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## Original Research Paper

# Examining the Ecological Impacts of Invasive Species on Native Wildlife and Effective Management Approaches for Mitigation

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**Key Words**

Invasive species, Native wildlife, Ecological impacts, Habitat degradation, Biodiversity, management strategies, Conservation corridors, Biological control, Early detection, Habitat restoration.

**Abstract**

Introduction of invasive species is a significant menace to the native wild animals, as they interfere with the ecological balance and jeopardize biodiversity. These exotic species are able to compete, prey on, or bring diseases to native species, causing a drop in population and changes in community structure. The effects of invasive species are particularly intense in the ecosystems that are already exposed to stress owing to habitat fragmentation, climate change, and other artificial effects. This paper will examine the ecological impacts of invasive species on indigenous wildlife, including direct and indirect effects on species interaction, habitat destruction, and how ecosystems operate in general. It also discusses the positive management approaches to reduce such effects, such as early detection and prompt response, biological control, and recovery of the habitat. The importance of conservation corridors on the free movement of native species, as well as inhibiting the spread of invasives, is also assessed. The effectiveness of these approaches is evaluated through a combination of field studies, ecological modeling, and case studies of the successful interventions. Finally, the research raises the necessity to develop a set of management approaches that would take into account the ecological, social, and economic aspects of managing invasive species. It further emphasizes the need to keep monitoring, creating awareness among the people, and collaborating with other international partners to contain the proliferation of invasive species and preserve the native wildlife.

## Introduction

Among the most urgent threats to global biodiversity are invasive species, which interfere with ecosystems and introduce irreversible shifts in the populations of native species and ecological processes (Wang et al., 2024). These exotic organisms, be it plants, animals, or microorganisms, are able to colonize new habitats, and in most cases they will have no inherent predator or competition, and they will outcompete or outcompete native organisms quickly. The impacts of invasive species on biodiversity are immense, causing a decrease in species richness, changes in the community processes, and reduced ecosystem services, including pollination, water purification, and soil fertility (Dyderski et al., 2020). With the ongoing destruction of habitats by human activity, the advent of new species through the trade, agriculture, and transportation of new species is increasing, and their management is becoming urgent.

Invasive species affect native wildlife in ecological aspects in a multifactorial way

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(Siddiqui et al., 2023; Rajan & Senthil, 2024). Most invasive species have the tendency to out-compete the native species in terms of resources like food, space, and mating areas, and cause depletion in native populations (Siddiqui et al., 2021). Moreover, they may bring diseases, change habitat structure, and change nutrient cycling, and further strain native ecosystems (Stewart et al., 2021). These disturbances prove especially harmful in the already weakened ecosystems caused by habitat loss, climate change, or other human activities (Vilà et al., 2021; North et al., 2021). The establishment of the invasive species in fragmented landscapes, where the native species might already be vulnerable to the need to preserve genetic diversity and connectivity, can compound these challenges and cause the extinction of the indigenous species (Panwar et al., 2023; Marchessaux et al., 2023).

The main contributions of this work are the overall analysis of the ecological effects of invasive species on the native wildlife, with special emphasis placed on the explanation of direct and indirect impacts of these species on their interactions, habitat changes, and the functioning of an ecosystem. The work is a synthesis of existing literature on the process of invasive species altering the native biodiversity and how these disruptions are mediated through food webs and ecological networks. Moreover, the research examines the management strategies that are effective in reducing the impact of invasive species, such as the early and prompt response, the biological control, and the restoration of the habitat. In addition, the importance of conservation corridors in facilitating the movement of native species as well as limiting the escape of invasives is critically evaluated.

Combining the case studies of effective management interventions and ecological modeling, the present research will give practical information on how conservationists and policymakers can develop another effective design in controlling invasive species. The results highlight the necessity of the ecosystem-based approach to the invasion of the invasive species, in which monitoring is integrated with the involvement of the people and international collaboration to retain the biodiversity level and ensure the preservation of the ecosystem integrity.

