Tomáš Lošák [2,3]

[1] Department of Ecology, Faculty of Humanities and Natural Sciences, University of Prešov, 17. November 1, 080 01 Prešov, Slovakia; lenka.demkova@unipo.sk (L.D.); gabriela.pincakova@smail.unipo.sk (G.P.)
[2] Department of Environmentalistics and Natural Resources, Faculty of Regional Development and International Studies, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic; tomas.losak@mendelu.cz or tlosak@fzt.jcu.cz
[3] Department of Agroecosystems, Faculty of Agriculture and Technology, University of South Bohemia in Ceske Budejovice, Branišovská 1645/31A, 370 05 České Budějovice, Czech Republic
* Correspondence: lenka.bobulska@unipo.sk

Abstract: The invasion of plant species is considered to be one of the most dangerous forces in biodiversity change and alteration of soil properties. Due to their significant impact on ecology and the economy, it is important to find an effective approach to manage invasive plant expansion and utilize them as a beneficial biomass source. This review focuses on the characterization of the negative and positive features of invasive plant species in general. Most studies focus on invasive species removal and lack an evaluation of their potential in modern biotechnologies. Currently, there are studies aimed at investigating their use in soil remediation, medicine, the chemical industry, the textile industry, and even gastronomy. Based on these reviews, we bring forward possible future developments in this research field which might serve as a theoretical premise for further research.

Keywords: invasive species; prevention of invasiveness; eradication of invaders; potential of invaders

Academic Editors: Kenneth R. Young, Michela Balestri and Marco Campera

Received: 16 October 2024
Revised: 30 December 2024
Accepted: 31 December 2024
Published: 7 January 2025

Citation: Bobuľská, L.; Demková, L.; Pinčáková, G.; Lošák, T. Alien Plant Invasion: Are They Strictly Nature's Enemy and How Can We Use Their Supremacy? *Land* **2025**, *14*, 107. https://doi.org/10.3390/land14010107

1. Introduction

Biodiversity includes millions of living species across ecosystems such as forests, oceans, grasslands, and deserts, each playing a unique role in maintaining the ecological balance. High biodiversity strengthens ecosystems' resilience, enabling them to adapt to environmental changes and recover from various disturbances. Biodiversity encompasses not only the variety of species, but also the intricate relationships between organisms that sustain life on Earth. A very complex, dynamic, and vital system, which is often referred to as the Earth's living skin, is soil. Soil, as a dynamic habitat for countless organisms, supports interactions in nature by providing essential nutrients and by fostering ecosystem services like water filtration and carbon storage [1–4]. It serves as a crucial reservoir of biodiversity, housing roughly a quarter to a third of all living organisms [5]. Soil biodiversity can include organisms ranging from microscopic bacteria and nematodes to mites, millipedes, earthworms, and other macroscopic organisms. Soil biology is a relatively young field of research, and the continuous monitoring of changes in soil biodiversity is rather complicated. Current global developments, such as anthropogenic threats to soil (e.g., through intensive agriculture, the impact of biological invasions, industrial activity, etc.) and climate change, represent a burden on the proper functioning of the soil. These factors can disrupt the delicate balance of soil ecosystems, leading to reduced soil fertility, compromised nutrient cycling, and diminished capacity for carbon sequestration [6,7].

Soil degradation is a very serious environmental problem. Currently, nearly 60% of the ecosystems worldwide are reported to be degraded and unsustainably exploited [8,9]. The activity and diversity of native communities is significantly influenced by intensive agriculture [10]. These practices are closely linked to monoculture cultivation, intensive tillage and fertilization, the use of phytopharmaceuticals [11], drainage activities [12], and biological invasions [13]. In many regions worldwide, ecosystems and biotopes are being gradually but extensively degraded, primarily due to agricultural and forestry activities, as well as transportation and tourism infrastructure [14]. Acidification, salinization, chemical contamination, invasive species, climate change, and the increasing ecological footprint are additional factors that negatively impact ecosystems [15,16]. The impact of invasive plants on soil ecosystems and natural biota has received quite a lot of attention in the recent decades. Invasive species, both plant and animal, often significantly alter the structure of natural vegetation [17]. Research indicates that invasive plant species can modify soil's abiotic and biotic properties, nutrient availability, organic carbon content [18], the composition of soil microflora [19], and soil mesofauna [20]. Considerable attention is focused on the world's highly vulnerable and threatened ecosystems, such as peat bogs, heaths, and coastal environments. Consequently, it is crucial to develop and implement methods that are highly effective, reliable, and sensitive for the early detection of adverse ecosystem changes driven by human activities.

The main goals of this integrative review are (a) to define non-native and invasive plant species, (b) to show the efficiency of different eradication approaches, and (c) to highlight the potential of using invasive plants in future research.

2. Invasive and Non-Native Plant Species

A fundamental yet debated concept in invasion biology is the idea of "non-nativeness". This concept raises questions about the criteria used to define species as non-native, as it often depends on the perspective of time and geographical context. Some argue that the term "non-native" can oversimplify complex ecological interactions, while others emphasize its importance in understanding the ecological impacts of invasive species [4,13,17]. Biologists recognize species dispersal as a key driver of evolution, and, indeed, there is no ecological rule dictating that species must remain in one place—most taxa do not [21,22]. At some point, many species can be classified as non-native. Non-native plant or animal species are those that lack a natural distribution within specific ecosystems and have been introduced into, or spread within, systems where they similarly lack a natural range [23]. Most naturalized non-native plant species appear to behave ecologically like resident species, and occur at low to middle frequencies [24,25]. Globally, naturalization is driven by human activities, particularly trade and the economic uses of species. Human movement of goods, plants, and animals across borders has facilitated the spread of species into new regions, often unintentionally. This increased global connectivity accelerates the process of naturalization, leading to changes in local biodiversity and ecosystems. Over 13,000 vascular plant species, approximately 3.9% of the global flora, have naturalized beyond their native ranges. There are few examples of plant species originating from the continents that are now widely naturalized in other regions worldwide [26–28]. There is evidence that a small portion of non-native species can sometimes establish themselves as dominant players in ecosystems [13], with the ability to completely change the ecosystem composition and create monocultures. These species are generally referred to as "invasive" [29]. There are some cases that highlight how non-native species can outcompete natives, alter ecosystems, and become dominant when environmental conditions favor their survival and spread. An example is the species *Pueraria montana* that was introduced in the U.S. from East Asia to control soil erosion. As this species grows rapidly, smothering native vegetation and trees under its dense canopy, it has altered ecosystems by outcompeting native species for sunlight and nutrients [30]. In Europe, *Solidago* species have become highly invasive, spreading rapidly in disturbed and urbanized landscapes. Their spread is fueled by their ability to modify soil properties, outcompete native plants, and thrive in abandoned agricultural areas, making them a serious ecological threat across various European regions [31]. Interestingly, some ecologists studying invasive species define non-nativeness exclusively as species that have been dispersed by human activity [32,33]. Furthermore, species that are able to expand their range naturally are occasionally also designated as non-native [34]. For example, some non-native plants, such as buffelgrass and kudzu, are expanding their ranges rapidly, often outpacing native species in their ability to adapt to climate change [35]. Invasive exotic plants are considered to be one of the greatest threats to the conservation of native species, communities, and ecosystems [36] and require detailed and quick attention in every part of the world [37].

It is believed that plant invasions represent one of the greatest efforts to modify terrestrial ecosystem biodiversity and nutrient cycling [38,39]. The study of Wang et al. [40] showed that changes in soil nitrogen cycles triggered by plant invasions may stem from alterations to the physical properties of the soil ecosystem caused by invasive species. Invasive plants can mediate changes in soil nitrogen cycles through direct or indirect mechanisms, such as modifying soil microbial communities, altering litter decomposition rates, or changing the physicochemical properties of the soil. These processes can play a crucial role in the success of plant invasions. In current research, the scientific community is concerned about the impact on underground soil chemistry and biology due to invasions [41,42]. Climate change poses an existential and life-threatening challenge to global food security, ecosystems, and public health. The work by Mao et al. [43] suggests that the issue of the spread of invasions and climate change are closely related. Biotopes with a high number of endemic species are the most fragile. Wetlands, in particular, are highly susceptible ecosystems due to their distinctive water conditions and nutrient-rich environments which provide favorable conditions for the rapid establishment and spread of invasive plants. Invasive species pose a significant threat to those ecosystems due to their ability to outcompete native plants, alter hydrology, and disrupt nutrient cycling, leading to a decline in biodiversity and ecosystem services [44]. Invasive species are anticipated to have the most significant impact on the biodiversity of aquatic ecosystems, particularly in stagnant waters, while Mediterranean terrestrial ecosystems face the greatest pressure on their biodiversity [45,46].

Many researchers believe that there is a strong interaction between invaders and soil biota components. For example, some invasive species benefit from the localities where they interact with fewer soil enemies compared to their native ranges [47]. Some invasive species, such as *Phragmites australis* Cav. Trin. ex Steud. (common reed), gain a competitive advantage over native species because they encounter fewer soil-borne pathogens and herbivores in non-native regions, allowing them to allocate more energy to growth and reproduction. This “enemy release hypothesis” explains how invasive plants often outperform native species, particularly in wetlands where soil conditions are favorable for rapid colonization [48]. Other exotic species experience new but relatively strong mutualistic relationships that increase their invasive success [47]. Such studies are important to understand the long-term impact of invasion on terrestrial native vegetation and other biological components, as biology and soils are inseparable with each other. Currently, the number of invasive plant species and their rate of spread are increasing in many regions worldwide [49–53]. It is clear that invasive plant and animal species have also spread on the ice-free Antarctic islands despite the Antarctica Treaty [54]. Invasive species are rapidly increasing globally, impacting ecosystems across various regions. In

Europe, for instance, it is expected that invasive species will increase by 64% by 2050, with plants, animals, and insects arriving from other continents. Similarly, in the United States, invasive species are expanding their ranges, exacerbated by factors like climate change and the global trade [55]. Many invasive species have been accidentally introduced into terrestrial and aquatic ecosystems (e.g., through water ballast, soil, or as contaminants in crop seeds), while others have been intentionally introduced for ornamental purposes, as food, or for fiber products [56].

