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INTERNATIONAL EXPERIENCE OF RESEARCH ON PLANT BIODIVERSITY CONSERVATION

The relevance of this study is driven by the need to understand the role of plant diversity conservation in the face of global environmental challenges and is reflected in the growing number of publications in the Scopus database (1973–2024), where 44,334 works were identified using the search terms “conservation” and “biodiversity”. The aim is to reveal the main trends and directions emerging in the international scientific field focused on flora protection. The methodology is based on collecting and statistically processing publications, as well as conducting digital analyses that make it possible to determine research dissemination dynamics and assess the contributions of different scientific disciplines and institutions. The theoretical significance of the work lies in the systematization of scientific knowledge about ecosystem-based approaches to species conservation, the interdisciplinary nature of the research, and global scientific collaboration. Its practical significance of the study is determined by the possibility of using the results obtained to adjust environmental strategies, optimizing resource planning and form international collaboration. The results obtained demonstrate a significant increase in research interest, which is confirmed by a steady increase in the number of scientific publications, especially noticeable since the end of the 20th century and continuing to the present. The conclusions emphasize the critical importance of a comprehensive approach and concerted efforts by the scientific community, government bodies, and the public in ensuring the long-term maintenance of plant biodiversity worldwide.

Keywords: plant, conservation, biodiversity, environment, ecosystem.

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Өсімдіктердің биоәртүрлілігін сақтау бойынша халықаралық зерттеу тәжірибесі

Бұл зерттеудің өзектілігі экологиялық сын-қатерлер жағдайында өсімдіктердің әртүрлілігін сақтаудың рөлін түсіну қажеттілігінен туындайды және Scopus (1973-2024 жылдар) мәліметтер базасындағы жарияланымдар санының статистикалық өсуінен көрінеді, онда “conservation” және “biodiversity” сұраныстары бойынша 44 334 жұмыс табылды. Мақсат-флораны қорғауға арналған халықаралық ғылыми салада қалыптасқан негізгі тенденциялар мен бағыттарды анықтау. Әдістеме басылымдарды жинауға және статистикалық өңдеуге, сондай-ақ зерттеулердің таралу динамикасын анықтауға және әртүрлі ғылыми пәндер мен институттардың үлестерін бағалауға мүмкіндік беретін талдаудың сандық түрлерін жүргізуге негізделген. Жұмыстың теориялық маңыздылығы түрлерді сақтаудың экожүйелік тәсілдері, зерттеулердің пәнаралық сипаты және жаһандық ғылыми кооперация туралы ғылыми білімді жүйелеу болып табылады. Зерттеудің практикалық маңыздылығы табиғатты қорғау стратегияларын түзету, ресурстық жоспарларды оңтайландыру және халықаралық ынтымақтастықты қалыптастыру үшін алынған нәтижелерді пайдалану мүмкіндігімен анықталады. Нәтижелер ғылыми қызығушылықтың айтарлықтай өсуін көрсетеді, бұл ғылыми жарияланымдар санының тұрақты өсуімен расталады, әсіресе XX ғасырдың аяғынан бастап қазіргі уақытқа дейін байқалады. Нәтижелер өсімдіктердің биоәртүрлілігін жаһандық деңгейде ұзақ мерзімді қолдау ісінде ғылыми қауымдастықтың, үкіметтік құрылымдардың және қоғамның кешенді көзқарасы мен бірлескен күш-жігерінің маңызды маңыздылығын көрсетеді.

Түйін сөздер: өсімдік, табиғатты қорғау, биоәртүрлілік, қоршаған орта, экожүйе.

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Международный опыт исследований по сохранению биоразнообразия растений

Актуальность данного исследования продиктована необходимостью осмысления роли сохранения растительного разнообразия в условиях экологических вызовов и отражена в статистическом росте числа публикаций в базе данных Scopus (1973–2024 годы), где по запросам «conservation» и «biodiversity» обнаружено 44 334 работы. Цель состоит в том, чтобы выявить основные тенденции и направления, складывающиеся в международном научном поле, посвященном охране флоры. Методология опирается на сбор и статистическую обработку публикаций, а также проведение цифровых видов анализа, позволяющих определить динамику распространения исследований и оценить вклад различных научных дисциплин и институтов. Теоретическая значимость работы заключается в систематизации научных знаний об экосистемных подходах к сохранению видов, междисциплинарном характере исследований и глобальной научной кооперации. Практическая значимость исследования определяется возможностью использования полученных результатов для корректировки природоохранных стратегий, оптимизации ресурсных планов и формирования международных коллабораций. Полученные результаты демонстрируют значительное увеличение исследовательского интереса, что подтверждается устойчивым ростом числа научных публикаций, особенно заметным с конца XX века и сохраняющимся по настоящее время. Выводы указывают на критическую важность комплексного подхода и совместных усилий научного сообщества, правительственных структур и общественности в деле долгосрочного поддержания биоразнообразия растений на глобальном уровне.

Ключевые слова: растение, охрана природы, биоразнообразие, окружающая среда, экосистема.

Abbreviations and designations

NGO – National Government Organisation; CNRS – French National Centre for Scientific Research; INRAE – France's National Research Institute for Agriculture, Food and Environment

Introduction

Plant biodiversity conservation is a key priority in modern science, as plant ecosystems play a crucial role in maintaining ecological balance and ensuring sustainable human development. Analyzing publications in the international Scopus database makes it possible to identify current trends, knowledge gaps, and promising research directions in this field. Such research is particularly relevant in the context of global climate change, degradation of natural landscapes, and increasing anthropogenic pressure, which call for enhanced scientific dialogue and knowledge exchange among researchers in different countries.

