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Recognizing knowledge gaps in biodiversity for the preservation of endangered flora

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Abstract

The diversity of life forms on Earth, known as biodiversity, plays a crucial role in maintaining ecological balance and supporting human welfare. Endangered flora, comprising various plant species at risk of extinction, represents one of the most susceptible elements of biodiversity. The preservation of these threatened plant species is essential for sustaining ecosystem equilibrium and securing natural resources for upcoming generations. To implement effective conservation strategies, it is vital to identify and tackle gaps in biodiversity research knowledge. This investigation offers a thorough examination of the current understanding regarding endangered flora conservation, focusing on several key aspects.

Evaluation and Surveillance of Threats: Comprehending the dangers faced by endangered plant species is crucial for their protection. Research should concentrate on assessing threats such as habitat destruction, climate change effects, invasive species, and overexploitation. Consistent monitoring is necessary to collect information on population dynamics, geographical distribution, and environmental factors that influence conservation strategies.

Taxonomic Classification and Species Recognition: Precise taxonomy and species identification are essential for developing targeted conservation approaches. In numerous instances, taxonomic uncertainties impede conservation efforts, resulting in mismanagement and neglect of certain plant species. Advanced genetic methods and the incorporation of traditional ecological wisdom can assist in resolving taxonomic challenges. Adaptation to Climate Change: Climate change presents significant obstacles to the preservation of endangered flora.

Keywords: Biodiversity, Endangered flora, Geographic distribution, Climate change

Introduction

The tropics harbour vast biodiversity, yet our knowledge remains fragmented. In recent decades, scientific and conservation efforts have intensified to address these gaps, driven by the alarming decline of species due to habitat destruction, overexploitation, pollution, invasive species, and climate change [9]. Aquatic ecosystems, covering less than 1% of the Earth's surface, support over 50% of fish species and 25% of vertebrates. Despite their ecological significance, policy measures often overlook freshwater habitats [13].

The demand for botanical resources is global, particularly for medicinal, aesthetic, and commercial purposes. Sub-Saharan Africa, rich in rare plant species, has become a prime target for botanical extraction. Trees like sandalwood, valued for their essential oils, and rosewood, crucial for fuel, are increasingly exploited [8]. Indigenous knowledge, passed down for generations, has played a crucial role in ecological management. However, only recently has the scientific community begun to acknowledge its value [5].

Data on biodiversity distribution, known as "nonlinear gaps," is often lacking in diverse ecosystems. Advanced computational models have been developed to enhance predictive accuracy and bridge these information voids [6]. Invasive alien plants (IAPs) pose a serious threat to biodiversity and ecosystem services. Due to the scattered nature of data and stakeholders, managing these species requires a collaborative approach. Approximately 80% of land is privately owned, necessitating adaptive stewardship for effective conservation [2].

Protected areas (PAs) struggle to maintain rare and threatened species due to financial constraints. Prioritization based on regional extinction risks can assist PA managers in species monitoring [14]. Despite their ecological significance, historical botanical collections are rarely recognized under global conservation frameworks. Efforts are needed to integrate these collections into biodiversity management strategies [11]. Birds, essential ecosystem contributors and environmental indicators, lack a coordinated global conservation framework. A research and conservation priority index (RCPI) has been proposed to address these gaps [7].

Improved wildlife monitoring is crucial for effective conservation, particularly in developing nations rich in biodiversity. Expanding ecological surveillance is essential to bridge critical knowledge gaps [15]. Environmental DNA (eDNA) has emerged as a valuable tool for species identification, aiding conservation efforts in ecologically significant yet understudied regions [1]. Addressing biodiversity knowledge gaps requires prioritization, especially in vulnerable ecosystems. Large carnivore populations have declined significantly, underscoring the need for systematic population monitoring [10]. Effective management of invasive species must incorporate community engagement rather than relying solely on government initiatives [3,4].

Materials and Methods

Endangered Flora Using the Registry of Animals, we cross-referenced data on 123 wildlife conservation areas to compile a repository of endemic plant species. This dataset includes 175 relationships, 1,061 groups, 10,965 species, and 762,655 distribution records. The Central Plants Checklist and the Angiosperm database provided taxonomic classifications, validated against national botany databases.

Georeferencing was applied at a quarter-degree square (QDS) resolution (~25 km x 25 km). Data sources included the National Vegetation Map, the Custodians of Endangered Wildflowers initiative, and multiple biodiversity databases, supplemented by additional field-verified records.

