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*Review article*

# *Forest ecosystem services*

## *Servicios ecosistémicos del bosque*

## *Serviços ecossistêmicos florestais*

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***ABSTRACT***

The article addresses a comprehensive documentary review of research published in high-impact databases between 2020 and 2025, using a bibliometric approach. It aims to analyze and synthesize the contributions of forests to society and the environment. Four

main categories of ecosystem services are identified: provision (food, water, timber), regulation (climate, air quality, flood control), support (biogeochemical cycles, soil formation), and cultural (recreation, spiritual values). The findings highlight the importance of forests in climate change mitigation, biodiversity conservation, and human well-being, as well as the challenges associated with their degradation and loss. The study emphasizes the need for integrated policies and sustainable approaches to forest management and highlights the role of interdisciplinary research and community participation. The review concludes that the economic and social valuation of these services is crucial to promoting their conservation and responsible use in a context of sustainable development.

**Keywords:** Biodiversity, Climate change, Ecosystems, Forest management.

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***RESUMEN***

El artículo abordó una revisión documental exhaustiva de investigaciones publicadas en bases de datos de alto impacto entre 2020 y 2025, con enfoque bibliométrico. Tuvo como objetivo de analizar y sintetizar los aportes de los bosques a la sociedad y el medio ambiente. Se identifican cuatro categorías principales de servicios ecosistémicos: provisión (alimentos, agua, madera), regulación (clima, calidad del aire, control de inundaciones), soporte (ciclos biogeoquímicos, formación de suelos) y culturales (recreación, valores espirituales). Los hallazgos destacan la importancia de los bosques en la mitigación del cambio climático, la conservación de la biodiversidad y el bienestar humano, así como los desafíos asociados a su degradación y pérdida. El estudio identificó la necesidad de políticas integradas y enfoques sostenibles para la gestión forestal, resalta la función de la investigación interdisciplinaria y la participación comunitaria. La revisión concluye que la valoración económica y social de estos servicios es crucial para promover su conservación y uso responsable en un contexto de desarrollo sostenible.

**Palabras clave**: servicios ecosistémicos, Biodiversidad, Cambio climático, Ecosistemas, Gestión forestal.

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***RESUMO***

O artigo "Serviços Ecossistêmicos Florestais" aborda uma exaustiva revisão documental de pesquisas publicadas em bases de dados de alto impacto entre 2020 e 2025, com abordagem bibliométrica. Seu objetivo é analisar e sintetizar as contribuições das florestas para a sociedade e o meio ambiente. São identificadas quatro categorias principais de serviços ecossistémicos: fornecimento (alimentos, água, madeira), regulação (clima, qualidade do ar, controlo de cheias), apoio (ciclos biogeoquímicos, formação do solo) e cultural (recreação, valores espirituais). As conclusões destacam a importância das florestas na mitigação das alterações climáticas, na conservação da biodiversidade e no bem-estar humano, bem como os desafios associados à sua degradação e perda. O estudo enfatiza a necessidade de políticas integradas e abordagens sustentáveis para o manejo florestal, destaca o papel da pesquisa interdisciplinar e da participação comunitária. A revisão conclui que a valorização económica e social destes serviços é crucial para promover a sua conservação e utilização responsável num contexto de desenvolvimento sustentável.

**Palavras-chave**: Biodiversidade, Mudanças climáticas, Ecossistemas, Manejo florestal.

## *INTRODUCTION*

Forests have played a central role in the development of life on Earth, as habitats of unparalleled biodiversity and as providers of essential services that sustain human well-being and ecosystem stability (Zhai *et al*., 2025). These services, called ecosystem services, include functions as diverse as the provision of natural resources (wood, food, water) (Bruno *et al*., 2025) , climate regulation, air purification, watershed protection ( Hallaj *et al*., 2024) , and the provision of spaces for recreation and spiritual connection with nature (Sprinz *et al*., 2024). Despite their importance, forests are facing an unprecedented crisis due to deforestation, environmental degradation and the impacts of climate change, which has led to an accelerated loss of forest cover and functionality on a global scale (You *et al* ., 2024) .

In recent decades, the scientific community has dedicated significant efforts to studying and quantifying the ecosystem services of forests, recognizing their ecological and socioeconomic value (Toriyama *et al*., 2025). Previous research has shown that forests act as carbon sinks, contributing to mitigating global warming (Forsman *et al*., 2024) and play a crucial role in regulating the hydrological cycle; in this way, they prevent floods and ensure the availability of freshwater (Sullivan *et al*., 2024). Furthermore, their importance in biodiversity conservation has been demonstrated, serving as a refuge for countless species, many of which are endemic and in danger of extinction (Sailo *et al*., 2024). *et al*., 2025). At the social and cultural level, forests have been fundamental to the livelihoods of local and indigenous communities, providing vital resources and spaces for traditional and recreational practices.

However, increasing anthropogenic pressure, driven by agricultural expansion ( Helseth *et al*., 2024) , uncontrolled urbanization (Hertegård & Widmark, 2025), unsustainable logging and mining (Du *et al*., 2024), has led to accelerated degradation of these ecosystems (Moges *et al*., 2024) . According to data from international organizations, it is estimated that approximately 10 million hectares of forests were lost annually between 2015 and 2020, which has had serious repercussions on the capacity of forests to provide ecosystem services (Sharma *et al*., 2025). This situation has been aggravated by global phenomena such as climate change, which has increased the frequency and intensity of droughts, forest fires and pests and puts the resilience of these ecosystems at risk (Sanabria Martínez *et al*., 2022).