Under current conditions, in which ecosystems are experiencing increasingly evident transformations, specialists pay special attention to conserving plant biodiversity through the use of local species, comprehensive habitat restoration, and active community engagement. This is confirmed by numerous studies showing, for example, the necessity of planting local flora in urban landscapes [1] and highlighting the importance of such flora in maintaining vital ecological functions [2]. They also point to the significant resilience of ecosystems to invasions and climate change when indigenous plants are introduced [3]. Meanwhile, effective measures for creating and maintaining migration corridors support species diversity [4], and overlooking the risk of gradual forest shading may reduce biological diversity levels [5]. In the context of combating invasive species, the benefits of comprehensive monitoring of community structure have been noted [6], which is particularly relevant when involving local residents in joint projects and agroecological programs [7, 8]. Restoration practices show promise for both the use of spontaneous succession in disturbed areas [9] and the incorporation of mutually beneficial interactions among species, including collaboration between plants and bivalves [10]. Meanwhile, managing peatlands with an awareness of climate fluctuations becomes both economically and ecologically significant [11], aligning with findings that indicate a tight link between microbial and plant diversity [12]. Engaging citizens in monitoring and supporting projects also brings about positive shifts in ecosystems [13, 14], while comprehensive planning and adaptive management aimed at both

preserving biodiversity and developing "green" energy help mitigate the impacts of fragmentation and climate change [15].

Between 1973 and 2024, 44,334 publications referring to "conservation" and "biodiversity" were recorded in the Scopus database, indicating growing scientific interest in protecting and conserving biodiversity. Researchers in the United States are the most active, with 11,037 papers, significantly outpacing colleagues in the United Kingdom (6,534) and Australia (5,177), reflecting strong support for environmental research in these countries. Notable contributions are also made by scientists in China (4,522) and Germany (3,746), along with countries in South America and Europe – such as Brazil (3,174), Canada (2,879), France (2,802), Spain (2,531), and Italy (2,479) – demonstrating the multidimensional nature of global collaboration. India (1,854) and South Africa (1,668) also represent substantial research capacity in developing regions, underscoring the value of a transnational approach to biodiversity conservation. Other participants include Switzerland (1,639), the Netherlands (1,528), Sweden (1,368), and Portugal (1,143), illustrating the distribution of interest across Europe. Latin American countries – such as Mexico (1,055), Argentina (630), and Chile (506) – showcase the region's high environmental priorities, and the activity in Asian countries, including Japan (971) and Indonesia (870), highlights the wide geographic engagement in nature protection research. Even states with a relatively smaller number of publications, such as Kazakhstan (35) or Luxembourg (40), contribute to the overall body of knowledge in this area, indicating that biodiversity conservation extends beyond local boundaries and becomes a collective human challenge requiring multifaceted and cross-cultural cooperation.

Our study, *"Plant Biodiversity Conservation: A Scopus-Based Publication Analysis",* aims to provide a comprehensive review of scientific literature retrieved by the keywords "conservation" and "biodiversity" and indexed in the Scopus database for the period from 1973 to 2024. We seek to identify major scientific trends, methodological approaches, and the most significant thematic areas shaping today's agenda in plant conservation. Objectives include performing a quantitative analysis of publication activity, determining how interest in this issue has changed over time, and identifying the leading research groups and organizations influencing the development of this field. Special attention will be paid to defining the most influential journals and authors, examining the geographic distribution of studies, and finding potential knowledge gaps. Based on the acquired data, we plan to outline promising future research directions, which will not only deepen our understanding of plant biodiversity conservation processes but also facilitate the design of effective ecosystem protection strategies at regional and global levels.

Studies devoted to ecological restoration and sustainable habitat management emphasize the need for an integrated approach that combines ecological, social, and economic dimensions, as reflected in the works by Wei et al. [16], Ma [17], Tian et al. [18], and Hong [19]. Rather than simply restoring the original structure of ecosystems, the objective is to enhance their functional potential in order to ensure long-term resilience against anthropogenic pressures and climate changes [20, 21]. A key factor is the prioritization of restoration areas based on analyses of ecological patterns [22, 23] and vulnerability [24], as well as the involvement of local communities and consideration of their needs to increase the effectiveness of implemented measures [25]. Moreover, the use of modern technologies such as remote sensing and geospatial modeling allows for a more accurate assessment of disturbed sites and the success of restoration activities [26], opening up prospects for more effective natural resource management.

In addition to on-site restoration of native communities, a variety of methods for preserving plant diversity outside their natural habitats are being explored. In-situ efforts include protecting species in their natural ecosystems and maintaining natural ecological interactions [27-29], whereas ex-situ approaches rely on establishing genetic resource repositories, botanical gardens, and similar facilities [30, 31]. The consolidation of these strategies is considered within the "One Plan Approach", in which both methods complement each other to improve the chances of conserving and restoring endangered species [32-34]. Tools such as seed banking and genetic analysis help respond quickly to emergencies and supplement work in protected areas, forming a foundation for sustainably replenishing wild populations [35-38]. It is also important to take into account geographic and genetic gaps, as well as to engage local communities and farming enterprises, to strengthen the role of traditional knowledge and practices in plant conservation [39-41].

The involvement of local residents and the formation of effective policy in biodiversity conservation are directly linked to the successful implementation of the measures described. Valdez [42] shows how collaborative decision-making that includes

community input fosters sustainable planning in the Andes and provides a more precise information framework. Similar conclusions are drawn by Simon et al. [43], underscoring that cooperation among scientific institutions, authorities, and the public simplifies resource monitoring and heightens citizens' awareness. Vogel [44] likewise points to the importance of community participation in preserving remaining woodland areas in Malawi, while Madaki [45] and Crowley et al. [46] emphasize the value of traditional knowledge. The role of effective communication in conservation efforts is explored by Uggla [47], illustrating how the emotional aspect of policy can be essential for garnering public support. Citizen-led initiatives and citizen science projects [48, 49] add impetus to implementing pro-biodiversity practices, and the analysis of how local politics and NGOs affect conservation [50] indicates that accounting for social, economic, and cultural factors is key to successful environmental actions.

Hence, regarding these three aspects – ecosystem restoration, integrating in-situ and ex-situ strategies, and community involvement – it emerges that a comprehensive approach, where scientific advances, policy mechanisms, and social engagement reinforce one another, is most effective for preserving plant diversity.