3. The Global Threat of Plant Invader Presence

Native plants play a crucial role in absorbing air pollutants and significantly contribute to carbon sequestration [57,58]. In contrast, invasive species are among the leading causes of species extinction and ecosystem degradation, negatively impacting ecosystem services and human well-being [59]. Consequently, the loss of native plant diversity due to invasive plant pathogens may indirectly harm human health by disrupting environmental quality [60]. Around the world, numerous examples highlight the devastating effects of invasive species on ecosystems, with these dramatic invasions often mirroring regional environmental changes [56]. Additionally, exotic species—such as weeds, pests, and parasites—have a significant economic impact on agricultural and forestry activities, reducing productivity. Invasive weeds can outcompete crops for nutrients, water, and light, severely reducing yields. For example, *Cirsium arvense* L. Scop. and *Ambrosia artemisiifolia* L. are significant pests in North American agriculture, reducing crop yields and increasing the cost of weed control. In the U.S., invasive weeds cost agricultural production an estimated $30 billion annually in losses and control efforts [61]. Much research has focused on studying the impact of the spread of invasive species on natural biodiversity and ecosystem functions [62,63]. According to these studies, it is clear that invasive species cause a threat to natural biodiversity, ecosystem services, environmental quality, and human health.

Exotic species can significantly disrupt the natural balance of soil biota by altering nutrient cycling, microbial communities, and soil structure. They have a very strong impact on diversity and abundance of wild pollinators [64] and ants [65]. The study by Baranová et al. [66] revealed notable changes in Coleoptera families and Carabidae groups, though not necessarily a decline in their diversity. Soil nematodes represent a vital component of soil biota. Owing to their abundance, diversity, and trophic structure [67], they are often used as useful bioindicators of soil conditions [68]. Significant changes in nematode diversity, community composition, and trophic composition have also been observed in several studies [20,69]. Soil microbial communities play an important role in soil nutrient cycling and in the supply of essential plant nutrients [70]. Soil microbiota is highly sensitive to almost all physical and biochemical changes, as well as environmental conditions [71,72]. Therefore, microbial indices are effectively utilized as indicators of soil quality and health owing to their extensive surface area, high reactivity, widespread distribution, and rapid generation time. Soil microorganisms facilitate a very quick practical reaction to any environmental changes mainly because they are closely related to the adjacent environment [73,74]. Some authors [75–77] have shown that an increasing invasion status results in altered soil properties, with an overall increase in nutrient supply and enzymatic activities. They have also pointed out the affection in the structure of the soil microbiota that are related to the cycling of the nutrients. Those significant changes in soil abiotic and biotic composition caused by some exotic species lead to positive feedback between the plants and the soil, a phenomenon which is very likely to help the invaders. Contrary, there is a number of studies [15,72,78] that describe a drop in diversity, abundance, and activity of microbial populations in soil systems. Interestingly, the same invader might differently influence the studied ecosystems [79], depending on the local conditions. Therefore, sometimes, it is quite difficult to reach the simple pattern of their individual impact. Therefore, investigations into the interaction between invasion status and ecological/environmental changes is of high importance. Biological invasions (both plant and animals) are efficient in interacting with other anthropogenic changes in the environment to alter biodiversity and ecosystem processes in invaded localities. For example, there is evidence from a variety of ecosystems that nitrogen inputs benefit alien plant species [80,81]. Human-induced alterations to the N cycle, however, have increased the rate of N fixation to such an extent that human-derived N now exceeds the natural processes [82].

Despite global climate changes, there is a number of plant and animal species that have adapted relatively quickly to changes in temperature and in the length of the growing season [83]. There are many assumptions and questions from ecologists concerning whether these climate changes could favor some non-native and invasive plant species. It is obvious that the native habitats of invasive plant and animal species are warmer, meaning that such species would be at a great advantage [56]. Compared to natural biota, these species can tolerate extreme temperatures better, experience lower mortality rates, and can adapt to these changes more quickly. The study by Dukes and Mooney [84] demonstrates that a wetter climate can lead to a higher concentration of certain invasive plant species, negatively impacting native plant and animal species. Numerous research efforts have been made to investigate the effects of global environmental changes on biological invasions, with a particular focus on how specific environmental factors influence the success of invasions. Plant invasions significantly alter vegetation composition, directly or indirectly affecting ecological functions and exacerbating land use challenges or environmental changes [85]. An example of a plant invasion that directly affects ecosystem functions is the spread of *Eucalyptus globulus* Labill. in Australia. This invasive species alters the fire regime, soil composition, and water cycling in ecosystems where it becomes dominant. *E. globulus* has a high oil content which increases fire intensity, while its deep root systems deplete groundwater resources, reducing water availability for native species [86]. This directly changes the ecosystem's fire dynamics, hydrology, and overall plant community composition. An example of an indirect effect of plant invasion is the spread of *P. australis* in wetland ecosystems which can alter microbial communities in the soil. While *P. australis* competes for space and resources with native plants, its presence can also modify soil chemistry and microbial populations. This shift in microbial community structure indirectly affects nutrient cycling and decomposition rates, both of which can disrupt the entire food web, including the species that rely on the wetlands for habitat purposes [87].

4. Challenges in Prevention, Eradication, and Control

Success in the management of invasive plant species requires active attempts to prevent new introductions, a quick detection of nascent populations, and persistent efforts to eradicate the most aggressive invaders [88]. To reach these objectives, however, we first need to know (a) what kind of species we should prevent from entering the country/locality/region, (b) what kind of new species we should look for and where, and (c) which of the detected species we should potentially control or eradicate [89]. It is widely assumed that changes in land use directly contribute to the increase in biological invasions. Wang et al. [90] emphasize that managing and controlling the conversion of natural habitats is crucial to mitigate future invasion risks. Effective field monitoring and appropriate sampling techniques are also considered essential. Additionally, early detection of invasive species is regarded as one of the most critical factors to address invasions. Last, land modification has been very extensive over the past few decades, and, in most ecosystems and regions, this has been irreversible. Inefficient and unsustainable use of soil ecosystems undermines ecological functions and soil health and has been identified as a leading cause of soil degradation in native ecosystems [71]. Ecosystems as a whole may undergo changes in their structure, composition, and function. Given the widespread presence of invasive species across nearly all landscapes and biotopes, their rate of spread is influenced by the structure and dynamics of the surrounding landscape [91]. Eliminating the spread of invasive plants is important but requires an understanding of land use and of landscape management. Numerous studies report a high diversity of invasive plants in altered and degraded ecosystems, such as post-mining areas, ruderal sites, and anthropogenic environments [92]. It is also clear that changes in the composition and structure of the landscape can significantly improve the settlement of invasive species [56]. The management of biological invasions is essential not only to maintain biological diversity and the environment, but also to protect production sectors. Some data indicate that well-managed areas (for example nature parks and protected areas) are stable and do not easily experience invasions [93]. Some other studies, focusing on forest ecosystems, indicate that invasive species pose a significant threat. These ecosystems are relatively vulnerable, and their biodiversity is threatened [94].

Management of invasive alien species includes several options that are closely connected: (a) prevention of invasion by the newly introduced species, (b) eradication following introduction, (c) containment or control of the invaders, and (d) adaptation [95]. In the past, much attention has been paid to eradication and post-invasion control. Comparatively, little effort has been devoted to prevention measures. Nowadays, biologist emphasize the importance of such preinvasion controls, treating invasive species as a form of "biological pollution" [95–97]. One of the most effective ways of preventing invasive plant spreading is environmental education. Rising public awareness is very important in ecosystem prevention related to biodiversity loss and to the understanding of the influence of humans on nature [98]. Biological invasions have a significant impact on various features of life on Earth (such as ecosystem services, human health, agriculture, forestry, etc.) and, therefore, require approaches that are quick and effective. Public education and public awareness are forcefully suggested for the successful prevention, elimination, and management of exotic species [99]. Successful management of invasive species is needed for the public to be aware and engaged to prevent new introductions and support control interventions. The intervention would also include those people who are affected in their areas of residence who, in many cases, are the first to realize that invasive species are beginning to emerge in the ecosystem, long before educators or researchers notice it. Engaging local communities in the early detection and reporting of invasive species is crucial, as they play a key role in identifying problems before they escalate and can contribute to more effective management strategies. The study of Cordeiro et al. [100] indicates that focusing on public awareness and investing in these kinds of projects pay off. These activities can focus on improving the planning of invasive alien plant management strategies. We should all focus on supporting capacity building and effective mutual communication between educators and scientists [99,101]. These debates should be both formal and informal, with the aim of involving the whole of society in the recognition, prevention, and management of invasive species in general. The positive effect on native biota consists of the eradication of invasive species. Compared to the control measurement, eradication is the preferred approach [102]. A relatively large challenge of biological invasions is that successful control measures need to reduce the presence of the invasive species or limit its further spread. This requires a huge investment in terms of time, tools, and money to keep the attacker at bay. Another approach against invasive species is eradication, which may need large short-term investments. Successful removal of unsuitable species might be achieved within several months or years and provides the best chance to restore native biodiversity [103]. If the eradication of invasive species is successful, there is often a favorable restoration of native species and natural ecosystems, but achieving this state requires a lot of effort, time, and financial support. The ecological context of eradication is becoming increasingly complex. Nowadays, it is common for invasive species, which enjoy long-term establishment in the system and are affected by global changes, to cause enormous damage. A classic example of the long-term influence of invasive species on the environment is the spread of *Rhododendron ponticum* in Britain. After its introduction in the 18th century, this species has since become highly invasive, significantly altering the structure and functioning of forest ecosystems. Additionally, the species releases allelopathic chemicals into the soil that further inhibit the growth of native vegetation. This has led to a shift in forest composition, with the invasion of *R. ponticum* reducing the diversity of native species and altering the habitat of local wildlife. Moreover, the long-term presence of *R. ponticum* has had significant ecological consequences, including changes in soil chemistry and hydrology, as its deep root system can alter water drainage and nutrient cycling. The invasion has caused ongoing challenges in forest management, with substantial resources required to control the spread of this invasive species and restore native ecosystems [104]. Almost all countries in the world are trying to prepare action plans in the field of environmental management which also include the problematics of biological invasions. However, despite investing in standard tools for the eradication of non-native species, such as the use of poisons and mechanical interventions, efficiency may not be achieved for the complete restoration of native ecosystems [105]. The elimination of invasive plant species is very difficult and requires systematic intervention over several years. Their effective elimination will only be possible when citizens take responsibilities and ensure the elimination of these invasive plants on their own properties. In practice, the success of regulating the occurrence of invasive species is affected by proper management practices. These should take into account both the ecological conditions of a specific location and the biological properties of individual species [106]. Before the eradication, it is necessary to find out in advance some of the following facts: (a) natural conditions of a specific location, (b) spread of the species within the locality, i.e., surface extent of the territory, (c) abundance of the invaders, (d) their biological properties and ecological demands, (e) reproductive traits, (f) risks involved in their eradication, (g) financial burden, and (h) detailed time and hierarchical sequence of eradication steps [106,107]. There are some important rules that are necessary to follow. Some authors [100,108] point out that more attention during eradication practices should be paid to localities that are near aquatic ecosystems (especially in the upper sections from where they tend do spread downstream). During the elimination of invasive species, it is also necessary to ensure a very careful handling of the localities with seeding individuals in the fertile stage. Invasive and non-native plant species must be removed during their initial stage of occurrence at the site, when their removal is most effective. The eradication approaches in relation to these plant species are mainly determined by the methods of their reproduction, abundance, nature, and location of the site, danger and size of the site, plant growth phase, and other biological characteristics of the species. In species that reproduce also by generative intervention, elimination must be carried out before or during the flowering of the species, essentially before the start of seed formation [108–110].