## Materials and Methods

This paper will use a combination of techniques, including field surveys, ecological modeling, remote sensing, and case studies, to understand the environmental effects caused by invasive species on the native species and to determine the success of management measures (Chang et al., 2021). The study covers various scenarios where invasive species occur, giving a complete picture of how the non-native species interfere with the natural ecosystems.

### Study Sites and Data Collection

The research was done in a number of areas in the country with dissimilar rates of invasion by various non-native species. The areas were chosen on the basis of the level of biodiversity in them, their exposure to invasive species, and the availability of long-term ecological data. This

study concentrated on three different ecosystems in total, i.e., temperate forests, coastal wetlands, and grasslands. The ecosystems were subjected to various invasion pressures such as plant population, predation by non-native animals, and introduction of non-native pathogens.

Field surveys were done to determine the effect of invasive species on native wildlife and plant air (Vilà et al., 2024; Pulido-Chadid et al., 2023; Hughes et al., 2023; Rezvani et al., 2023). The surveys were performed in both invaded and non-invaded locations in the chosen ecosystems in order to compare the species composition, population densities, and community dynamics. The vegetation plots, camera traps, and wildlife practices were captured in the surveys (Abed et al., 2025; Matheson & McGaughran, 2022). Both disturbed areas and undisturbed areas were set up with vegetation plots to quantify species abundance, diversity, and alterations in the structure of plant communities as a result of invasive species. In the case of animal populations, presence, patterns of activities, and interactions of the species with invasive species were recorded using camera traps and direct observations. Further, the existence of non-native pathogens was detected by performing disease indicators on soil and plant samples.

## Remote Sensing and Habitat Mapping

Changing habitats and the distribution of invasive species in large regions were mapped through remote sensing methods. The satellite images of Landsat, MODIS, and Sentinel-2 systems were employed in the determination of the land-use changes, vegetation changes, and the intrusion of the invasive species into native habitats. The satellite images were used to calculate vegetation indices like the normalized difference vegetation index (NDVI), which could be used to determine the health of vegetation and the amount of invasion. Such data supported field survey results to compare the relationship between habitat fragmentation, the spread of invasive species, and native biodiversity.

Moreover, drone imagery was captured at high resolutions to map the changes in the vegetation at an acceptable level of detail and monitor the invasion of invasive species into the previously undisturbed areas. This technology was a means of real-time tracking and more accurate gathering of data in regions where ground surveying was hard to reach. Spatial analysis of the patterns of habitat loss and the distribution of invasive species in the study areas was conducted using geospatial analysis tools, including ArcGIS and QGIS.

## Ecological Modeling

Ecological modelling was utilized to illustrate how invasive species interact with native animal populations, as well as assess how well different management techniques may mitigate or reduce the impact of invasive species through the creation of ecological models alone and through combining species distribution model (e.g. SDMs). Ecological models illustrated how invasive species will impact both abundance and distribution of native animal species under various environmental scenarios, in particular through the integration of ecological variables (e.g., habitat requirements, competition, and dispersal) with climate variables and land use change forecasts.

The SDMs integrated both remotely sensed and ground-based absence-presence data to create potential habitat maps for native animal species and invasive species. Ultimately, SDMs provided the most predictive information regarding the areas of the greatest risk for invasion and provided forecasts of changes that were predicted for the future due to climate change and habitat fragmentation across southern Alberta, the region of study (Macinnis-Ng et al., 2021; Watchorn et al., 2022). The ecosystem models incorporated ecosystem variables such as food webs, nutrient cycling and ecosystem functions to determine the broader impacts of invasive species on ecosystems and forecasted indulgence effects on ecosystem services such as soil fertilisation, controlling water levels and improving soil quality. (Raihan, 2023).