Materials and methods

2.1 Materials

The analysis of publications addressing plant biodiversity conservation is based on a broad corpus of data collected over the period from 1973 to 2024, encompassing 44,334 academic works. Searches were performed in the Scopus database using the keywords "conservation" and "biodiversity". The discovered materials exhibit considerable diversity in format, with the majority accounted for by scientific articles (34,988), followed by reviews (3,899), conference papers (2,215), book chapters (914), as well as notes (675) and letters (644). A smaller yet noteworthy proportion of publications consists of short surveys (491), editorials (325), books (89), "Data Papers" (69), retracted articles (9), reports (7), errata (6), and conference reviews (3). This wide range of publication types illustrates the interdisciplinary nature of the topic and highlights the variety of research perspectives.

Among the journals most frequently publishing works in the selected area, *Biological Conservation* (1,786), *Conservation Biology* (1,406), *Biodiversity and Conservation* (1,378), *PLOS ONE* (1,197), and *Forest Ecology and Management* (988) stand out. *Science of the Total Environment* (939), *Ecological Indicators* (829), *Journal of Environmental Management* (737), *Nature* (716), and *Science* (714) also make noteworthy contributions. This distribution of publications indicates that plant biodiversity conservation involves not only strictly biological and ecological dimensions, but also a wide range of related fields – from resource management to analyzing anthropogenic impacts on ecosystems. In addition, specialized journals focusing on particular aspects of ecology, forestry, and agriculture (e.g., *Forests* and *Agriculture, Ecosystems and Environment*), as well as comprehensive interdisciplinary outlets such as *Scientific Reports* and *Global Change Biology*, further broaden the landscape. Such a breadth of coverage and variety of sources supply a foundation for an all-encompassing investigation into the evolution of scientific interest and trends in plant conservation studies, as well as for identifying advanced practices for ecosystem preservation.

2.2 Instrument

Initial processing and statistical evaluation of the collected sample are performed using the SPSS software package, which enables basic descriptive analyses (means, medians, modes, standard deviations). The choice of this tool is justified by its recognized efficiency for handling extensive data sets, its flexibility in result visualization, and its wide array of statistical methods suitable for environmental and related scientific research.

2.3 Procedure

At the initial stage, data was collected through a targeted search for publications in the Scopus database. The search filters took into account the time frame (1973-2024), as well as the specified keywords relevant to the research topic. Further, each entry (article, review, conference report, etc.) was pre-sorted to remove duplicate results and materials unrelated to the topic. At the same step, a database was created indicating the type of source, the year of publication, the name of the journal, the list of authors, and other metadata.

The second stage was the statistical processing of the selected materials using SPSS. Here, general indicators of publication activity were calculated, the distribution of works by year, and the main statistical characteristics (averages, medians, and standard deviations) were identified.

In the final step, content analysis tools were used for qualitative research of text fields and metadata. As part of this analysis, the encoding of the most frequently encountered keywords, expressions, and thematic areas was carried out. The results of statistical and content analysis were summarized in gen-

eral diagrams, tables and graphs, forming a systematic picture of research activity, which provided a holistic view of the structure, focuses and dynamics of accumulated scientific knowledge on plant biodiversity conservation.

Results and discussion

A comprehensive statistical and content analysis made it possible to identify a number of key trends and focal points in studies on plant diversity conservation and protection. As part of the analysis, changes in publication counts over time were examined, providing insights into how scientific interest evolved during the observation period. The geographic scope of research indicated the contribution of various countries to the development of this field, revealing worldwide distribution of researcher activity. Investigation into branches of knowledge and leading organizations shed light on the most influential research centers shaping the study agenda. An analysis of journals identified major platforms for publishing relevant works, while an assessment of keywords in article titles helped pinpoint principal thematic focuses and the most frequent terms. Finally, the study of citations enabled the selection of the most influential research, which frames the current debate and sets the course for the ongoing advancement of scientific thought in this domain.

An examination of the number of publications from 1973 to 2024 related to plant diversity conservation showed a stable upward trend. In the early part of this timeline, data were almost absent (only isolated studies appeared in 1973, and for an extended period afterward no publications were recorded), but starting in the mid-1990s, a gradual increase was observed. A more marked rise began after the year 2000: from 260 works in 2000 to 1,486 in 2010, underscoring the growing interest among researchers in plant biodiversity issues. From 2011 onward, the number of publications has continued to climb, reaching 2,880 by 2020 and 3,251 by 2021, indicating heightened global scientific attention to the topic (Figure 1).

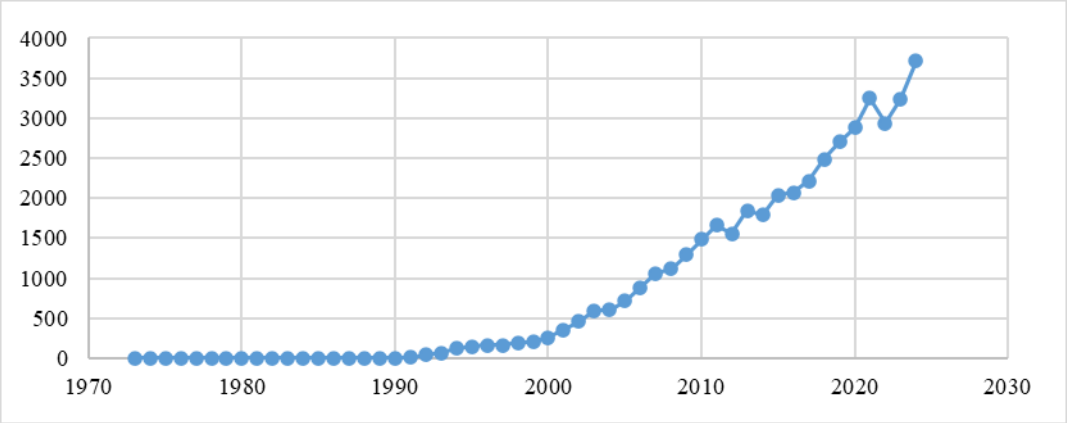

Figure 1 – Dynamics of publication activity in plant biodiversity conservation research: analysis of Scopus data for 1973–2024

(Source: authors' calculations based on Scopus-indexed publications)

Against the backdrop of this growth, a maximum value (3,716) was recorded in 2024, pointing to a further expansion of research interest. High figures for 2023 (3,242 publications) and 2022 (2,934) likewise underscore that ongoing support for public awareness campaigns and scientific programs related to protecting and restoring plant communities continues to drive active publishing. The consistent increase in the number of studies, particularly in the last few decades, indicates that plant biodiversity conservation research has firmly established itself in the scientific discourse, promoting the growth of multidisciplinary research and informing scientifically grounded environmental management strategies.