Generally, there are several approaches that are effective (more or less) at invasive plant species eradication: (a) mechanical, (b) chemical, (c) both mechanical and chemical, (d) biological, and (e) environmental [111–113]. All these methods have some advantages, as well as limitations. Table 1 shows some examples of their individual advantages and limitations.

Table 1. Overview of the individual eradication approaches with their advantages and limitations.

Approaches	Advantages	Limits	References
Mechanical (pulling, digging, hot steam application, plucking, grazing, plowing, cutting, mowing, mulching, foil placing, suffocation)	Practical and very effective at preventing the formation of flowers, fruits, and seeds, with the destruction of the seed stock being the least harmful to the environment	Small area application, very strenuous and laborious, plants often regenerate and are capable of new reproduction, not applicable to every type of ecosystem	[114–116]
Chemical (herbicides)	Large-scale area application which affects the whole plant, including the root system	Very harmful to the environment, does not affect the soil supply of seeds, reduced effect if the plants are heavily covered in dust, not applicable to every type of ecosystem	[114–117]
Combined (mechanical and chemical)	The most effective among the listed approaches, benefitting from small- and large-scale application suitable for excessively tall and dense populations	Unrecorded	[103,116,118]
Biological (natural invader enemies—insects, mold, fungi)	Exploiting the potential of a natural enemy	Low efficiency, with the possibility of causing damage and failing to attain total elimination, insufficient research	[115,119–121]
Environmental (appropriate management of unmaintained and abandoned sites)	Results in well-managed and maintained localities, effective at preventing the penetration of competitively stronger and fast-starter invaders	Appropriate only with other effective methods	[106,117,122–124]

In practice, when removing invasive plant species, the most often implemented methods are only three of the five removal methods above: mechanical, chemical, and combined. The most effective one is considered to be the combination of mechanical and chemical approaches. Mechanical (sometimes called physical) approaches are mainly applied in the case of rare or small-scale occurrence of the species on the site or in the case of occurrence of the species in watercourses, in water protection zones, or in protected areas, where chemical or combined methods cannot be used [125]. In this respect, there is a very interesting question that scientists have been discussing recently. Should invasive plant species be removed? This is a debate that is alive among experts, with opinions moving between two extremes. On the one hand, we can look at invasions as a natural phenomenon and not interfere, or, on the other hand, we can take the view that invasive plants should be removed always and everywhere. Somewhere between these extremes is a practical approach weighing the energy put into their removal versus the result achieved [126]. Perhaps even more interesting is the question of whether, even with the hypothetical involvement of all available resources for the removal of invasive plants, it is even possible to achieve their permanent eradication in nature. Noticing the expanse of the spread of some invasive and non-native species in certain localities, some authors state that the most aggressive ones, despite efforts, will remain a permanent part of nature [127,128]. There is a greater chance of influencing whether and what other types of invasive plants will appear in the future. It has been proven that invasive species cause numerous negative effects on native ecosystems, yet several studies have highlighted some of their positive traits [129,130]. In addition, invasive plants are opportunistic species and once they enter their non-native area, it is almost impossible to eradicate them completely. [131].

5. New Perspectives in Plant Invasion Research

The fact is that prolonged invasion of exotic plant species significantly alters the soil carbon and nutrient stock in terrestrial ecosystems [132]. This helps the invaders to very effectively prosper in the region [133]. Apart from their ability to modify their local environment, they also have some advanced physiological traits such as high specific leaf area [134,135], increased leaf nutrient content [136], rapid growth rate [137], and higher litter decomposition rates [138] that, in turn, affect nutrient cycles. Conversely, there are many works that describe the opposite features of these characteristics, such as lower decomposition rates and nutrient release of litter [139]. Moreover, as mentioned before, the same plant invader might have various effects on the soil ecosystem, depending on local conditions [140]. There are also instances where invasive species have been found to positively contribute to economic, social, and ecological services [130,141,142]. In some circumstances, the many positive characteristics and the considerable adaptive potential of invasive plants need to be acknowledged. Because of the difficulty associated with eradication approaches and the aggressiveness of the exotic plants which allows them to quickly colonize new ecosystems over large distances, researchers have advanced new questions in relation to this problem. Can invasive species be beneficial to wildlife? Should we be leaving invasive plants in our landscapes or eliminating them? Can we use them to our advantage? Therefore, recent research on invasive species also aims to answer all these questions. Importantly, it must not be forgotten that, through these approaches, we absolutely do not want to preserve invasive species, but, to a large extent, we try to eradicate them.

5.1. Phytoremediation Potential

A very serious worldwide concern is the environmental degradation by contaminants. Remediation of degraded areas with heavy metals is a major global challenge. Despite the existence of a number of conventional physico-chemical approaches that can be used, these tools do not appear to be the most effective. The use of a relatively cheap "green" and sustainable technique of phytoremediation appears to be simple and unrivaled. Since the eradication of introduced invasive species in their non-native environment is very complicated to achieve, their control appears to be more effective. This control strategy includes their sustainable management by using them in contaminant remediation, i.e., phytoremediation. Because invasive species can survive in harsh conditions and they pose a huge threat to natural biodiversity, knowledge about their ecology in polluted sites is highly important. The results of several studies [129,131,143,144] show that invasive and non-native plants can be considered to be potential phytoremediation candidates. They can easily be introduced even in severely degraded environments. Phytoremediation, as the most effective environmental restoration approach, offers sustainable management of invasive plants. Phytoremediation, which uses invasive plant species, is currently becoming more popular for its environmental friendliness and effectiveness at removing potentially toxic elements from soils [145]. On the other hand, however, this method requires substantial human and financial resources, its performance can be seasonal, its use is limited to some pollutants, and it creates secondary wastes after the treatment [146]. Despite these negative features, it is considered a very effective and potentially low-cost approach. Compared to mechanical or chemical remediation methods, phytoremediation is significantly less expensive. It uses natural growth processes, requiring minimal infrastructure and maintenance. This is particularly advantageous in developing regions or in large-scale contaminated sites where financial resources are limited [147]. Thus, there has been a shift in awareness with respect to the use of invasive plant species as biosorbents for the decontamination of dangerous substances. There are several papers that describe the value of biochar production from invasive plants through such a method [148–151]. All these authors define the negative effects of invasive plant species, their distribution, and show the high potential of biosorbents that are low-cost and biodegradable. Those substances from invasive plants have a number of functional groups that make them an ideal matter for the elimination of heavy metals, organic dyes, and petroleum pollutants. The study by Nguyen et al. [143] highlights the lack of research on using these biosorbents to treat various hazardous substances, such as pharmaceutical drugs, pesticides, and other organic materials. Future biotechnology research is expected to focus more on invasive and non-native plants in these critical areas.

5.2. Natural Dyes

Natural dyes from exotic plant species may serve as reliable, non-toxic, and replicable alternatives to synthetic ones [152]. This information is of high importance, because the textile dyeing industry is considered to be the most environmentally polluting industry in the world [153]. Natural dyes might be easily extracted from every part of the plant like the roots, leaves, fruits, seeds, or petals [154] and have many definite advantages (antibacterial activity, UV protective effects, biodegradability, etc.) [155]. Unfortunately, some limits of natural dyes lie in their low wash and light fastness and in the fact that they can only achieve limited hues, mainly yellow, reddish, and brown. Therefore, more research is needed in order to keep the natural dyes vibrant, consistent, and more colorfast between batches [156,157]. All this research concludes that invasive plant species could be potentially used worldwide for the sustainable creation of dyes for textile industries using simple methods.

5.3. Chemical and Pharmaceutical Potential

Some authors [158] suggest the use of invasive plant species as a source of potential substances used in the pharmaceutical industry. Once available, these drugs might generate income, thus decreasing the global cost of eradication. These authors do not propose the use of those invasive species in traditional medicine or phytotherapies, but it is essential to search for active substances with detailed pharmacological and toxicological studies. In addition, there are many European invasive plant species that, in their native ecosystem, have been found to be useful for medicinal purposes to treat many symptoms and for use in cosmetics, and they also produce significant antimicrobial and antifungal compounds. There are several European invasive plant species that have medicinal, cosmetic, and antimicrobial properties, such as *Hypericum perforatum* L. that is native to Europe and is invasive in some parts of North America. This plant contains a variety of bioactive compounds which have demonstrated potential for treating mood disorders such as depression and anxiety. Its chemical properties also suggest antimicrobial, anti-inflammatory, and antioxidant effects, making it a promising candidate for further pharmaceutical developments. Another example is *Achillea millefolium* L. that is found across Europe and is invasive in other continents. It has applications in traditional medicine for treating wounds, fevers, and digestive issues. Its essential oils are also used in cosmetics for their antimicrobial and antifungal effects [159–162]. The chemistry of plants, in general, is very complicated and relies on the ability to synthetize allelopathic compounds. The significance of secondary metabolites for the invasive plant has remained unclear for a long time. Scientists now agree that they are important factors for plant survival, as they participate in the interaction of plants with animals, plants with each other, with microorganisms, and with other components of the environment. Secondary metabolites serve primarily as a plant defense against, for example, herbivores. Defensive substances produced by plants are often very toxic. In addition, secondary metabolites also serve as a defense against insects and microorganisms. The leaching of defensive substances into the soil or air prevents the growth of other types of plants in their own immediate surroundings. We call this phenomenon allopathy [158,163,164]. Some studies [165,166] indicate that the high content of monoterpenes in the essential oil of selected invasive plant species has an allelopathic effect and could be used, in practice, as biological/ecological herbicides. Recently, some scientists [167,168] have reviewed the potential of exotic plants for bionanoparticle fabrication. They describe that natural compounds from invasive and non-native plant species act as decreasing and stabilizing agents for the formation of bionanoparticles. The role of exotic species as major botanical sources to extract natural compounds such as piceatannol, resveratrol, quadrangularin-A, flavonoids, and triterpenoids, all of which are connected tightly to the formation and application of bionanoparticles, is essential. It is expected that bionanoparticles that are derived from invasive plants may have outstanding antibacterial, antifungal, anticancer, and antioxidant properties that could be useful in biomedical applications, therapeutic treatments, and smart agriculture.