Genetic Data To assess taxonomic biases in DNA sequencing, GenBank records were analysed using R version 3.5.2. This extensive repository, containing DNA sequences from approximately 260,000 species, was queried for indigenous organisms to evaluate the availability of genetic data.

The present study received approval from the Institutional Ethics Committee of St. Joseph Arts & Science College (Autonomous), Cuddalore (Ref No: SJASC/IEC/2024/3917). A detailed Participant Information Sheet was provided to all participants, and written informed consent was obtained prior to their participation in the study.

Species Distribution Modelling (SDM) We utilized 19 bioclimatic variables from the WorldClim dataset at a 10 arc-minute resolution. SDMs were developed in R using generalized linear models, random forests, and gradient boosting methods. Since true absence data were unavailable, pseudo-absences were generated using national boundary constraints. Models were trained with 75% of occurrence data and validated with 25%. To enhance predictive accuracy, models were combined using an Area Under the Curve (AUC) weighting system. Only species with at least five recorded occurrences were included (n=8,295). For species with fewer occurrences (n=691), spatial range estimates were derived using ArcGIS 10.5.

Climate Suitability Analysis To identify ecologically favourable regions, SDM outputs were overlaid with climate suitability maps. Spatial resolution was standardized across datasets, ensuring comparability. Areas with high predicted species richness were identified, although real-world factors such as habitat fragmentation and interspecies interactions may influence actual distributions. Coastal grid cells covering 50% land area or less were excluded to avoid underestimation of richness.

Spatial and Taxonomic Gaps Sampling coverage was assessed by comparing observed species richness with SDM-predicted diversity. Collection effort was evaluated using sampling density metrics. Road network overlays helped identify potential biases in sampling distribution. Genetic data availability was cross-referenced with IUCN Red List classifications to determine whether threatened species were underrepresented in genetic databases. Finally, spatial and taxonomic data gaps were analyzed to highlight priority areas for future research and conservation efforts. By integrating these approaches, our study aims to enhance biodiversity knowledge, prioritize conservation efforts, and inform data-driven ecological management strategies.

The present study was granted ethical approval by the Institutional Ethics Committee of St. Joseph Arts & Science College (Autonomous), Cuddalore (Ref No: IEC/SJASC/2024/67214). A detailed Participant Information Sheet was provided to all participants, and written informed consent was obtained prior to their inclusion in the study.

Results

The spatial distribution of biodiversity data gaps

By combining Species Distribution Models (SDMs) and existing biodiversity frequency reports, we mapped the regional characteristics of actual and predicted native species diversity across 1790 grid cells. Our findings indicate that 4% of the country's indigenous organisms remain untested, despite our SDMs showing that every grid cell contains an area with a temperature within a seasonal range of at least 69. While SDMs and reported records display similar overall patterns of relative diversity, the predicted established biodiversity from SDMs aligns well with current knowledge, even in grid cells with complete ecosystems. The Tropical Cape Biome, also referred to as the Coral Cape Ecological Hotspot, is expected to have the highest native species count, with 4908 species per grid cell. The Indian Oceans Coastal Area communities encompass the grid cells with the greatest predicted unique complexity. The Western Floristic Country, a biological hotspot, contains the flora with the highest mean predicted total wealth, boasting a predicted maximum of 5,303 varieties per grid cell for unique complexity.

Distribution of biodiversity data gaps

This collection encompasses species from 175 families and 1061 genera, exhibiting diverse biological data organization across taxonomic and chronological scales. The leading 10 families, in terms of native species count, account for 61% of the indigenous plants in the database. Forty family groups are represented by just one native species each. The Proteaceae, Asteraceae, and Fabaceae families boast the highest number of unique species location occurrence records. The top 10 families by sample constitute 69% of all occurrence records in the database. In this study, three groups are represented by a single record. As expected, if all species had equal sampling probability, generally, more species-rich groups were sampled more extensively than less species-rich ones. However, sampling intensity varies significantly among families. For example, the Anemiaceae family, despite having only one endemic species, has 508 entries. Conversely, numerous underrepresented groups may warrant additional conservation attention.

Diversity of threaded

Regarding the family-wise distribution of endangered species, the IHR's Fab plants (84 threatened species), Cyperaceae (65 species), and Poaceae (36 species) families were the most prevalent (Figure 1). The at-risk groups were further categorized into five life forms: climbers (15 species), bryophytes (5 species), pteridophytes (15 species), and plants (286 species; Figure 2). The vulnerable species exhibit significant disparities in their distribution across states, influenced by forest cover and geographical location (Table 1).