An analysis of the geographical distribution of publications on plant biodiversity conservation shows the United States in the lead, with 11,037 works. Next are the United Kingdom (6,534) and Australia (5,177), highlighting the active involvement of researchers from these countries in advancing this scientific area. China (4,522) and Germany (3,746) complete the top five, demonstrating sub-

stantial contributions from their research teams and confirming the extensive international character of the subject matter. Brazil (3,174), Canada (2,879), France (2,802), Spain (2,531), and Italy (2,479) also register significant figures, forming a top-10 group of countries with the highest volume of publications, and reflecting a diverse range of interest in the topic (Figure 2).

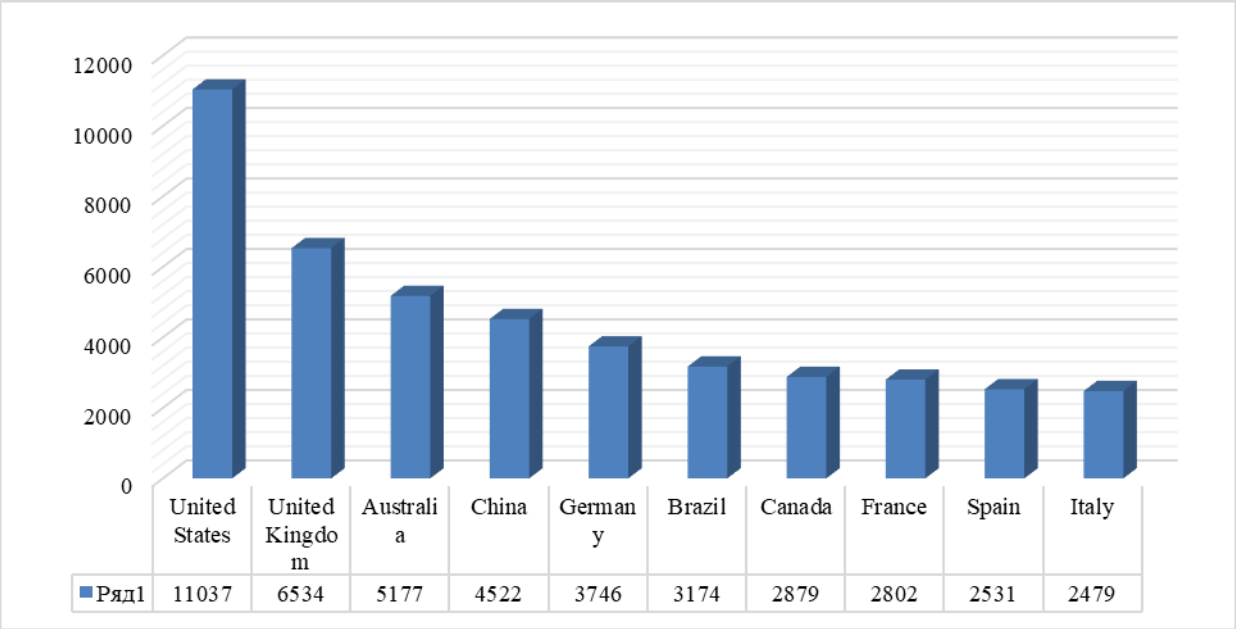

Figure 2 – Top 10 countries by the number of publications on plant biodiversity conservation: analysis of Scopus data for 1973–2024

(Source: authors' calculations based on Scopus-indexed publications)

Other nations – ranging from India (1,854) to Kazakhstan (35) – also make a notable contribution to the global body of knowledge, underscoring that the protection of natural resources and the genetic diversity of plants resonates worldwide. Examination of this distribution not only reveals the scientific activity in each country but also clarifies the extent of national research development on this issue, the level of collaboration among states, and the opportunities for mutually beneficial exchange of expertise aimed at more effective solutions to the planet's environmental challenges.

An analysis of publication distribution by field of knowledge showed that studies on plant biodiversity conservation are most actively pursued in Environmental Science (27,137 works) and Agricultural and Biological Sciences (24,624), underscoring the priority of ecological and biological dimensions in this subject area. Meanwhile, a sizable portion of publications is found in Social Sciences (4,936), pointing to the importance of a sociocultural context and an interdisciplinary perspective in nature conservation. Multidisciplinary (3,791) also plays a substantial role, combining research that cuts across different scientific domains and promotes a holistic examination of how ecosystems and societies interact (Figure 3).

Other fields, including Earth and Planetary Sciences (3,605) and Biochemistry, Genetics and Molecular Biology (3,519), reflect the fundamental underpinnings of biodiversity research and the search for genetic adaptation mechanisms in plants. Engineering (1,284), Computer Science (1,271), and Energy (1,219) illustrate the development of applied approaches, examining technological solutions for preserving biodiversity and optimizing energy and technical processes with ecological requirements in mind. Medicine (1,159), Decision Sciences (996), and Economics, Econometrics and Finance (872) round out the overall picture, emphasizing health issues, socio-economic analysis, and policymaking considerations – factors without which it is difficult to realistically assess and implement strategies for safeguarding plant diversity.