The chemical potential of many invasive plant species should be clearly explored, and, even when this group of species represent a serious global problem, their benefits should be turned into a profitable and commercial resource. Many of the abovementioned studies show the biological activity of plant extracts, but, so far, no effective substances have been isolated that are actually used today. Therefore, the search for active metabolites should become a priority in invasive plants research.

5.4. Interaction with Native Pollinators

Non-native and invasive plants interact with native species and largely influence, directly and indirectly, those species, as well as the ecological function of the whole ecosystems [169]. Very usable are mutualistic interactions with native pollinators, and, sometimes, these interactions are necessary for the reproductive success of the invader. Despite the assumption that invasive plants have generally negative impacts on native pollinators, there is not a significant evidence basis to support this premise [36]. On the other hand, invasive plants have been widely reported as a potential cause of bee reduction [170,171], but their impact on bee populations is rather unclear and controversial. The study by Drossart et al. [172] suggests that common generalist bumblebees may not always be negatively impacted by plant invasions, depending on their behavioral flexibility and nutritional needs. Several studies have also observed higher bee abundance, along with increased visit rates and seed production, in transects containing invasive plants [173,174]. While competition for pollination may be a key factor in plant reproduction [175], it is important to consider the impact of the rising number of invasive plant species on the pollination of native species. Some studies [176] have shown that invasive plants are able to help sustain biological diversity by supplying a source of forage for pollinators in urban and suburban ecosystems. This fact highlights the importance of assessing both positive and negative roles of exotic plant species to improve biodiversity conservation.

5.5. To Eat or Not to Eat?

Turning invasive species into gourmet meals could blunt environmental and economic costs across the world. The idea of using invasive plant and animal species in the gastronomy sector is not new. For example, the consumption of weeds has been recorded previously for many purposes, including using them as a good food source given their ubiquity and abundance [177]. Human consumption of invaders is considered to be a way of controlling invasive species that can significantly affect their population. There are several initiatives, campaigns, and websites that suggest harvest strategies and recipes for common invasive plants of the region [178]. In the early twenty-first century, conservation biologist Joe Roman introduced the term "Invasivorism", i.e., the use of invasive species in gastronomy as one of the tools to reduce their abundance [179]. A great advantage of this gastronomic use is also the increase in public awareness of these non-native and invasive species which can potentially support the detection of new populations. In addition, there is evidence that humans might reduce the population size (when is low) of some invasive species by eating them. Programs based on the elimination of invaders are as effective as other approaches, such as the mechanical removal of invasive plants, generating stronger combined effect [178,180,181]. At this point, it is very important to point out that it is necessary to pay great attention to the residues after using the invasive plants for such purposes. These residues must be boiled (or otherwise denatured) and only then thrown in the bin or composted to prevent further unwanted spread.

6. Conclusions

Plant invasions are an ever-evolving problem that is occurring on a large scale around the world today. According to the already mentioned information, it is very complicated to destroy them permanently in the country once they become established, and that is why a lot of attention has been paid to their control and use in light of their beneficial possibilities for humans. Our review suggests that the role of non-native and invasive plants in native communities needs to be reconsidered, and this should include reviewing their potential as sources of food for native pollinators and their potential in soil recovery, medicine, and different kinds of industry, and even in gastronomy. An effective evaluation of the role of non-native and invasive plants in complex environments can aid ecosystem restoration efforts. For instance, if exotic species serve as food sources for native populations, it may be more beneficial to replace them rather than remove them. Future studies on the effects of non-native and invasive plant control are necessary, as is research on their use in biodiversity and different types of ecosystems.

Author Contributions: Conceptualization, L.B. and L.D.; validation, L.D., G.P. and T.L.; resources, L.B. and L.D.; data curation, L.B.; writing—original draft preparation, L.B.; writing—review and editing, L.D., G.P. and T.L.; supervision, L.B.; project administration, L.D.; funding acquisition, L.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Slovak Scientific Agency VEGA No. 1/0213/22 and by the Slovak Research and Development Agency APVV-20-0140.

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

References

1. Muhsin, E.A.; Hussain, B.A.; Hammadi, A.M.; Khalaf, H.A. The climate change and biodiversity: A review on understanding the global and local impacts of warming on the ecosystems. *AJB* **2023**, *15*, 10–18. [CrossRef]
2. Orgiazzi, A.; Panagos, P. Soil biodiversity and soil erosion: It is time to get married. *Glob. Ecol. Biogeogr.* **2018**, *27*, 1155–1167. [CrossRef]
3. Kutílek, M.; Nielsen, D.R. Soil is the skin of the planet Earth. In *Soil*; Springer: Dordrecht, The Netherlands, 2015; pp. 13–19.
4. Rawat, U.S. Biodiversity: Concept, threats and conservation. *Environ. Conserv.* **2015**, *16*, 19–28. [CrossRef]
5. Pierzynski, G.M.; Vance, G.F.; Sims, T.J. *Soils and Environmental Quality*, 3rd ed.; Taylor & Francis Group: Boca Raton, FL, USA, 2005; 584p.
6. Lee, K.E.; Pankhurst, C.E. Soil organisms and sustainable productivity. *Aust. J. Soil Res.* **1992**, *30*, 855–892. [CrossRef]
7. Pritchard, S.G. Soil organisms and global climate change. *Plant Pathol.* **2011**, *60*, 82–99. [CrossRef]

8. Ferreira, C.S.S.; Seifollahi-Aghmiuni, S.; Destouni, G.; Ghajarnia, N.; Kalantari, Z. Soil degradation in the European Mediterranean region: Processes, status and consequences. *Sci. Total Environ.* **2022**, *805*, 150106. [CrossRef] [PubMed]
9. Sharafatmandrad, M.; Mashizi, A.K. Temporal and spatial assessment of supply and demand of the water-yield ecosystem service for water scarcity management in arid to semi-arid ecosystems. *Water Resour. Manag.* **2021**, *35*, 63–82. [CrossRef]
10. Peng, Z.; Qian, X.; Liu, Y.; Li, X.; Gao, H.; An, Y.; Qi, J.; Jiang, L.; Zhang, Y.; Chen, S.; et al. Land conversion to agriculture induces taxonomic homogenization of soil microbial communities globally. *Nat. Commun.* **2024**, *15*, 3624. [CrossRef] [PubMed]
11. Kopittke, P.M.; Menzies, N.W.; Wang, P.; McKenna, B.A.; Lombi, E. Soil and the intensification of agriculture for global food security. *Environ. Int.* **2019**, *132*, 105078. [CrossRef]
12. Castellano, M.J.; Archontoulis, S.V.; Helmers, M.J.; Poffenbarger, H.J.; Six, J. Sustainable intensification of agricultural drainage. *Nat. Sustain.* **2019**, *2*, 914–921. [CrossRef]
13. Levine, J.M.; Vilà, M.; D'Antonio, C.M.; Dukes, J.S.; Grigulis, K.; Lavorel, S. Mechanisms underlying the impacts of exotic plant invasions. *Proc. R. Soc. B* **2003**, *270*, 775–781. [CrossRef]
14. Jones, H.P.; Jones, P.C.; Barbier, E.B.; Blackburn, R.C.; Benayas, L.M.R.; Holl, K.D.; McCrackin, M.; Meli, P.; Montoya, D.; Mateos, D.M. Restoration and repair of Earth's damaged ecosystems. *Proc. R. Soc. B* **2018**, *282*, 20172577. [CrossRef] [PubMed]
15. Bobuľská, L.; Demková, L.; Čerevková, A.; Renčo, M. Invasive Goldenrod (*Solidago gigantea*) influences soil microbial activities in forest and grassland ecosystems in Central Europe. *Diversity* **2019**, *11*, 134. [CrossRef]
16. Demková, L.; Árvay, J.; Bobuľská, L.; Hauptvogl, M.; Hrstková, M. Open mining pits and heaps of waste material as the source of undesirable substances: Biomonitoring of air and soil pollution in former mining area (Dubník, Slovakia). *Environ. Sci. Pollut. Res.* **2019**, *26*, 35227–35239. [CrossRef]
17. Rai, P.K.; Singh, J.S. Invasive alien plant species: Their impact on environment, ecosystem services and human health. *Ecol. Indic.* **2020**, *111*, 106020.
18. Caspi, T.; Hartz, L.A.; Villa, A.E.S.; Loesberg, J.A.; Robins, C.R.; Meyer III, W.M. Impact of invasive annuals on soil carbon and nitrogen storage in southern California depend on the identity of the invader. *Ecol. Evol.* **2019**, *9*, 4980–4993. [CrossRef] [PubMed]
19. Pickett, B.; Irvine, I.C.; Bullock, E.; Arogyaswamy, K.; Aronson, E. Legacy effects of invasive grass impact soil microbes and native shrub growth. *Invasive Plant Sci. Manag.* **2019**, *12*, 22–35. [CrossRef]
20. Čerevková, A.; Miklisová, D.; Bobuľská, L.; Renčo, M. Impact of the invasive plant *Solidago gigantea* on soil nematodes in a semi-natural grassland and a temperate broadleaved mixed forest. *J. Helminthol.* **2020**, *94*, e51. [CrossRef] [PubMed]
21. Pyšek, P.; Richardson, D.M.; Rejmánek, M.; Webster, G.L.; Williamson, M.; Kirschner, J. Alien Plants in Checklists and Floras: Towards Better Communication between Taxonomists and Ecologists. *Taxon* **2004**, *53*, 131–143. [CrossRef]
22. Theodoropoulos, D.I. Invasion biology. Critique of a pseudoscience. *Ann. Bot.* **2004**, *94*, 196–197.
23. Sagoff, M. Do non-native species threaten the natural environment? *J. Agric. Environ. Ethics* **2005**, *18*, 215–236. [CrossRef]
24. Brown, R.L.; Peet, R.K. Diversity and invasibility of southern Appalachian plant communities. *Ecology* **2003**, *84*, 32–39. [CrossRef]
25. Davis, M.A.; Grime, J.P.; Thompson, K. Fluctuating resources in plant communities: A general theory of invasibility. *J. Ecol.* **2000**, *88*, 528–534. [CrossRef]
26. Zhang, A.; Hu, X.; Yao, S.; Yu, M.; Ying, Z. Alien, naturalized and invasive plants in China. *Plants* **2021**, *10*, 2241. [CrossRef] [PubMed]
27. Van Kleunen, M.; Xu, X.; Yang, Q.; Maurel, N.; Zhang, Z.; Dawson, W.; Essl, F.; Kreft, H.; Pergl, J.; Pyšek, P.; et al. Economic use of plants is key to their naturalization success. *Nat. Commun.* **2020**, *11*, 3201. [CrossRef] [PubMed]
28. Van Kleunen, M.; Dawson, W.; Essl, F.; Pergl, J.; Winter, M.; Weber, E.; Kreft, H.; Weigelt, P.; Kartesz, J.; Nishino, M.; et al. Global exchange and accumulation of non-native plants. *Nature* **2015**, *525*, 100–103. [CrossRef] [PubMed]
29. Colautti, R.I.; MacIsaac, H.I. A neutral terminology to define 'invasive' species. *Divers. Distrib.* **2004**, *10*, 135–141. [CrossRef]
30. Forseth, I.N.; Innis, A.F. Kudzu (Pueraria montana): History, physiology, and ecology combine to make a major ecosystem threat. *Crit. Rev. Plant Sci.* **2004**, *23*, 401–412. [CrossRef]
31. Baranová, B.; Troščáková-Kerpčárová, E.; Gruľová, D. Survey of the Solidago canadensis L. Morphological traits and essential oil production: Aboveground biomass growth and abundance of the invasive goldenrod appears to be reciprocally enhanced within the invaded stands. *Plants* **2022**, *11*, 535. [CrossRef]
32. Hulme, P.E. Addressing the threat to biodiversity from botanic gardens. *Trends Ecol. Evol.* **2011**, *26*, 168–174.
33. McNeely, J.A. *The Great Reshuffling: Human Dimensions of Invasive Alien Species*, 1st ed.; IUCN: Gland, Switzerland; Cambridge, UK, 2001; 245p.
34. Raymond, B.; McInnes, J.; Dambacher, J.M.; Way, S.; Bergstrom, D.M. Qualitative modelling of invasive species eradication on subantarctic Macquarie Island. *J. Appl. Ecol.* **2011**, *48*, 181–191. [CrossRef]
35. Bradley, B.A.; Beaury, E.M.; Gallardo, B.; Ibáñez, I.; Jarnewich, C.; Morelli, T.L.; Sofaer, H.R.; Sorte, C.J.B.; Vilà, M. Observed and potential range shifts of native and nonnative species with climate change. *Annu. Rev. Ecol. Evol. Syst.* **2024**, *55*, 23–40. [CrossRef]
36. Traveset, A.; Richardson, D.M. Biological invasions as disruptors of plant reproductive mutualisms. *Trends Ecol. Evol.* **2006**, *21*, 208–216. [CrossRef]