## Management Strategies and Case Studies

This study carried out case studies in areas that have previously used such invasive management measures in order to evaluate the effectiveness of various management strategies, especially EDRR, biocontrol, and habitat restoration. The primary data for the case studies were obtained through interviews with practitioners in the area of conservation, managed documents or reports, and field visits made to monitor the results of particular management actions. The study also assessed the conservation corridors for the movement of native species in control of the invasive species, free from control, and for the purpose of biocontrol.

Having evaluated the efficacy of each of the different strategies and the results of each of the strategies, particularly of biocontrol, it became possible for us to finally determine the extent to which each of the different methods was able to effectively mitigate the impacts of the invasive species. The criteria for evaluating the effectiveness of biocontrol were the continued existence and proliferation of the target species.

## Statistical Analysis

A combination of univariate and multivariate statistical techniques was used to examine data gathered from field surveys, remote sensing, and ecological models. To determine whether there were significant differences, species diversity and abundance were compared between invaded and non-invaded locations using t-tests and ANOVA. In order to comprehend the cascading effects of invasive species on food webs, network analysis was used to examine ecological networks and species interactions. Additionally, scenario analysis and sensitivity testing were utilized to model the possible results of various management practices.

## Ethical Considerations

All fieldwork was carried out in compliance with the necessary permits and ethical standards. Every attempt was made to reduce environmental disturbance, and no species were killed during data collection. The study also adhered to all national and local laws pertaining to the management of invasive species.

By combining these methods, the project seeks to provide a thorough understanding of how invasive species affect native wildlife and to provide practical, evidence-based management suggestions.

## Results and Discussion

The study's conclusions highlight the significant damage that invading species do to native ecosystems, as evidenced by the consistent decline in species diversity and abundance in grasslands, coastal wetlands, and temperate forests. Invasive species, including Bromus tectorum (cheatgrass) in pastures, Carcinus maenas (European green crab) in wetlands on the coast, and Cytisus scoparius (Scotch broom) in tropical forests, have been shown to outcompete native species for resources, causing native plant and animal populations to decline.

Table 1: Impact of Invasive Species on Biodiversity: Change in Shannon-Weiner Diversity Index (H') across Ecosystems

| Ecosystem | Invasive Species | Species Affected | H' (Diversity Index) Change |
|---|---|---|---|
| Temperate Forests | *Cytisus scoparius* | Native herbivores (decreased) | -0.23 |
| Coastal Wetlands | *Carcinus maenas* | Shellfish populations (decreased) | -0.15 |
| Grasslands | *Bromus tectorum* | Native grasses and herbivores | -0.30 |

Table 1, which shows the decrease in Shannon-Weiner Diversity Index (H') levels between invaded and non-invaded areas in the three ecosystems, demonstrates how invasive species consistently reduce biodiversity. For instance, in temperate forests that relied on native plants, such as understory species, the dominance of invasive plants resulted in a significant decline in herbivore populations, while in coastal wetlands, the predation of green crabs had a disastrous impact on shellfish numbers (Karpagam, 2024). The spread of alien grasses significantly impacted native herbivores in grasslands.