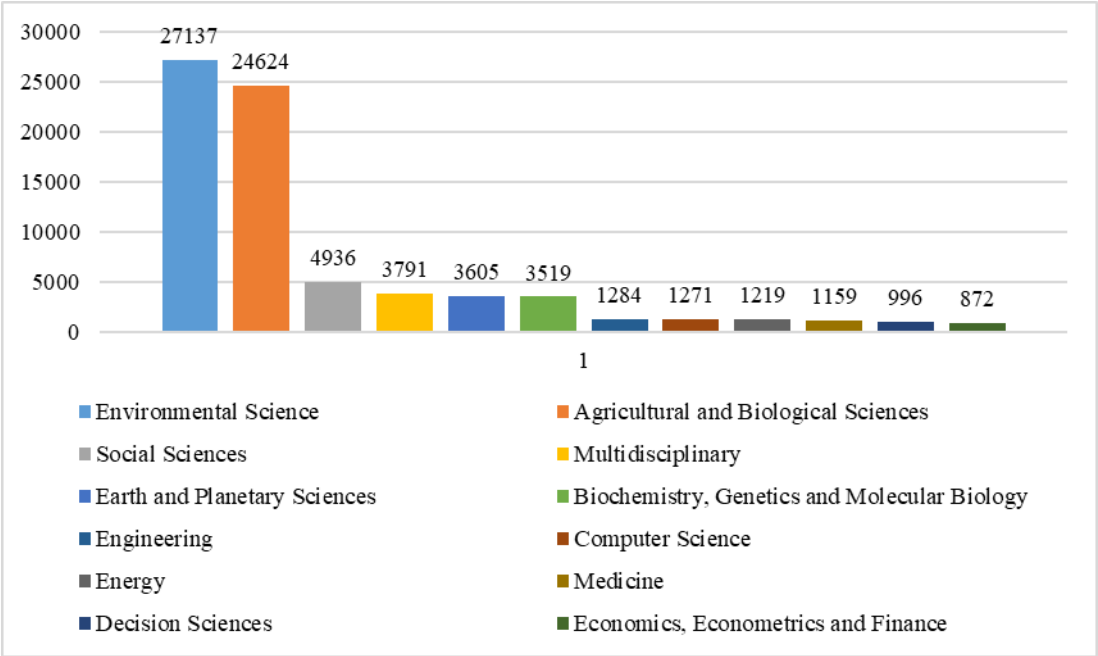

Figure 3 – Top 12 fields by the number of scientific publications on plant biodiversity conservation: analysis of Scopus data for 1973–2024
(Source: authors' calculations based on Scopus-indexed publications)

An analysis of publication counted by organizations indexed in Scopus indicates a high concentration of scientific activity in the largest research centers. Leading the list is the Chinese Academy of Sciences (1,558 works), followed by the CNRS Centre National de la Recherche Scientifique (1,270) and The University of Queensland (1,026), attesting to these institutions' particular focus on environmental issues. The University of Oxford (662) and the Commonwealth Scientific and Industrial Research Organisation (658) also significantly advance research in plant diversity conservation. INRAE (640), Sveriges lantbruksuniversitet (614), the University of Cambridge (608), Wageningen University & Research (588), and the University of Chinese Academy of Sciences (582) complete the top 10, underscoring its multinational character (Figure 4).

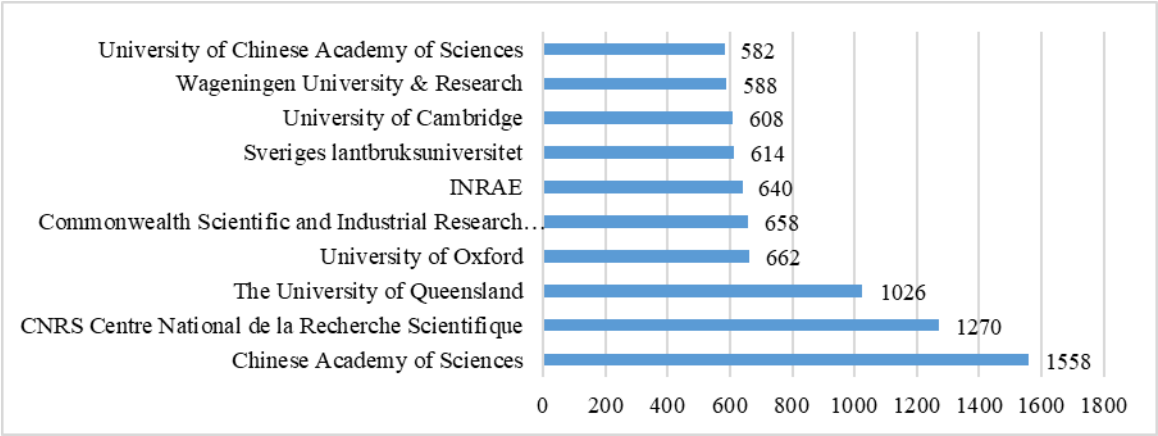

Figure 4 – Top 10 organizations by the number of scientific publications on plant biodiversity conservation: analysis of Scopus data for 1973–2024
(Source: authors' calculations based on Scopus-indexed publications)

In addition to these entities, others such as Nature Conservancy (581), The Australian National University (557), James Cook University (554), and various other educational and conservation organizations actively study and implement practices for preserving plant communities. The considerable presence of universities, research institutes, and NGOs in this list highlights the global scale and broad spectrum of research interests aimed at solving major environmental problems.

An examination of the contribution of scientific journals to studies on plant biodiversity conservation points to a clear lead for *Biological Conservation*, with 1,786 publications, followed by *Conservation Biology* (1,406) and *Biodiversity and Conservation* (1,378). *PLOS ONE* (1,197), *Forest Ecology and Management* (988), and *Science of the Total Environment* (939) also hold steady positions. By synthesizing findings from diverse research areas – ranging from applied cases to general theoretical issues – these journals help form a systematic understanding of tasks related to ecosystem protection and the genetic diversity of plants, while fostering new approaches to restoring natural landscapes (Figure 5).