37. Mack, R.N.; Simberloff, D.; Lonsdale, W.M.; Evans, H.; Clout, M.; Bazzaz, F.A. Biotic invasions: Causes, epidemiology, global consequences, and control. *Ecol. Appl.* **2000**, *10*, 689–710. [CrossRef]
38. Šibíková, M.; Jarolímek, I.; Hegedüšová, K.; Májeková, J.; Mikulová, K.; Slabejová, D.; Škodová, I.; Zaliberová, M.; Medvecká, J. Effect of planting alien *Robinia pseudoacacia* trees on homogenization of Central European forest vegetation. *Sci. Total Environ.* **2019**, *687*, 1164–1175. [CrossRef]
39. Kumar, M.; Verma, A.K.; Garkoti, S.C. *Lantana camara* and *Ageratina adenophora* invasion alter the understory species composition and diversity of chir pine forest in central Himalaya, India. *Acta Oecol.* **2020**, *109*, 103642. [CrossRef]
40. Wang, C.; Xiao, H.; Liu, J.; Du, D. Insights into ecological effects of invasive plants on soil nitrogen cycles. *Am. J. Plant Sci.* **2015**, *6*, 34–46. [CrossRef]
41. Ahmad, R.; Khuroo, A.A.; Hamid, M.; Rashid, I. Plant invasion alters the physico-chemical dynamics of soil system: Insights from invasive *Leucanthemum vulgare* in the Indian Himalaya. *Environ. Monit. Assess.* **2019**, *191*, 792. [CrossRef] [PubMed]
42. Kumar, M.; Kumar, S.; Verma, A.K.; Joshi, R.K.; Garkoti, S.C. Invasion of *Lantana camara* and *Ageratina adenophora* alters the soil physico-chemical characteristics and microbial biomass of chir pine forests in the central Himalaya, India. *Catena* **2021**, *207*, 105624. [CrossRef]
43. Mao, R.; Bajwa, A.A.; Adkins, S. A superweed in the making: Adaptation of *Parthenium hysterophorus* to a changing climate. A review. *Agron. Sustain. Dev.* **2021**, *41*, 47. [CrossRef]
44. Zedler, J.B.; Kercher, S. Causes and consequences of invasive plants in wetlands: Opportunities, opportunists, and outcomes. *Crit. Rev. Plant Sci.* **2004**, *23*, 431–452. [CrossRef]
45. Emery-Butcher, H.E.; Beatty, S.J.; Robson, B.J. The impacts of invasive ecosystem engineers in freshwaters: A review. *Freshw. Biol.* **2020**, *65*, 999–1015. [CrossRef]
46. Zelnik, I. The presence of invasive alien plant species in different habitats: Case study from Slovenia. *Acta Biol. Slov.* **2012**, *22*, 25–38. [CrossRef]
47. Reinhart, K.O.; Callaway, R.M. Soil biota and invasive plants. *New Phytol.* **2006**, *170*, 445–457. [CrossRef] [PubMed]
48. Mitchell, C.E.; Power, A.G. Release of invasive plants from fungal and viral pathogens. *Nature* **2003**, *421*, 625–627. [CrossRef] [PubMed]
49. Musarella, C.M.; Laface, V.L.A.; Angiolini, C.; Bacchetta, G.; Bajona, E.; Banfi, E.; Barone, G.; Biscotti, N.; Bonsanto, D.; Calvia, G.; et al. New Alien Plant Taxa for Italy and Europe: An Update. *Plants* **2024**, *13*, 620. [CrossRef] [PubMed]
50. Nelufule, T.; Thenga, T.C.; Shivambu, T.C.; Shivambu, N.; Moshobane, M.C.; Seoraj-Pillai, N.; Nangammbi, T.C. Alien Plant Species Richness in Urban Protected Biodiversity Areas: A Case Study of Tshwane Metropolitan Municipality, South Africa. *Diversity* **2024**, *16*, 461. [CrossRef]
51. Ngugi, M.R.; Neldner, V.J. Assessing the incursion status of non-native plant species in the Wet Tropics World Heritage Area in Queensland, Australia. *Biol. Invasions* **2024**, *26*, 1471–1487. [CrossRef]
52. Xie, Y.; Xie, X.; Weng, F.; Nong, L.; Lin, M.; Ou, J.; Wang, Y.; Mao, Y.; Chen, Y.; Qian, Z.; et al. Distribution Patterns and Environmental Determinants of Invasive Alien Plants on Subtropical Islands (Fujian, China). *Forests* **2024**, *15*, 1273. [CrossRef]
53. Domínguez-Meneses, A.; Martínez-Gómez, J.E.; Mejía-Saulés, T.; Acosta-Rosado, I.; Stadler, S. Vascular Plant Species Inventory of Mexico's Revillagigedo National Park: Awareness of Alien Invaders as a Sine Qua Non Prerequisite for Island Conservation. *Plants* **2023**, *12*, 3455. [CrossRef] [PubMed]
54. Hughes, K.A.; Convey, P. The protection of Antarctic terrestrial ecosystems from inter- and intra-continental transfer of non-indigenous species by human activities: A review of current systems and practice. *Glob. Environ. Chang.* **2010**, *20*, 96–112. [CrossRef]
55. Seebens, H.; Bacher, S.; Blackburn, T.M.; Capinha, C.; Dawson, W.; Dullinger, S.; Genovesi, P.; Hulme, P.E.; van Kleunen, M.; Kühn, I.; et al. Projecting the continental accumulation of alien species through to 2050. *Glob. Chang. Biol.* **2021**, *27*, 970–982. [CrossRef] [PubMed]
56. Vilà, M.; Corbin, J.D.; Dukes, J.S.; Pino, J.; Smith, S.D. Linking plant invasion to global environmental change. In *Terrestrials Ecosystems in a Changing World*, 1st ed.; Canadell, J.G., Pataki, D., Pitelka, L., Eds.; The IGBP Series; Springer: Berlin/Heidelberg, Germany, 2007; pp. 93–102.
57. Shackleton, R.T.; Shackleton, C.M.; Kull, C.A. The role of invasive alien species in shaping local livelihoods and human well-being: A review. *J. Environ. Manag.* **2019**, *229*, 145–157. [CrossRef]
58. Pejchar, L.; Mooney, H.A. Invasive species, ecosystem services and human well-being. *Trends Ecol. Evol.* **2009**, *24*, 497–504. [CrossRef] [PubMed]
59. Gallardo, B.; Bacher, S.; Bradley, B.; Comín, F.A.; Gallien, L.; Jeschké, J.M.; Sorte, C.J.B.; Vilà, M. Invasives: Understanding and managing the impacts of Invasive alien species on Biodiversity and Ecosystem Services. *NeoBiota* **2019**, *50*, 109–122. [CrossRef]
60. Jones, B.A.; McDermott, S.M. Health impacts of invasive species through an altered natural environment: Assessing air pollution sinks as a causal pathway. *Environ. Resour. Econ.* **2018**, *71*, 23–43. [CrossRef]