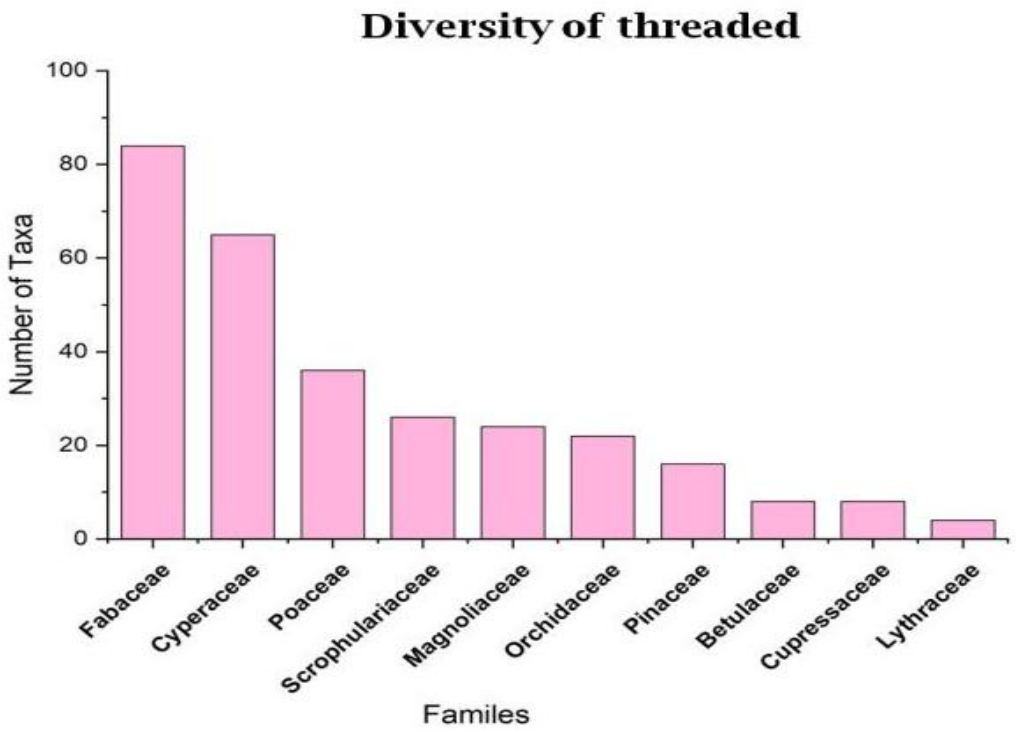

Figure 1: Dominant families of threatened of IHR

Table 1: Outcomes of IHR

Families	Number of Taxa
Fabaceae	84
Cyperaceae	65
Poaceae	36
Scrophulariaceae	26
Magnoliaceae	24
Orchidaceae	22
Pinaceae	16
Betulaceae	8
Cupressaceae	8
Lythraceae	4

The Eastern Himalayan region, comprising states such as SK, MN, ML, TR, MZ, NL, and AR, along with two constituent areas (AS hills and WB hills), harbors a greater number of endangered species compared to the Western Himalayan states (UK, JK, and HP). Despite this, the Eastern Himalayan territories have been subject to less scientific investigation, leaving much of their wildlife largely unexplored. Among the Indian Himalayan Region (IHR) sectors, SK (203 species), HP (190 species), and JK (189 species) boast the highest counts of threatened groups (refer to table 2).

Table 2: Life of threatened taxa

States of IHR	Number of taxa					
	H	S	T	C	Br	Pt
MZ	80	32	25	7	0	1
NL	75	35	33	10	1	5
SK	125	40	45	8	1	4
TR	60	25	60	10	0	1
UK	78	20	48	4	1	3
WB	30	0	15	0	0	1
AR	75	30	40	20	0	3
AS	60	10	35	2	0	2
HP	120	40	55	5	3	5
JK	130	40	45	5	1	7
MN	100	25	33	5	0	2
ML	110	38	45	10	0	2

The table summarizes the distribution of different plant taxa across 12 states of the Indian Himalayan Region (IHR). Trees (T) and herbaceous plants (H) are the most abundant groups, with JK (Jammu & Kashmir) and SK (Sikkim) having the highest numbers of taxa. Shrubs (S) and climbers (C) show moderate representation, while bryophytes (Br) and pteridophytes (Pt) are comparatively rare across all states. This indicates that the IHR harbors rich diversity in higher plants, particularly herbs and trees, whereas lower plants are less widespread.