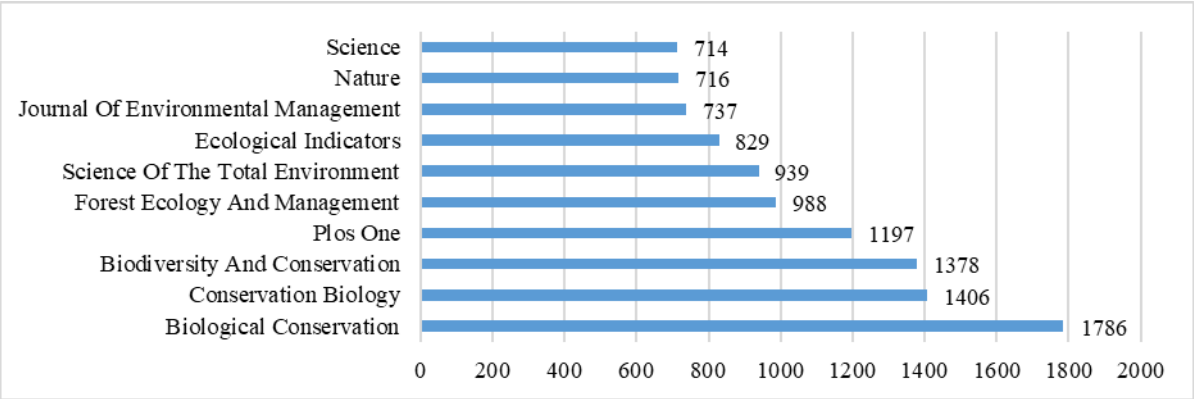

Figure 5 – Top 10 scientific journals by the number of publications on plant biodiversity conservation: analysis of Scopus data for 1973–2024
(Source: authors' calculations based on Scopus-indexed publications)

The ranking also includes journals covering related facets of ecology, sustainable resource use, and applied research, such as *Ecological Indicators* (829), *Journal of Environmental Management* (737), *Nature* (716), and *Science* (714). The presence of both specialized journals focusing on conservation and high-profile general-interest journals underscores the significance of the topic for a wide range of researchers and demonstrates the multidisciplinary character of modern scholarship on plant diversity conservation.

Occupying top positions by citation count are foundational works that address various aspects of biodiversity conservation and the related ecological risks. The most-cited publication is *"Biodiversity hotspots for conservation priorities"* by Myers, N., Mittermeler, R.A., Mittermeler, C.G., Da Fonseca, G.A.B., and Kent, J. (2000), with 22,942 references, highlighting its role in shaping major directions in nature conservation studies. Next are *"Global consequences of land use"* (Foley, J.A., DeFries, R., Asner, G.P., et al., 2005) with 9,782 citations and *"A safe operating space for humanity"* (Rockström, J., Steffen, W., Noone, K., et al., 2009) with 8,404, reflecting a strong focus on land-use change and global environmental security. Also included in this group of highly influential publications are *"Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems"* (Willett, W., Rockström, J., Loken, B., et al., 2019), with 6,329 citations, and *"Solutions for a cultivated planet"* (Foley, J.A., Ramankutty, N., Brauman, K.A., et al., 2011) with 5,913, underscoring the significant role of the food system in the context of ecology and global development (Table 1).

Table 1 – Top 10 most-cited works in plant biodiversity conservation: Scopus-based analysis for 1973–2024

Title of the Work	Authors	Source	Year	Citations
Article 1. Biodiversity hotspots for conservation priorities	Myers, N., Mittermeler, R.A., Mittermeler, C.G., Da Fonseca, G.A.B., Kent, J.	*Nature*, 403(6772), стр. 853–858	2000	22942
Review 2. Global consequences of land use	Foley, J.A., DeFries, R., Asner, G.P., Ramankutty, N., Snyder, P.K.	*Science*, 309(5734), стр. 570–574	2005	9782
Short Survey 3. A safe operating space for humanity	Rockström, J., Steffen, W., Noone, K., Crutzen, P., Foley, J.A.	*Nature*, 461(7263), стр. 472–475	2009	8404
Review 4. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems	Willett, W., Rockström, J., Loken, B., Nishtar, S., Murray, C.J.L.	*The Lancet*, 393(10170), стр. 447–492	2019	6329
Article 5. Solutions for a cultivated planet	Foley, J.A., Ramankutty, N., Brauman, K.A., Tilman, D., Zaks, D.P.M.	*Nature*, 478(7369), стр. 337–342	2011	5913
Article 6. Extinction risk from climate change	Thomas, C.D., Cameron, A., Green, R.E., Phillips, O.L., Williams, S.E.	*Nature*, 427(6970), стр. 145–148	2004	5857
Review 7. A general framework for analyzing sustainability of social-ecological systems	Ostrom, E.	*Science*, 325(5939), стр. 419–422	2009	5426
Review 8. Freshwater biodiversity: Importance, threats, status and conservation challenges	Dudgeon, D., Arthington, A.H., Gessner, M.O., Stiassny, M.L.J., Sullivan, C.A.	*Biological Reviews of the Cambridge Philosophical Society*, 81(2), стр. 163–182	2006	5424
Article 9. Global food demand and the sustainable intensification of agriculture	Tilman, D., Balzer, C., Hill, J., Befort, B.L.	*Proceedings of the National Academy of Sciences of the United States of America*, 108(50), стр. 20260–20264	2011	5404
Article 10. Global threats to human water security and river biodiversity	Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Liermann, C.R., Davies, P.M.	*Nature*, 467(7315), стр. 555–561	2010	5346

(Source: Authors' calculations based on the database of indexed articles in Scopus; Export Date: 4 January 2025)

Also noteworthy are other works, including *"Extinction risk from climate change"* (Thomas, C.D., Cameron, A., Green, R.E., et al., 2004), cited 5,857 times, as well as *"A general framework for analyzing sustainability of social-ecological systems"* (Ostrom, E., 2009) and *"Freshwater biodiversity: Importance, threats, status and conservation challenges"* (Dudgeon, D., Arthington, A.H., Gessner, M.O., et al., 2006), with 5,426 and 5,424 citations respectively, indicating the interdisciplinary nature of this research and the widespread demand for its results in scientific discussions. Publications such as *"Global food demand and the sustainable intensification of agriculture"* (Tilman, D., Balzer, C., Hill, J., Befort, B.L., 2011; 5,404 citations) and *"Global threats to human water security and river biodiversity"* (Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., et al., 2010; 5,346 citations) round out the top 10, underscoring strong interest in agricultural production, water security, and the preservation of freshwater ecosystems in the context of overall sustainable development.