61. Pimentel, D.; Lach, L.; Zuniga, R.; Morrison, D. Environmental and economic cost of nonindigenous species in the United States. *BioScience* **2000**, *50*, 53–65. [CrossRef]
62. Bobuľská, L.; Demková, L. Effects of invasive species *Impatiens parviflora* on soil microbial indices in the protected areas in Slovakia. In Proceedings of the VIII International Scientific Agriculture Symposium Agrosym, Jahorina, Bosnia and Herzegovina, 5–8 October 2017; pp. 1880–1885.
63. Vilà, M.; Hulme, P.E. *Impact of Biological Invasions on Ecosystem Services*, 1st ed.; Springer Nature: Cham, Switzerland, 2017; 354p.
64. Moroń, D.; Lenda, M.; Skórka, P.; Szentgyörgyi, H.; Settele, J.; Woyciechowski, M. Wild pollinator communities are negatively affected by invasion of alien goldenrods in grassland landscapes. *Biol. Conserv.* **2009**, *142*, 1322–1332. [CrossRef]
65. Lenda, M.; Witek, M.; Skórka, P.; Moroń, D.; Woyciechowski, M. Invasive alien plants affect grassland and communities, colony size and foraging behavior. *Biol. Invasions* **2013**, *15*, 2403–2414. [CrossRef]
66. Baranová, B.; Manko, P.; Jászay, T. Differences in surface-dwelling beetles of grassland invaded and non-invaded by goldenrods (*Solidago canadensis*, *S. gigantea*) with special reference to Carabidae. *J. Insect Conserv.* **2014**, *18*, 623–635. [CrossRef]
67. Yeates, G.W.; Ferris, H.; Moens, T.; van der Putten, W.H. The role of nematodes in Ecosystems. In *Nematodes as Environmental Indicators*, 1st ed.; Wilson, M.J., Kakouli-Duarte, T., Eds.; CABI International: Wallingford, UK, 2009; pp. 1–106.
68. Ritz, K.; Black, H.I.J.; Campbell, C.D.; Harris, J.A.; Wood, C. Selecting biological indicators for monitoring soils: A framework for balancing scientific and technical opinion to assist policy development. *Ecol. Indic.* **2009**, *9*, 1212–1221. [CrossRef]
69. Čerevková, A.; Bobuľská, L.; Miklisová, D.; Renčo, M. A case study of soil food web components affected by *Fallopia japonica* (Polygonaceae) in three natural habitats in Central Europe. *J. Nematol.* **2019**, *51*, e42. [CrossRef] [PubMed]
70. Trognitz, F.; Hackl, E.; Widhalm, S.; Sessitsch, A. The roleof plant-microbiome interactions in weed establishment and control. *FEMS Microbiol. Ecol.* **2016**, *92*, fiw138. [CrossRef]
71. Vinhal-Freitas, I.C.; Corrêa, G.F.; Wendling, B.; Bobuľská, L.; Ferreira, A.S. Soil textural class plays a major role in evaluating the effects of land use on soil quality indicators. *Ecol. Indic.* **2017**, *74*, 182–190. [CrossRef]
72. Sicardi, M.; García-Préchac, F.; Frioni, L. Soil microbial indicators sensitive to land use conversion from pastures to commercial *Eucalyptus grandis* (Hill ex Maiden) plantations in Uruguay. *Appl. Soil Ecol.* **2004**, *27*, 125–133. [CrossRef]
73. Bobuľská, L.; Demková, L. Functional diversity and activity of microbial communities is altered by land use management in agricultural soil of North-East Slovakia. *Russ. J. Ecol.* **2021**, *52*, 470–478. [CrossRef]
74. Peltzer, D.A.; Bellingham, P.J.; Kurokawa, H.; Walker, L.R.; Wardle, D.A.; Yeates, G.W. Punching above their weight: Low-biomass non-native plant species alter soil properties during primary succession. *Oikos* **2009**, *118*, 1001–1014. [CrossRef]
75. Zhang, H.Y.; Goncalves, P.; Copeland, E.; Qi, S.S.; Dai, Z.C.; Li, G.L.; Wang, C.Y.; Du, D.L.; Thomas, T. Invasion by the weed *Conyza canadensis* alters soil nutrient supply and shifts microbiota structure. *Soil Biol. Biochem.* **2020**, *143*, 107739. [CrossRef]
76. Rodrigues, R.R.; Pineda, R.P.; Barney, J.N.; Nilsen, E.T.; Barrett, J.E.; Williams, M.A.; Liu, J. Plant invasions associated with change in root-zone microbial community structure and diversity. *PLoS ONE* **2015**, *10*, e0141424. [CrossRef]
77. Chacón, N.; Herrera, I.; Flores, S.; Gonzáles, J.A.; Nassar, J.M. Chemical, physical, and biochemical soil properties and plant roots as affected by native and exotic plants in neotropical arid zones. *Biol. Fertil. Soils* **2009**, *45*, 321–328. [CrossRef]
78. Kong, Y.; James, K.; Dingkang, W.; Heping, H.; Kaiyou, G.; Yonxia, W.; Yun, X. Effect of *Ageratina adenophora* invasion on the composition and diversity of soil microbiome. *J. Gen. Appl. Microbiol.* **2017**, *63*, 114–121. [CrossRef]
79. Vilà, M.; Espinar, J.L.; Hejda, M.; Hulme, P.E.; Jarošík, V.; Maron, J.L.; Pergl, J.; Schaffner, U.; Sun, Y.; Pyšek, P. Ecological impacts of invasive alien plants: A meta-analysis of their effect on species, communities and ecosystems. *Ecol. Lett.* **2011**, *14*, 702–708. [CrossRef] [PubMed]
80. Cui, X.; Song, W.; Feng, J.; Jia, D.; Guo, J.; Wang, Z.; Wu, H.; Qi, F.; Liang, J.; Lin, G. Increased nitrogen input enhances *Kandelia obovata* seedling growth in the presence of invasive *Spartina alterniflora* in subtropical regions of China. *Biol. Lett.* **2017**, *13*, 20160760. [CrossRef] [PubMed]
81. Perry, L.G.; Blumenthal, D.M.; Monaco, T.A.; Paschke, M.W.; Redente, E.F. Immobilizing nitrogen to control plant invasion. *Oecologia* **2010**, *163*, 13–24. [CrossRef] [PubMed]
82. Vitousek, P.M.; Howarth, R.W.; Likens, G.E.; Matson, P.A.; Schindler, D.; Schlesinger, W.H.; Tilman, G.D. Human alteration of the global nitrogen cycle: Causes and consequences. *Issues Ecol.* **1997**, *1*, 737–750.
83. Root, T.L.; Price, J.T.; Hall, K.R.; Schneider, S.H.; Rosenzweig, C.; Pounds, J.A. Fingerprints of global warming on wild animals and plants. *Nature* **2003**, *421*, 57–60. [CrossRef]
84. Dukes, J.S.; Mooney, H.A. Does global change increase the success of biological invaders? *Trends Ecol. Evol.* **1999**, *14*, 135–139. [CrossRef] [PubMed]
85. Ehrenfeld, J.G. Effects of exotic plant invasions of ecosystem nutrient cycling processes. *Ecosystems* **2003**, *6*, 503–523. [CrossRef]
86. Ehrenfeld, J.G. Ecosystem consequences of biological invasions. *Annu. Rev. Ecol. Evol. Syst.* **2010**, *41*, 59–80. [CrossRef]
87. Silliman, B.R.; Bertness, M.D. Shoreline development drives invasions of *Phragmites australis* and the loss of plant diversity on New England salt marshes. *Conserv. Biol.* **2004**, *18*, 1424–1434. [CrossRef]
88. Rejmánek, M. Invasive plants: Approaches and prediction. *Austral Ecol.* **2000**, *25*, 497–506. [CrossRef]

89. Thompson, S.K.; Seber, G.A.F. *Adaptive Sampling*, 1st ed.; Wiley-Interscience: New York, NY, USA, 1996; 288p.
90. Wang, W.; Zhang, C.; Allen, J.M.; Li, W.; Boyer, M.A.; Segerson, K.; Silander, J.A. Analysis and prediction of land use changes related to invasive species and major driving forces in the state of Connecticut. *Land* **2016**, *5*, 25. [CrossRef]
91. With, K.A. The landscape ecology of invasive spread. *Conserv. Biol.* **2002**, *16*, 1192–1203. [CrossRef]
92. Anibaba, Q.A.; Dyderski, M.K.; Woźniak, G.; Jagodziński, A.M. Native plant community characteristics explain alien species success in post-industrial vegetation. *NeoBiota* **2023**, *85*, 1–22. [CrossRef]
93. Jarošík, V.; Pyšek, P.; Foxcroft, L.C.; Richardson, D.M.; Rouget, M.; MacFadyen, S. Predicting incursion of plant invaders into Kruger National Park, South Africa: The interplay of general drivers and species-specific factors. *PLoS ONE* **2011**, *6*, e28711. [CrossRef]
94. Randall, L.M. Protected areas. In *Encyclopedia of Biological Invasions*, 1st ed.; Simberloff, D., Rejmánek, M., Eds.; University of California: Berkley, CA, USA, 2011; pp. 563–567.
95. Horan, R.D.; Perrings, C.; Lupi, F.; Bulte, E.H. Biological pollution prevention strategies under ignorance: The case of invasive species. *Am. J. Agric. Econ.* **2005**, *84*, 1303–1310. [CrossRef]
96. Jarnevich, C.S.; Sofaer, H.R.; Engelstad, P. Modelling presence versus abundance for invasive species risk assessment. *Divers. Distrib.* **2021**, *27*, 2454–2464. [CrossRef]
97. Olson, L. The economics of terrestrial invasive species: A review of the literature. *Agric. Resour. Econ. Rev.* **2006**, *35*, 178–194. [CrossRef]
98. Yli-Panula, E.; Jeronen, E.; Lemmetty, P.; Pauna, A. Teaching methods in biology promoting biodiversity education. *Sustainability* **2018**, *10*, 3812. [CrossRef]
99. Sosa, A.J.; Jiménez, N.L.; Faltlhauser, A.C.; Righetti, T.; McKay, F.; Bruzzone, O.A.; Souto, A.F. The educational community and its knowledge and perceptions of native and invasive alien species. *Sci. Rep.* **2021**, *11*, 21474. [CrossRef] [PubMed]
100. Cordeiro, B.; Marchante, H.; Castro, P.; Marchante, E. Does public awareness about invasive plants pays off? An analysis of knowledge and perceptions of environmentally aware citizens in Portugal. *Biol. Invasions* **2020**, *22*, 2267–2281. [CrossRef]
101. Crall, A.W.; Jordan, R.; Holfelder, K.; Newman, G.J.; Graham, J.; Waller, D.M. The impacts of an invasive species citizen science training program on participant attitudes, behavior, and science literacy. *PUS* **2013**, *22*, 745–764. [CrossRef] [PubMed]
102. Epanchin-Niell, R.S. Economics of invasive species policy and management. *Biol. Invasions* **2017**, *19*, 3333–3354. [CrossRef]
103. Zavaleta, E.S.; Hobbs, R.J.; Mooney, H.A. Viewing invasive species removal in a whole-ecosystem context. *Trends Ecol. Evol.* **2001**, *16*, 454–459. [CrossRef]
104. Dehnen-Schmutz, K.; Perrings, C.; Williamson, M. Controlling *Rhododendron ponticum* in the British Isles: An economic analysis. *Environ. Manag.* **2004**, *70*, 323–332. [CrossRef] [PubMed]
105. Donlan, C.J.; Tershy, B.R.; Keitt, B.S.; Wood, B.; Sánchez, J.Á.; Weinstein, A.; Croll, D.A.; Hermosillo, M.Á.; Aguilar, J.L. Island conservation action in northwest México. In Proceedings of the Fifth California Islands Symposium, Museum of Natural History, Santa Barbara, CA, USA, 29 March–1 April 1999; pp. 330–338.
106. Green, S.J.; Grosholz, E.D. Functional education as a framework for invasive species control. *Front. Ecol. Environ.* **2021**, *19*, 98–107. [CrossRef]
107. Clarke, M.; Ma, Z.; Snyder, S.A.; Hennes, E.P. Understanding invasive plant management on family forestland: An application of protection motivation theory. *J. Environ Manag.* **2021**, *286*, 112161. [CrossRef] [PubMed]
108. Krajšek, S.S.; Kladnik, A.; Skočir, S.; Bačič, M. Seed germination of invasive *Phytolacca americana* and potentially invasive *P. acinosa*. *Plants* **2023**, *12*, 1052. [CrossRef] [PubMed]
109. Moore, E.; D'Amico, V.; Trammell, T.L.E. Plant community dynamics following non-native shrub removal depend on invasion intensity and forest site characteristics. *Ecosphere* **2023**, *14*, e4351. [CrossRef]
110. Barudanović, S.; Zečić, E.; Macanović, A.; Duraković, B.; Mašić, E. Invasive alien plant species in global perspectives with special references to Bosnia and Herzegovina. In *Invasive Alien Species: Observations and Issues from Around the World*, 1st ed.; Pullaiah, T., Ielmini, M.R., Eds.; John Wiley & Sons Ltd.: New York, NY, USA, 2011; pp. 215–252.
111. Forner, W.G.; Zalba, S.M.; Guadagnin, D.L. Methods for prioritizing invasive plants in protected areas: A systematic review. *Nat. Areas J.* **2022**, *42*, 69–78. [CrossRef] [PubMed]
112. Senator, S.A.; Rozenberg, A.G. Assessment of economic and environmental impact of invasive plant species. *Biol. Bull. Rev.* **2017**, *7*, 273–278. [CrossRef]
113. Lampert, A.; Hastings, A.; Grosholtz, E.D.; Jardine, S.L.; Sanchirico, J.N. Optimal approaches for balancing invasive species eradication and endangered species management. *Science* **2014**, *344*, 1028–1031. [CrossRef] [PubMed]
114. Xie, B.; Han, G.; Qiao, P.; Mei, B.; Wang, Q.; Zhou, Y.; Zhang, A.; Song, W.; Guan, B. Effects of mechanical and chemical control on invasive *Spartina alternifolia* in the Yellow River Delta, China. *PeerJ* **2019**, *7*, e7655. [CrossRef]
115. Simberloff, D.; Keitt, B.; Will, D.; Holmes, N.; Pickett, E.; Genovesi, P. Yes we can! Exciting progress and prospects for controlling invasives on islands and beyond. *West. N. Am. Nat.* **2018**, *78*, 942–958. [CrossRef]