Population trends of threatened taxa

Over the past few generations, the composition of plant species has changed in response to various ecological and social disturbances. An examination of endangered plant community patterns in the IHR revealed that 38% of species maintained stable populations, 12% exhibited declining trends, and only 2% showed increasing trends (Figure 3 and table 3). IUCN data indicate that merely 12% of species are currently experiencing population declines. Furthermore, 35% of vulnerable plant species remain unassessed due to inaccessible locations or insufficient published research.

Table 3: Numerical outcomes of distribution state (IHR)

Number of Texas	States
UK	124
WB	25
SK	203
TR	103
MZ	121
NL	110
MN	147
ML	170
HP	190
JK	189
AR	147
AS	101

The table shows the total number of taxa recorded in different states of the Indian Himalayan Region (IHR). Himachal Pradesh (HP) and Jammu & Kashmir (JK) have the highest species richness, with 190 and 189 taxa respectively, indicating high biodiversity. In contrast, West Bengal (WB) has the lowest, with only 25 taxa. Other states like ML, MN, SK, and AR also show relatively high diversity, highlighting regional variation in plant species richness across the IHR.

Discussion

Recent research has increasingly emphasized that endangered plant species do not exist in isolation but are embedded within complex ecological networks. Isbell et al. and Achieng et al. have highlighted that plant survival is closely linked to interactions with pollinators, seed dispersers, soil microbiota, and symbiotic partners, and that biodiversity loss disrupts these interconnected systems [5,1]. Similarly, studies focusing on biodiversity hotspots have demonstrated that disruptions to associated insect and animal communities can indirectly accelerate plant population declines, reinforcing the need to consider ecosystem-level processes rather than single-species conservation [9,10]. Consequently, conservation strategies that focus solely on individual species without accounting for these ecological interactions risk failure, as the fundamental processes supporting growth, reproduction, and resilience remain unaddressed.

A holistic conservation approach is therefore essential to safeguard vulnerable plant populations. Hernandez et al. emphasized that effective conservation planning must integrate ecological research, threat assessment, and prioritization frameworks to address both species-level and ecosystem-level needs [4]. Innovative conservation techniques such as ex situ propagation, seed banking, and in vitro technologies have been widely recommended by Kulak et al. and Ye et al., who demonstrated their importance in preserving genetic diversity and preventing irreversible losses, particularly for narrowly distributed or critically endangered plant taxa [7,15]. In addition, large-scale collaborative initiatives, such as those described by Pirie et al., illustrate how coordinated global networks can successfully reduce extinction risk when conservation actions are informed by rigorous science and shared expertise [11,12].

Community engagement and traditional ecological knowledge also play a critical role in holistic conservation strategies. Sinthumule underscored that incorporating indigenous and local knowledge systems enhances conservation effectiveness by aligning scientific interventions with long-standing sustainable practices [13]. Furthermore, Kor and Diazgranados demonstrated that identifying important plant areas based on ecological, cultural, and utilitarian values can help prioritize habitats that are vital for both biodiversity conservation and human well-being [6]. Monitoring and evaluation remain equally important, as emphasized by Stephenson et al., who noted that systematic assessment of flora, fauna, and funga is essential for measuring conservation impact and adapting management strategies over time [14].

Overall, integrating ecosystem-based conservation, advanced propagation techniques, scientific research, and community participation provides a robust framework for protecting endangered plant species. Such an approach not only safeguards individual species but also maintains the ecological networks and ecosystem services upon which their long-term survival depends, as consistently highlighted across contemporary conservation literature [1,4,5,14].

Conclusion

Conserving endangered plant species is vital for maintaining ecological balance and securing resources essential for human survival. Addressing knowledge gaps in biodiversity research is improving conservation strategies. Implementing Threat Assessment and Monitoring is crucial for understanding and mitigating the impacts of overexploitation, invasive species, habitat loss, and global climate change. Accurate taxonomic identification and species recognition are fundamental to developing effective conservation plans that incorporate traditional ecological knowledge. These approaches also underscore the importance of advanced genetic tools. The study further emphasizes the urgent need for environmentally sustainable adaptation strategies in response to changing climate conditions. By establishing targeted conservation initiatives and bridging these information gaps, efforts can be made to safeguard threatened plant species, thereby strengthening ecosystems and ensuring an environmentally sustainable legacy for future generations.