An analysis of the five most-cited articles reveals principal lines of research in the study of linguistic conflicts and the interplay of language with human cognitive and emotional processes. In "Correspondence of the brain's functional architecture during activation and rest" by Smith et al. (2009), resting-

state fMRI was used to explore structural connectivity in the brain, potentially resolving language conflicts at the neural level. Accumulating 3,947 citations, this article emphasizes the importance of investigating the brain's functional architecture to elucidate how language perception and regulation operate.

A comparative analysis of five of the most significant studies on plant biodiversity conservation reveals a range of theoretical and applied approaches to addressing global environmental issues. The review includes *"Biodiversity hotspots for conservation priorities"* (Myers, N., Mittermeler, R.A., Mittermeler, C.G., et al., 2000), *"Global consequences of land use"* (Foley, J.A., DeFries, R., Asner, G.P., et al., 2005), *"A safe operating space for humanity"* (Rockström, J., Steffen, W., Noone, K., et al., 2009), *"Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems"* (Willett, W., Rockström, J., Loken, B., et al., 2019), and *"Solutions for a cultivated planet"* (Foley, J.A., Ramankutty, N., Brauman, K.A., et al., 2011). These works employ both qualitative and quantitative methods, along with interdisciplinary principles, to elucidate the link between the state of natural ecosystems, agricultural production, and human well-being (Table 2).

Table 2 – Top 5 comparative analysis of studies on plant biodiversity conservation: methods, results, and conclusions (top 5)

Authors	*The title of the work*	*Methods Used*	*Results*	*Conclusions*
Myers, N., Mittermeler, R.A., Mittermeler, C.G., Da Fonseca, G.A.B., Kent, J.	*Article* 1. Biodiversity hotspots for conservation priorities	The study employed a combination of qualitative and quantitative analyses to identify and evaluate biodiversity hotspots. The researchers expanded their criteria to include 25 hotspots, requiring that each hotspot contain endemic plant species comprising at least 0.5% of all plant species worldwide. The analysis incorporated data from over 100 scientists with extensive experience in the relevant countries and utilized around 800 references from the professional literature. Key questions regarding species/area ratios and congruence among taxa were also addressed, allowing for a comprehensive assessment of biodiversity in these critical regions.	The findings revealed that the identified hotspots contain a significant number of endemic species, with the total number of endemics being almost three times greater than in previous studies. For instance, the Tropical Andes was noted to have at least 20,000 known plant endemics, while the Cape Floristic Province was reported to have exactly 5,682 known plant endemics. The study highlighted the variability in data precision and accuracy, emphasizing that while some figures are rounded, they still provide a sound basis for conservation prioritization. The results underscored the urgent need for targeted conservation efforts in these biodiversity-rich areas.	The study concluded that focusing conservation efforts on biodiversity hotspots is essential for maximizing the impact of limited resources. By identifying and prioritizing these areas, conservation planners can effectively address the threats faced by unique species and their habitats. The authors argued that even in the face of data uncertainty, it is crucial to evaluate potential hotspots to ensure that their conservation needs are recognized and addressed. Ultimately, the research advocates for a strategic approach to conservation that prioritizes regions with high levels of endemism and significant threats, thereby enhancing global biodiversity preservation efforts.

Continuation of the table

Authors	*The title of the work*	*Methods Used*	*Results*	*Conclusions*
Foley, J.A., DeFries, R., Asner, G.P., Ramankutty, N., Snyder, P.K.	*Review* 2. Global consequences of land use	In the article «Global Consequences of Land Use,» Jonathan A. Foley employs a comprehensive review of existing literature and data to analyze the impacts of land use on global ecosystems and agricultural productivity. The study synthesizes findings from various disciplines, including ecology, geography, and environmental science, to assess the effects of land conversion, agricultural practices, and urbanization on biodiversity, soil health, and ecosystem services. By integrating quantitative data on land use changes with qualitative assessments of ecological consequences, the research provides a holistic view of the challenges posed by modern land management practices.	The results of Foley's research indicate significant negative consequences of current land use practices on both agricultural productivity and ecological health. The study highlights that approximately 1.5 million hectares of arable land are lost annually due to salinization and soil degradation, leading to an estimated $11 billion in lost agricultural production. Furthermore, it reveals that up to 40% of global croplands are experiencing issues such as soil erosion, reduced fertility, and overgrazing. The findings also emphasize the detrimental effects of habitat loss on pollinator populations, which are crucial for food production, thereby illustrating a trade-off between short-term agricultural gains and long-term sustainability.	Foley concludes that modern agricultural practices, while aimed at increasing food production, often result in long-term ecological damage that undermines future agricultural viability. The article calls for a reevaluation of land use strategies to prioritize sustainable practices that balance food security with environmental conservation. It advocates for integrated land management approaches that consider the ecological impacts of land use decisions, emphasizing the need for policies that promote biodiversity, soil health, and the preservation of ecosystem services essential for sustaining agricultural productivity in the long run.
Rockström, J., Steffen, W., Noone, K., Crutzen, P., Foley, J.A.	*Short Survey* 3. A safe operating space for humanity	The article employs a framework based on the concept of «planetary boundaries» to assess the limits within which humanity can safely operate without causing significant environmental degradation. This framework integrates data from various scientific disciplines, including ecology, climate science, and biogeochemistry. The authors analyze key Earth-system processes and their control variables, using both qualitative and quantitative methods to evaluate the current state of these processes against established thresholds.	The findings indicate that three of the nine identified planetary boundaries—namely, the rate of biodiversity loss, climate change, and human interference with the nitrogen cycle—have already been exceeded. The analysis reveals that these transgressions pose significant risks to the resilience of Earth's systems, potentially leading to abrupt and irreversible changes. The results underscore the urgent need for global action to mitigate these impacts and restore balance within the Earth system.	The article concludes that humanity is approaching critical thresholds that could lead to catastrophic environmental changes if not addressed promptly. It emphasizes the importance of recognizing and respecting planetary boundaries as a means to ensure sustainable development. The authors call for immediate and coordinated global efforts to reduce human impacts on the environment, highlighting that failure to act could result in severe consequences for both ecosystems and human societies.