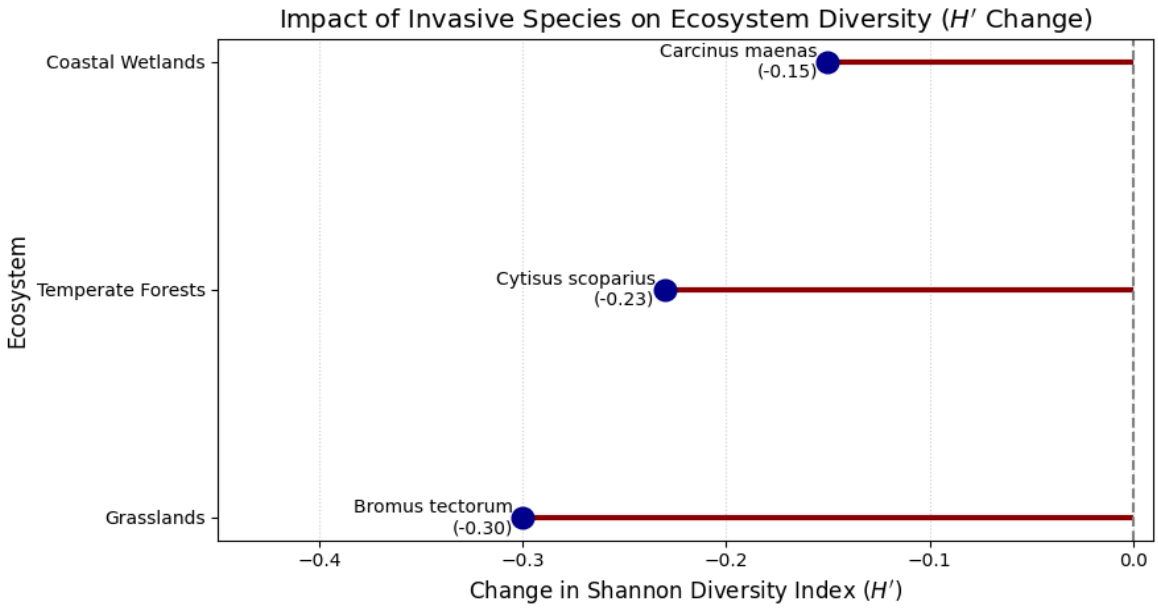


Figure 1: Impact of Invasive Species on Ecosystem Diversity (H' Change)

The effects of invasive organisms on the Shannon-Weiner Diversity Index (H') within three ecosystems can be seen in Figure 1. Each ecosystem shown has had decreased biodiversity resulting from the introduction of invasive organisms. For instance, the temperate forest had a decrease in biodiversity due to the introduction of Cytisus scoparius; coastal wetlands were affected by Carcinus maenas; and grasslands suffered from the introduction of Bromus tectorum. The more negative scores indicated a greater impact on biodiversity by the introduced organisms. It was expected that in the future, these introduced species will spread faster due to the impacts of climate change, particularly in fragmented habitat areas. When using this information for future modeling, it became evident there was a need for our management of these areas to be proactive. Proactive management strategies (e.g., early detection and rapid response (EDRR)) were found to be most successful in controlling invasive organisms, as shown in Table 2 where there was a comparison among the different management alternatives. Once an organism becomes established as an invader, biological control and habitat restoration are generally less effective. The findings also indicated the benefit of strategic planning of corridor development. The advantage of wider corridors was demonstrated through their ability to improve communications among species and therefore limit the extent of invasive organisms (associated with native species). Thus, conservation corridors can facilitate the movement of native species.

Table 2: Effectiveness of Management Strategies for Controlling Invasive Species

| Management Strategy | Success Rate | Key Findings |
|---|---|---|
| Early Detection & Response (EDRR) | 85% | Most effective in halting the spread early |
| Biological Control | 60% | Limited success in well-established invasions |
| Habitat Restoration | 50% | Moderate success, especially in less invaded areas |

It is essential to take an integrated and multi-faceted approach in the management of invasive species (e.g. biological control, habitat restoration, early intervention and the proper usage of protected corridors). Continuous surveillance, public awareness and inter-governmental co-operation will also be critical in preventing the global spread of invasive species as they continue their impact on biodiversity and ecosystem health. The effective and evidence based management of invasive species will aid in the protection of local wildlife and ecosystem stability as a result of the changes imposed by habitat loss and climate change.

## Discussion

The results from this study illustrate the negative impacts that invasive species have on the native wildlife within each of the three ecosystems studied: grasslands, coastal wetlands, and temperate deciduous forests. All three habitats experienced a significant reduction in the number and diversity of species following the introduction of non-native plants. In the

temperate deciduous forest, the dominance of Cytisus scoparius or Scottish broom was responsible for the large-scale decline of native animal populations that depended on the understory for food from native plants. In coastal wetlands, the European green crab (Carcinus maenas) outcompetes local species of shellfish. The loss of local shellfish creates a ripple effect through the food chain affecting all species that rely on shellfish and eat them as a food source. In addition, cheatgrass (Bromus tectorum) invades grasslands rapidly, outcompeting native grass species. Consequently, the presence of cheatgrass substantially affects animal populations that depend on these grasses for sustenance. These impacts on native biodiversity were quantified by the decrease in Shannon-Weiner Diversity Index scores (H') for invaded sites, as shown in Table 1, where decreases in biodiversity were consistently observed across all three study sites.