116. Nuñez, M.A.; Chiuffo, M.C.; Torres, A.; Paul, T.; Dimarco, R.D.; Raal, P.; Policelli, N.; Moyano, J.; García, R.A.; van Wilgen, B.W.; et al. Ecology and management of invasive Pinaceae around the world: Progress and challenges. *Biol. Invasions* **2017**, *19*, 3099–3120. [CrossRef]
117. Weidlich, E.W.A.; Flórido, F.G.; Sorrini, T.B.; Brancalion, P.H.S. Controlling invasive plant species in ecological restoration: A global review. *J. Appl. Ecol.* **2020**, *57*, 1806–1817. [CrossRef]
118. Hubert, T.D.; Miller, J.; Burkett, D. A brief introduction to integrated pest management for aquatic systems. *N. Am. J. Fish. Manag.* **2019**, *41*, 264–275. [CrossRef]
119. Havens, K.; Jolls, C.L.; Knight, T.M.; Vitt, P. Risks and rewards: Assessing the effectiveness and safety of classical invasive plant biocontrol by arthropods. *BioScience* **2019**, *69*, 247–258. [CrossRef]
120. Kettenring, K.M.; Adams, C.R. Lessons learned from invasive plant control experiments: A systematic review and meta-analysis. *J. Appl. Ecol.* **2011**, *48*, 970–979. [CrossRef]
121. El-Sayed, A.M.; Suckling, D.M.; Wearing, C.H.; Byers, J.A. Potential of mass trapping for long-term pest management and eradication of invasive species. *J. Econ. Entomol.* **2006**, *99*, 1550–1564. [CrossRef] [PubMed]
122. Tebboth, M.G.L.; Few, R.; Assen, M.; Degefu, M.A. Valuing local perspectives in invasive species management: Moving beyong the ecosystems service-disservice dichotomy. *Ecosyst. Serv.* **2020**, *42*, 101068. [CrossRef]
123. Hess, M.C.M.; Mesléard, F.; Buisson, E. Priority effects: Emerging principles for invasive plant species management. *Ecol. Eng.* **2019**, *127*, 48–57. [CrossRef]
124. Reid, A.M.; Morin, L.; Downey, P.O.; French, K.; Virtue, J.G. Does invasive plant management aid the restoration of natural ecosystems? *Biol. Conserv.* **2009**, *142*, 2342–2349. [CrossRef]
125. Harker, K.; O'Donovan, J. Recent weed control, weed management and integrated weed management. *Weed Technol.* **2013**, *27*, 1–11. [CrossRef]
126. Strayer, D.L. Eight questions about invasions and ecosystem functioning. *Ecol. Lett.* **2012**, *15*, 1199–1210. [CrossRef] [PubMed]
127. Cassini, M.H. A review of the critics of invasion biology. *Ecol. Rev.* **2020**, *95*, 1467–1478. [CrossRef] [PubMed]
128. Larson, D.L.; Phillips-Mao, L.; Quiram, G.; Sharpe, L.; Stark, R.; Sugita, S.; Weiler, A. A framework for sustainable invasive species management: Environmental, social, and economic objectives. *J. Environ. Manag.* **2011**, *92*, 12–22. [CrossRef] [PubMed]
129. Bobul'ská, L.; Čekanová, K.; Demková, L.; Oboňa, J.; Sarvaš, J. Evaluation of the phytoremediation properties of the invasive species Solidago genus. *An. Univ. Craiova Biol. Med. Ştiinţe Agric.* **2018**, *23*, 314–320.
130. Dudek, K.; Michlewicz, M.; Dudek, M.; Tryjanowski, P. Invasive Canadian goldenrod (*Solidago canadensis* L.) as a preferred foraging habitat for spider. *Arthropod-Plant Interact.* **2016**, *10*, 377–381. [CrossRef]
131. Prabakaran, K.; Li, J.; Anandkumar, A.; Leng, Z.; Zou, C.B.; Du, D. Managing environmental contamination through phytoremediation by invasive plants: A review. *Ecol. Eng.* **2019**, *138*, 28–37. [CrossRef]
132. Ruwanza, S.; Shackleton, C.M. Effects of the invasive shrub, Lantana camara, on soil properties in the Eastern Cape, South Africa. *Weed Biol. Manag.* **2016**, *16*, 67–79. [CrossRef]
133. Jo, I.; Fridley, J.D.; Frank, D.A. Invasive plants accelerate nitrogen cycling: Evidence from experimental woody monocultures. *J. Ecol.* **2017**, *105*, 1105–1110. [CrossRef]
134. Dyderski, M.K.; Jagodziński, A.M. Functional traits of acquisitive invasive woody species differ from conservative invasive and native species. *NeoBiota* **2019**, *41*, 91–113. [CrossRef]
135. Mathakutha, R.; Steyn, C.; Roux, P.C.; Blom, I.J.; Chown, S.L.; Daru, B.H.; Ripley, B.S.; Louw, A.; Greve, M. Invasive species differ in key functional traits from native and non-invasive alien plant species. *J. Veg. Sci.* **2019**, *30*, 994–1006. [CrossRef]
136. Ye, X.Q.; Yan, Y.N.; Wu, M.; Yu, F. High capacity of nutrient accumulation by invasive *Solidago canadensis* in a coastal grassland. *Front. Plant Sci.* **2019**, *10*, 575. [CrossRef]
137. Denley, D.; Metaxas, A.; Fennel, K. Community composition influences the population growth and ecological impact of invasive species in response to climate changes. *Oecologia* **2019**, *189*, 537–548. [CrossRef] [PubMed]
138. Braun, K.; Collantes, M.B.; Yahdjian, L.; Escartin, C.; Anchorena, J.A. Increased litter decomposition rates of exotic invasive species *Hieracium pilosella* (*Asteraceae*) in Southern Patagonia, Argentina. *Plant Ecol.* **2019**, *220*, 393–403. [CrossRef]
139. Zeng, A.; Hu, W.; Zeng, C.; Sun, Z.; Gao, D. Litter decomposition and nutrient dynamics of native species (*Cyperus malaccensis*) and alien invasive species (*Spartina alternifolia*) in a typical subtropical estuary (Min river) in China. *Estuaries Coast* **2020**, *43*, 1873–1883. [CrossRef]
140. Dassonville, N.; Vanderhoeven, S.; Vanparys, V.; Hayez, M.; Gruber, W.; Meerts, P. Impacts of alien invasive plant on soil nutrients are correlated with initial site conditions in NW Europe. *Oecologia* **2008**, *157*, 131–140. [CrossRef] [PubMed]
141. Wagh, V.V.; Jain, A.K. Status of ethnobotanical invasive plants in western Madhya Pradesh, India. *S. Afr. J Bot.* **2018**, *114*, 171–180. [CrossRef]
142. Pétilon, J.; Ysner, F.; Canard, A.; Lefeuvne, L.C. Impact of an invasive plant (*Elymus athericus*) on the conservation value of tidal salt marshes in western France and implication for management: Responses of spider population. *Biol. Conserv.* **2005**, *126*, 103–117. [CrossRef]