Conflict of Interest: Nil

References

1. Achieng, A.O., Arhonditsis, G.B., Mandrak, N., Febria, C., Opaa, B., Coffey, T.J., Masese, F.O., Irvine, K., Ajode, Z.M., Obiero, K. and Barasa, J.E., (2023). Monitoring biodiversity loss in rapidly changing Afrotropical ecosystems: an emerging imperative for governance and research. Philosophical Transactions of the Royal Society B, 378(1881), p.20220271.
2. Buechley, E.R., Santangeli, A., Girardello, M., Neate-Clegg, M.H., Oleyar, D., McClure, C.J. and Şekercioğlu, Ç.H., (2019). Global raptor research and conservation priorities: Tropical raptors fall prey to knowledge gaps. Diversity and Distributions, 25(6), pp.856-869.
3. Fleischmann, A., München, B.S. and GeoBio-Center, L.M.U., (2018). Carnivorous plants and conservation–the role of carnivorous plant enthusiasts.
4. Hernandez, J.O., Buot Jr, I.E. and Park, B.B., (2022). Prioritizing choices in the conservation of flora and fauna: Research trends and methodological approaches. Land, 11(10), p.1645.
5. Isbell, F., Balvanera, P., Mori, A.S., He, J.S., Bullock, J.M., Regmi, G.R., Seabloom, E.W., Ferrier, S., Sala, O.E., Guerrero-Ramírez, N.R. and Tavella, J., (2023). Expert perspectives on global biodiversity loss and its drivers and impacts on people. Frontiers in Ecology and the Environment, 21(2), pp.94-103.
6. Kor, L. and Diazgranados, M., (2023). Identifying important plant areas for useful plant species in Colombia. Biological Conservation, 284, p.110187.
7. Kulak, V., Longboat, S., Brunet, N.D., Shukla, M. and Saxena, P., (2022). In vitro technology in plant conservation: Relevance to biocultural diversity. Plants, 11(4), p.503.
8. Lannuzel, G., Pouget, L., Bruy, D., Hequet, V., Meyer, S., Munzinger, J. and Gâteblé, G., (2022). Mining rare Earth elements: Identifying the plant species most threatened by ore extraction in an insular hotspot. Frontiers in Ecology and Evolution, 10, p.740.
9. León-Cortés, J.L., Haaland, C., Pryke, J.S. and Maes, D., (2023). Special issue on insect conservation in biodiversity hotspots. Journal of insect conservation, 27(1), pp.1-2.
10. Moir, M.L. and Young, D.A., (2023). Insects from the southwest Australia biodiversity hotspot: a barometer of diversity and threat status of nine host-dependent families across three orders. Journal of Insect Conservation, 27(1), pp.3-18.
11. Pirie, M.D., Blackhall-Miles, R., Bourke, G., Crowley, D., Ebrahim, I., Forest, F., Knaack, M., Koopman, R., Lansdowne, A., Nürk, N.M. and Osborne, J., (2022). Preventing species extinctions: A global conservation consortium for Erica. Plants, People, Planet, 4(4), pp.335-344.
12. Pirie, M.D., Blackhall-Miles, R., Bourke, G., Crowley, D., Ebrahim, I., Forest, F., Knaack, M., Koopman, R., Lansdowne, A., Nürk, N.M. and Osborne, J., (2022). Preventing species extinctions: A global conservation consortium for Erica. Plants, People, Planet, 4(4), pp.335- 344.
13. Sinthumule, N.I., (2023). Traditional ecological knowledge and its role in biodiversity conservation: a systematic review. Frontiers in Environmental Science, 11, p.1164900.
14. Stephenson, P.J., Londoño-Murcia, M.C., Borges, P.A., Claassens, L., Frisch-Nwakanma, H., Ling, N., McMullan-Fisher, S., Meeuwig, J.J., Unter, K.M.M., Walls, J.L. and Burfield, I.J., (2022). Measuring the impact of conservation: the growing importance of monitoring fauna, flora and funga. Diversity, 14(10), p.824.
15. Ye, J., Shan, Z., Peng, D., Sun, M., Niu, Y., Liu, Y., Zhang, Q., Yang, Y., Lin, Q., Chen, J. and Zhu, R., (2023). Identifying gaps in the ex situ conservation of native plant diversity in China. Biological Conservation, 282, p.110044.