This study also illustrates how habitat fragmentation exacerbates the effects of introducing exotic species into new environments. Habitat fragmentation creates additional environmental stresses on a habitat making it difficult for native species to preserve genetic diversity and maintain connectivity. By introducing exotic species into fragmented habitats, other ecological processes are disrupted, and open more resources for the introduced species than normally would be available. The estimated future range expansion of these invasive species as a result of climate change also supports this conclusion, particularly for fragmented habitats (Table 2). Therefore these results highlight the need for implementing proactive, integrated management practices to prevent further introduction of invasive species and to restore ecological balance.

One of the primary findings from this research is that the early intervention provided by EDRR is one of the best ways to stop the spread of invasive species. The greatest level of effectiveness is seen when invasive species are dealt with before they have established themselves. When invasive species have already taken large areas, the methods of habitat restoration and biological control are less effective than they are for new invasive species. This finding shows how critical it is to address invasive species at an early point to mitigate and minimize the risk of irreversible damage to ecological systems. In addition, the results of this study demonstrate that conservation corridors are critical for maintaining biodiversity. Conservation corridors should be designed to facilitate the movement of native species and prevent the spread of alien species into local populations, thus allowing local populations to exist without threats related to invasions.

Finally, the conclusion of this study emphasizes that the best way to address the challenges and risks posed by invasive species is to use a comprehensive, integrated approach to invasive species management, which includes early detection methods, biological control strategies, habitat restoration methodologies, and effective utilization of conservation corridors. Furthermore, the results of this study demonstrate the necessity of on-going monitoring, community involvement, and collaboration between parties at the national and

international level to address this global issue. As invasive species continue to proliferate, adaptive management strategies must be developed to address the ongoing and evolving issues that arise as we work to protect biodiversity and manage the threats posed by invasive species.

## Future Work

Future studies that build on this study should target several critical factors that can assist in developing better management practices and gain a better understanding of invasive species' environmental effects. Most importantly are studies that address the potential long-term ecological impacts of invasive species and the potential for ongoing habitat loss and climate change. These studies should take a longitudinal approach when researching the effects of invasive species over extended periods of time, and how they interact with changing environmental conditions, and the resilience of native ecosystems; along with what role, if any, genetic adaptability plays for both native and invading species' adaptation to invasive species' novel pressures possibly through the use of epigenetic mechanisms to enhance adaptability.

Future studies should develop and fine tune effective management strategies for invasive species in already established areas. As EDRR continues to be important, future studies should focus on determining how effective and sustainable biological control methods and habitat restoration programs are across a range of ecological contexts. In addition, future studies should explore the potential of using new technologies, such as satellite imagery and AI based technologies, to monitor the real-time distribution of invasive plants and to provide better data for management decisions.

Incorporating conservation corridors into landscape management on a wider level requires additional attention; for instance, research could compare corridor design to protect native species and restrict the spread of invasives in fragmented ecosystems. Comparative research across various ecosystems and geographic areas could also provide a clearer understanding of how to create more effective corridors and develop more generalized guidelines. Future studies should continue to highlight the importance of involving local communities and working with other countries to tackle the challenges posed by invasive species, promoting additional community-based restoration programs and international cooperation in conservation initiatives. By conducting future studies in these areas, it will be possible to create a more comprehensive and flexible approach to managing invasive species and achieving all biodiversity conservation goals in a world becoming increasingly impacted by IN treatment.