(Source: authors' calculations based on Scopus-indexed articles; top 10 by number of citations)

The analysis of methods shows that – from identifying endemic "hotspots" of flora to assessing the impact of agricultural practices on soil and climate – the authors provide a comprehensive view of priority tasks in environmental conservation. The results, whether highlighting the rapid loss of biodiversity, evaluating risks to the food system, or defining planetary boundaries, underscore the pressing need for global actions and strategic planning. In their conclusions, the researchers unanimously point out that only by shifting toward sustainable resource management, preserving crucial ecosystem functions, and prioritizing the protection of unique endemic species can we ensure the long-term stability of the biosphere and the well-being of future generations.

Overall, the statistical and content analysis conducted indicates a sustained and steadily increasing interest among the global scientific community in plant biodiversity conservation, fostered by the interdisciplinary nature of research, broad geographic coverage, and the active role of large scientific organizations and journals. Year-by-year publication trends show a remarkable growth in the number of studies, confirming the lasting importance of the topic and its strong foothold in recent decades' scientific discourse. Geographic distribution data reflect the involvement of researchers from almost every region of the globe and the formation of international scientific networks aimed at tackling key environmental problems. Examination of subject areas reveals a leading role for ecology and biology, while also highlighting the contributions of social, economic, and technical fields, illustrating the multifaceted tasks of nature protection. Analysis of leading organizations points to a handful of major research centers that generate a significant volume of results and shape the primary directions of scientific inquiry, while the study of prominent journals underscores the widespread demand for this topic both in specialized and interdisciplinary outlets. Finally, the assessment of citation counts for key publications and the review of methodological features in the most notable works confirm that sustainable ecosystem management, strategic prioritization of protected areas, and the synthesis of knowledge from multiple scientific spheres remain fundamental requirements for effective plant diversity conservation.

The goal of this study was to systematize and characterize publication activity related to plant biodiversity conservation based on Scopus data, encompassing an analysis of publication trends, geographic distribution, subject-area structures, leading scientific organizations and sources, as well as the most-cited works.

A noticeable and steady rise in publications since the late 20th century underscores an increasing concern for flora conservation and demonstrates the scientific community's recognition of the significance of this topic. Active research has been identified in numerous world regions, with leading participation from countries that possess traditionally strong scientific infrastructures and extensive experience in environmental studies, as confirmed by the quantity and quality of their publications.

Subsequent analysis showed that in addition to biological and ecological investigations, a substantial portion of studies is devoted to social, economic, and engineering approaches to preserving plant diversity. These interdisciplinary aspects underscore the need for integrated studies that bring together knowledge from various scientific domains, while the high citation rate of key articles reflects the relevance and value of their findings in global science.

The outcomes indicate that sharpening the focus on plant biodiversity conservation could substantially improve nature protection strategies, lead to more effective management and legislative frameworks, and foster the development of international partnerships and collaborations. Expanding and refining the empirical data pool will enhance the understanding of ecosystem processes, which in turn will boost the effectiveness of existing programs and help shape new initiatives targeting the long-term safeguarding of vulnerable plant communities. Notably, insight into genetic and ecosystem-level processes, as well as an assessment of the socio-economic factors influencing plant health, enables a more targeted and specific approach to preserving and restoring plant resources. Such a comprehensive strategy ultimately strengthens ecological stability in various regions and promotes a globally resilient network of natural systems.

Looking forward, the development of more precise biodiversity monitoring methods – including remote sensing and genetic analysis – and collaboration among research teams in diverse regions and fields are recommended for an all-encompassing perspective on the challenges. Particular attention should be paid to the economic, cultural, and social factors shaping decision-making around plant ecosystems, ensuring that proposed strategies remain both viable and grounded. The use of Big Data and innovative digital platforms for collecting, analyzing, and sharing information opens the door to quicker, more accurate scientific conclusions, potentially guiding adaptive policies and manage-

ment solutions. Involving local communities and NGOs in the planning and execution of flora protection measures, as well as advancing citizen science initiatives, can significantly broaden the scale and accelerate the pace of data gathering. Ultimately, effectively addressing the tasks of plant biodiversity conservation requires consolidated efforts among researchers, governments, international organizations, and businesses, guaranteeing a long-term and ecologically responsible utilization of resources.

Conclusion

The analysis performed enabled the tracing of a multi-decade trajectory of scientific interest in plant biodiversity conservation and identified key clusters of research activity. The rise in the number of publications, particularly in recent decades, points to heightened attention to ecological issues and underscores the necessity of strategic approaches that incorporate not only biological and genetic concerns, but also social, economic, and political factors. Pinpointing the major global research centers and leading journals in this field indicates the existence of established collaborative networks among researchers, experts, and practitioners working collectively to address the challenge of preserving unique flora.

The multifaceted nature of research-ranging from specialized morphological and genetic studies to wide-ranging reviews of ecosystem services and resource management policies – demonstrates the significance of an interdisciplinary approach. Aspects such as community involvement, the examination of legislative measures, and the application of remote sensing and other digital technologies have become crucial parts of a comprehensive strategy that can ensure long-term effectiveness in conservation efforts. The high citation counts of numerous fundamental and applied studies signal the broad demand for results that define future research pathways and establish a scientific base for management decisions.

The consolidation of knowledge and experience accumulated across different countries, as well as the adaptation of proven best practices to local contexts, are pivotal in enhancing the success of measures aimed at preserving and restoring valuable ecosystems. A deep understanding of biodiversity dynamics, including evaluating extinction risks and habitat shifts due to climate change or anthropogenic factors, offers opportunities for proactive planning. Global partnerships that unite scientists, policymakers, the business sector, and civil society can be a mainstay for creating more sustainable economic models oriented toward safeguarding natural heritage. This form of cooperation overcomes fragmented efforts and unifies diverse resources to support strategic research, implement new technologies, and launch outreach programs dedicated to fostering a culture of responsible stewardship toward plant life.

Conflict of interest

All authors read this article and were acquainted with the article content and they have no conflicts of interest.

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