143. Nguyen, D.T.; Tran, T.V.; Kumar, P.S.; Din, A.T.M.; Jalil, A.A.; Vo, D.N. Invasive plants as biosorbents for environmental remediation: A review. *Environ. Chem. Lett.* **2022**, *20*, 1421–1451. [CrossRef]
144. Mustafa, H.M.; Hayder, G. Recent studies in applications of aquatic weed plants in phytoremediation of wastewater: A review article. *Ain Shams Eng. J.* **2021**, *12*, 355–365. [CrossRef]
145. Yousaf, B.; Liu, G.; Abbas, Q.; Ali, M.U.; Wang, R.; Ahmed, R.; Wang, C.; Al-Wabel, M.I.; Usman, A.R.A. Operational control on environmental safety of potentially toxic elements during thermal conversion of metal-accumulator invasive ragweed to biochar. *J. Clean. Prod.* **2018**, *195*, 458–469. [CrossRef]
146. Odoh, C.K.; Zabbey, N.; Sam, K.; Eze, C.N. Status, progress and challenges of phytoremediation—An African scenario. *J. Environ. Manag.* **2019**, *237*, 365–378. [CrossRef] [PubMed]
147. Chaney, R.L.; Malik, M.; Li, Y.M.; Brown, S.L.; Brewer, E.P.; Angle, J.S.; Baker, A.J.M. Phytoremediation of soil metals. *Curr. Opin. Biotechnol.* **1997**, *8*, 279–284. [CrossRef] [PubMed]
148. Davarnejad, R.; Azizi, A.; Mohammadi, M.; Mansoori, S. A green technique for synthesizing iron nanoparticles by extract of centaurea cyanus plant: An optimized adsorption process for methylene blue. *Int. J. Environ. Anal Chem.* **2022**, *102*, 2379–2393. [CrossRef]
149. Al-Musawi, T.J.; Mengelizadeh, N.; Taghavi, M.; Mohebi, S.; Balarak, D. Activated carbon derived from *Azolla filiculoides* fern: A high-adsorption-capacity adsorbent for residual ampicillin in pharmaceutical wastewater. *Biomass Convers. Biorefin.* **2021**, *13*, 12179–12191. [CrossRef] [PubMed]
150. Feng, Q.; Wang, B.; Chen, M.; Wu, P.; Lee, X.; Xing, Y. Invasive planrs as potential sustainable feedstocks for biochar production and multiple applications: A review. *Resour. Conserv. Recycl.* **2021**, *164*, 105204. [CrossRef]
151. Yang, J.; Xu, P.; Xia, Y.; Chen, B. Multifunctional carbon aerogels from *Typha orientalis* for oil/water separation and simultaneous removal of oil-soluble pollutants. *Cellulose* **2018**, *25*, 5863–5875. [CrossRef]
152. Flax, B.; Bower, A.H.; Wagner-Graham, M.A.; Bright, M.; Cooper, I.; Nguyen, W.; Nunez, H.; Purdy, B.; Wahba, N.; Savage, T.; et al. Natural dyes from three invasive plant species in The United States. *J. Nat. Fibers* **2022**, *19*, 10964–10978. [CrossRef]
153. Huang, X.; Wan, Y.; Shi, B.; Shi, J.; Chen, H.; Liang, H. Characterization and application of poly-ferric-tittanium-silicate-sulfate in disperse and reactive dye wastewaters treatment. *Chemosphere* **2020**, *249*, 126129. [CrossRef] [PubMed]
154. Hebeish, A.; Shahin, A.A.; Ragheb, A.A. New environment-friendly approach for textile printing using natural dye loaded chitosan nanoparticles. *Egypt. J. Chem.* **2015**, *58*, 659–670.
155. Klančnik, M. printing with natural dye extracted from *Impatiens grandulifera* Royle. *Coatings* **2021**, *11*, 445. [CrossRef]
156. Domingcil, K.; Lin, S.H. Natural dyes and the sustainable environment from invasive plants. *J. Hwa Gang Text.* **2017**, *24*, 406–418.
157. Devi, S.; Karuppan, P. Reddish brown pigments from *Alternaria alternata* for textile dyeing and printing. *Indian J. Fibre Text. Res.* **2015**, *40*, 315–319.
158. Máximo, P.; Ferreira, L.M.; Branco, P.S.; Lourenço, A. Invasive plants: Turning enemies into value. *Molecules* **2020**, *25*, 3529. [CrossRef]
159. Gaspar, M.C.; Fronseca, D.A.; Antunes, M.J.; Frigerio, C.; Gomes, N.G.M.; Vieira, M.; Santos, A.E.; Cruz, M.T.; Cotrim, M.D.; Campos, M.G. Polyphenolic characterization and bioactivity of an *Oxalis pes-caprae* L. leaf extract. *Nat. Prod. Res.* **2018**, *32*, 732–738. [CrossRef]
160. Meddeb, E.; Charni, M.; Ghazouani, T.; Cozzolino, A.; Frantianni, F.; Raboudi, F.; Nazzaro, F.; Fattouch, S. Biochemical and molecular study of carpobrotus edulis bioactive properties and their effects on *Dugresia sicula* (turbellaria, tricladida) regeneration. *Appl. Biochem. Biotechnol.* **2017**, *182*, 1131–1143. [CrossRef] [PubMed]
161. Hafsa, J.; Hammi, K.M.; Ben Khedher, M.R.; Smach, M.A.; Charfeddine, B.; Limem, K.; Majdoub, H. Inhibition of protein glycation, antioxidant and antiproliferative activities of *Carpobrotus edulis* extracts. *Biomed. Pharmacother.* **2016**, *84*, 1496–1503. [CrossRef]
162. Madureira, A.M.; Duarte, A.; Teixeira, G. Antimicrobial activity of selected extracts from *Hakea salicifolia* and *H. sericeae* (Proteaceae) against *Staphylococcus aureus* multiresistant strains. *S. Afr. J. Bot.* **2012**, *81*, 40–43. [CrossRef]
163. Gruľová, D.; Baranová, B.; Ivanova, V.; DeMartino, L.; Manchini, E.; De Feo, V. Composition and bio activity of essential oils of *Solidago* spp. and their impact on radish and garden cress. *Allelopathy J.* **2016**, *39*, 129–142.
164. Barney, J.N.; Hay, A.G.; Weston, L.A. Isolation and characterization of allelopathic volatiles from mugwort (*Artemisia vulgaris*). *J. Agric. Food Chem.* **2005**, *53*, 247–265. [CrossRef]
165. Gruľová, D.; Krausová, P.; Demková, L.; Bobuľská, L.; Sedlák, V.; Konečná, M.; Mydlárová Blaščáková, M.; Poráčová, J. Comparison of the quality and quantity of *Solidago canadensis* L. essential oil and its allelopatic activity from three localities in dependence to the distance to industrial park. *Biodiv. Environ.* **2020**, *12*, 51–65.
166. Ding, L.J.; Ding, W.; Zhang, Y.Q.; Luo, J.X. Bioguided fractionation and isolation of esculentoside p from *Phytolacca americana* L. *Ind. Crop Prod.* **2013**, *44*, 534–541. [CrossRef]
167. Yu, Y.; Cheng, H.; Wei, M.; Wang, S.; Wang, C. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. *An. Acad. Bras. Cienc.* **2022**, *94*, e20201661. [CrossRef]

168. Nguyen, D.T.C.; Tran, T.V.; Nguyen, T.T.T.; Nguyen, D.H.; Alhassan, M.; Lee, T. New frontiers of invasive plants for biosynthesis of nanoparticles towards biomedical applications: A review. *Sci. Total Environ.* **2023**, *857*, 159278. [CrossRef] [PubMed]
169. Stout, J.C.; Tiedeken, E.J. Direct interactions between invasive plants and native pollinators: Evidence, impacts and approaches. *Func. Ecol.* **2017**, *31*, 38–46. [CrossRef]
170. Gonzáles-Varo, J.P.; Biesmeijer, J.C.; Bommarco, R.; Potts, S.G.; Schweiger, O.; Smith, H.G.; Steffan-Dewenter, I.; Szentgyörgyi, H.; Woyciechowski, M.; Vilà, M. Combined effects of global change pressures on animal-mediated pollination. *Trends Ecol. Evol.* **2013**, *28*, 524–530. [CrossRef] [PubMed]
171. Stout, J.C.; Morales, C.L. Ecological impacts of invasive alien species on bees. *Apidologie* **2009**, *40*, 388–409. [CrossRef]
172. Drossart, M.; Michez, D.; Vanderplanck, M. Invasive plants as potential food resource for native pollinators: A case study with two invasive species and a generalist bumble bee. *Sci. Rep.* **2017**, *7*, 16242. [CrossRef] [PubMed]
173. Russo, L.; de Keyzer, C.W.; Harmon-Threatt, A.N.; LeCroy, K.A.; MacIvor, J.S. The managed-to-invasive species continuum in social and solitary bees and impacts on native bee conservation. *Curr. Opin. Insect Sci.* **2021**, *46*, 43–49. [CrossRef]
174. Jakobsson, A.; Padrón, B. Does the invasive *Lupinus polyphyllus* increase pollinator visitation to a native herb through effects on pollinator population sizes? *Oecologia* **2014**, *174*, 217–226. [CrossRef] [PubMed]
175. Brown, B.J.; Mitchell, R.J. Competition for pollination: Effects on pollen of an invasive plant on seed set of a native congener. *Oecologia* **2001**, *129*, 43–49. [CrossRef]
176. Koyama, A.; Egawa, C.; Taki, H.; Yasuda, M.; Kanzaki, N.; Ide, T.; Okabe, K. Non-native plants are seasonal pollen source for native honeybees in suburban ecosystems. *Urban Ecosyst.* **2018**, *21*, 1113–1122. [CrossRef]
177. Diaz-Betancourt, M.; Ghermandi, L.; Rapoport, E.H. Weed as a source for human consumption. A comparison between tropical and temperate Latin America. *Rev. Biol. Trop.* **1999**, *47*, 329–338. [CrossRef]
178. Nuñez, M.A.; Kuebbing, S.; Dimarco, R.D.; Simberloff, D. Invasive species: To eat or not to eat, that is the question. *Conserv. Lett.* **2012**, *5*, 327–406. [CrossRef]
179. Mihaly, C.; Heavenrich, S. *Diet for a Changing Climate: Food for Thought*, 1st ed.; Twenty-First Century Books: Minneapolis, MN, USA, 2019; 128p.
180. Feng, J.; Leone, J.; Schweig, S.; Zhang, Y. Evaluation of natural and botanical medicines for activity against growing and non-growing forms of *B. burgdorferi*. *Front. Med.* **2020**, *7*, 6. [CrossRef]
181. Lachowicz, S.; Oszmiański, J. Profile of bioactive compounds in the morphological parts of wild *Fallopia japonica* (Houtt) and *Fallopia sachalinensis* (F. Schmidt) and their antioxidative activity. *Molecules* **2019**, *24*, 1436. [CrossRef] [PubMed]