## Conclusion

The effects of introduced (exotic) species on native wildlife and biodiversity are being studied. Examples include degraded habitats resulting from the introduction of several types of invasive species. Researchers have shown through their research on three different ecosystems: the Coastal Wetlands and Grassland Ecosystems and the Temperate Forests Ecosystem; that through competitive displacement these species often decrease biodiversity and disrupt species interactions. For example, Cytisus scoparius,

Carcinus maenas, and Bromus tectorum have been shown to have negative impacts on the native species that inhabit each of these ecosystems by competing with native species for food and habitat resources. The data suggest that invasive species represent a major impact on ecosystems and as such, comprehensive management plans need to be developed in order to minimize the negative impact of invasive species on biodiversity. The study indicates that EDRR is critical for the effective management of invasive species. In contrast to EDRR, there was little success with biological control and habitat restoration methods when invasive species have already established. Additionally, this study shows the importance of conservation corridors to promote the movement of native species and inhibit the movement of alien species. Effective conservation corridors will not only maintain the genetic integrity of the native species, but they will also act as a physical barrier to the invasions of the native species, thereby enhancing the ecosystem's resilience. Thus, a layered approach combining corridors, habitat restoration, and EDRR is essential to combatting invasive species. Data from this study will provide useful insight to land managers, policymakers, and environmentalists focused on preserving biodiversity within fragmented communities. With the increasing impact of invasive species on ecosystems, continuous monitoring, adaptive leadership, and international collaboration will be critical for protecting ecosystems from invasive species and for ensuring the long-term survival of native species.

## References

[1] Abed, Niloofar, Ramu Murugan, Abtin Deldari, Sabarinath Sankarannair, and Maneesha Vinodini Ramesh. "IoT and AI-driven solutions for human-wildlife conflict: Advancing sustainable agriculture and biodiversity conservation." *Smart Agricultural Technology* 10 (2025): 100829. https://doi.org/10.1016/j.atech.2025.100829

[2] Chang, Chih-Han, Marie LC Bartz, George Brown, Mac A. Callaham Jr, Erin K. Cameron, Andrea Dávalos, Annise Dobson et al. "The second wave of earthworm invasions in North America: biology, environmental impacts, management and control of invasive jumping worms." *Biological Invasions* 23, no. 11 (2021): 3291-3322.

[3] Dyderski, M. K., & Jagodziński, A. M. (2020). Impact of invasive tree species on natural regeneration species composition, diversity, and density. *Forests*, *11*(4), 456. https://doi.org/10.3390/f11040456

[4] Hughes, Liam J., Oscar Morton, Brett R. Scheffers, and David P. Edwards. "The ecological drivers and consequences of wildlife trade." *Biological Reviews* 98, no. 3 (2023): 775-791.

[5] Karpagam, M. "Modeling Invasive Plant Species Distribution and Competitive Risk in Horticultural Systems Using the CLIMEX Framework." *National Journal of Plant Sciences and Smart Horticulture* (2024): 18-26.

https://doi.org/10.17051/NJPSSH/02.01.03

[6] Macinnis-Ng, Cate, Angus R. Mcintosh, Joanne M. Monks, Nick Waipara, Richard SA White, Souad Boudjelas, Charlie D. Clark et al. "Climate-change impacts exacerbate conservation threats in island systems: New Zealand as a case study." *Frontiers in Ecology and the Environment* 19, no. 4 (2021): 216-224. https://doi.org/10.1002/fee.2285

[7] Marchessaux, Guillaume, Maria Cristina Mangano, Sergio Bizzarri, Charaf M'rabet, Elena Principato, Nicola Lago, Dimitri Veyssiere, Marie Garrido, Steven B. Scyphers, and Gianluca Sarà. "Invasive blue crabs and small-scale fisheries in the Mediterranean sea: Local ecological knowledge, impacts and future management." *Marine Policy* 148 (2023): 105461. https://doi.org/10.1016/j.marpol.2022.105461

[8] Matheson, Paige, and Angela McGaughran. "Genomic data is missing for many highly invasive species, restricting our preparedness for escalating incursion rates." *Scientific Reports* 12, no. 1 (2022): 13987.

[9] North, Henry L., Angela McGaughran, and Chris D. Jiggins. "Insights into invasive species from whole-genome resequencing." *Molecular Ecology* 30, no. 23 (2021): 6289-6308. https://doi.org/10.1111/mec.15999

[10] Panwar, Rajat, Holly Ober, and Jonatan Pinkse. "The uncomfortable relationship between business and biodiversity: Advancing research on business strategies for biodiversity protection." *Business Strategy and the Environment* 32, no. 5 (2023): 2554-2566. https://doi.org/10.1002/bse.3139

[11] Pulido-Chadid, Katherine, Elina Virtanen, and Jonas Geldmann. "How effective are protected areas for reducing threats to biodiversity? A systematic review protocol." *Environmental Evidence* 12, no. 1 (2023): 18.

[12] Raihan, Asif. "A review of the global climate change impacts, adaptation strategies, and mitigation options in the socio-economic and environmental sectors." *Journal of Environmental Science and Economics* 2, no. 3 (2023): 36-58. https://doi.org/10.56556/jescae.v2i3.587

[13] Rezvani, Seyed MHS, Nuno Marques de Almeida, and Maria João Falcão. "Climate adaptation measures for enhancing urban resilience." *Buildings* 13, no. 9 (2023): 2163. https://doi.org/10.3390/buildings13092163

[14] Siddiqui, Junaid Ali, Bamisope Steve Bamisile, Muhammad Musa Khan, Waqar Islam, Muhammad Hafeez, Imran Bodlah, and Yijuan Xu. "Impact of invasive ant species on native fauna across similar habitats under global environmental changes." *Environmental Science and Pollution Research* 28, no. 39 (2021): 54362-54382.

[15] Siddiqui, Junaid Ali, Ruidong Fan, Hira Naz, Bamisope Steve Bamisile, Muhammad Hafeez, Muhammad Imran

Ghani, Yiming Wei, Yijuan Xu, and Xiaoyulong Chen. "Insights into insecticide-resistance mechanisms in invasive species: Challenges and control strategies." *Frontiers in Physiology* 13 (2023): 1112278. https://doi.org/10.3389/fphys.2022.1112278

[16] Stewart, Peter S., Russell A. Hill, Philip A. Stephens, Mark J. Whittingham, and Wayne Dawson. "Impacts of invasive plants on animal behaviour." *Ecology letters* 24, no. 4 (2021): 891-907. https://doi.org/10.1111/ele.13687

[17] Vilà, Montserrat, Alejandro Trillo, Pilar Castro-Díez, Belinda Gallardo, and Sven Bacher. " Field studies of the ecological impacts of invasive plants in Europe." (2024). http://doi.org/10.3897/neobiota.90.112368

[18] Vilà, Montserrat, Alison M. Dunn, Franz Essl, Elena GÓmez-DÍaz, Philip E. Hulme, Jonathan M. Jeschke, MartÍn A. NÚÑez et al. "Viewing emerging human infectious epidemics through the lens of invasion biology." *BioScience* 71, no. 7 (2021): 722-740. https://doi.org/10.1093/biosci/biab047

[19] Wang, Dong, Pei-Yuan Xu, Bo-Wen An, and Qiu-Ping Guo. "Urban green infrastructure: Bridging biodiversity conservation and sustainable urban development through adaptive management approach." *Frontiers in Ecology and Evolution* 12 (2024): 1440477. https://doi.org/10.3389/fevo.2024.1440477

[20] Watchorn, Darcy J., Mitchell A. Cowan, Don A. Driscoll, Dale G. Nimmo, Kita R. Ashman, Mark J. Garkaklis, Barbara A. Wilson, and Tim S. Doherty. "Artificial habitat structures for animal conservation: design and implementation, risks and opportunities." *Frontiers in Ecology and the Environment* 20, no. 5 (2022): 301-309. https://doi.org/10.1002/fee.2470