A significant number of authors were identified who address forest systems and management; among them, Krsnik *et al* . (2023). The importance of the protection of these by the resident communities was also exposed Moreira *et al.* (2024) and the need to develop initiatives to safeguard forests (Li *et al* ., 2025b).

The importance of community participation in this regard is demonstrated in the literature, as stated by Duque Ramos (2024). Anthropological factors are also necessary in this type of analysis (Duşcu & Rîş noveanu, 2025), without losing sight of the ecological approach (Aubin *et al*., 2024) and its relationship with urban planning (Bekele *et al* ., 2025) .

Given this scenario, the need arose to carry out an updated and comprehensive synthesis of scientific knowledge on the ecosystem services of forests (Jo *et al* ., 2024 ; Huang *et al*., 2024) to identify trends, research gaps, and priority areas for action. This article was based on a comprehensive documentary review of studies published between 2020 and 2025 in high-impact databases, with the aim of analyzing the state of the art in this field. This period was selected in response to the urgent need to incorporate the most recent advances in a context of global environmental crisis, where up-to-date information is crucial for informed decision-making.

The relevance of this study lay in its interdisciplinary approach, which integrated ecological, social, and economic perspectives to understand the multidimensionality of forest ecosystem services. Furthermore, the article sought to contribute to the dialogue between science, policy, and society, promoting forest management that balances human needs with ecosystem preservation. In an increasingly interconnected and vulnerable world, this type of research has emerged as a key input for advancing truly sustainable development, where forest conservation is not seen as an obstacle, but as an opportunity to build a more resilient and equitable future.

In this regard, the article aimed to analyze scientific production on forest ecosystem services through a bibliometric review of indexed publications between 2020 and 2025. At the same time, it emphasized the need to strengthen collaboration among key stakeholders, including governments, local communities, academia, and the private sector, to implement effective strategies that ensure the long-term sustainability of these ecosystems. In this way, the study was presented as a significant contribution to the field of environmental studies, laying the groundwork for future research and concrete actions in favor of forests and the societies that depend on them.

In this study, a bibliometric approach was taken (Sánchez Castillo *et al*., 2024) and a mixed documentary review of publications on forest ecosystem services, taking into account the distribution of citations, main areas of disciplinary interaction, keywords and co-authorship between countries, and main lines of research (Camastra *et al* ., 2025)

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This study was structured based on a bibliometric and documentary review aimed at the quantitative and qualitative analysis of scientific production on forest ecosystem services, in the period between 2020 and 2025, with the aim of portraying the recent discussion about the conservation, valuation and management of forest ecosystems in a scenario of high climate variability.

The *academic databases* consulted were the most internationally recognized for their rigor and multidisciplinary coverage: Scopus, Web of Science (WoS) and PubMed. The findings were downloaded on March 10, 2025, making this exercise a time-bound, concrete, and reproducible exercise.

The *search strategy* for relevant studies included keywords in English and Spanish, as follows: "ecosystem" services", "forest ecosystem", "forest ecosystem services", "forest management", "biodiversity", "climate change", "cultural ecosystem services", "ecosystem valuation," "ecosystem services," "forest ecosystems," and "forest management." These words were combined using Boolean operators and applying filters for language, document type, and publication date (study period), taking into account the specific connotations of each database.

Regarding ***the inclusion criteria,*** articles available in both English and Spanish during the study period were considered; duplicates, incomplete works, presentations, theses, conference proceedings, and studies directly related to the research interest were also excluded.

Subsequently, to ***refine and analyze the results,*** tools such as Microsoft Excel were used to organize the records, eliminate duplicates, and construct the analysis matrix; VOSviewer (version 1.6.20) was used to create keyword co-occurrence maps, co-authorship networks, and density maps. Similarly, the Bibliometrix database was run in R to analyze metrics, topic evolution, disciplinary relationships, and scientific trends. In this way, a comprehensive approach to academic production was established, identifying collaboration patterns, predominant themes, and research gaps.

## *DEVELOPMENT*

The bibliometric analysis yielded a total of 319 major publications on forest ecosystem services between 2020 and 2024, with 2024 being the year with the highest number of publications, with 81 articles; then 20230 with 73 publications. Regarding the countries with the highest scientific production, it is worth mentioning the United States, China, Brazil, India, and Spain. The most frequent topics in the area were regulatory services, biodiversity in contexts of climate change, economic valuation of services, sustainable forest management, and cultural services. Table 1 presents a summary with the main data by year (Table 1).

**Table 1. -** *Main publications by year and topic*

| Year | Number of publications | Most productive country | Dominant theme |
|---|---|---|---|
| **2020** | 45 | USA | Regulatory services |
| **2021** | 52 | China | Biodiversity and climate change |
| **2022** | 68 | Brazil | Sustainable forest management |
| **2023** | 73 | India | Economic valuation |
| **2024** | 81 | Spain | Cultural services |

The bibliometric analysis carried out in the "Forest Ecosystem Services" study identified trends, patterns, and gaps in scientific production published between 2020 and 2025. The results reflected a significant growth in the number of publications related to forest ecosystem services (n=7,932), where studies focused on topics such as climate change mitigation, conservation and sustainable management of forest resources, and community-based management. Below, it can be seen how the highest density is found in keywords such as ecosystem service, biodiversity, China, and forests (Figure 1).

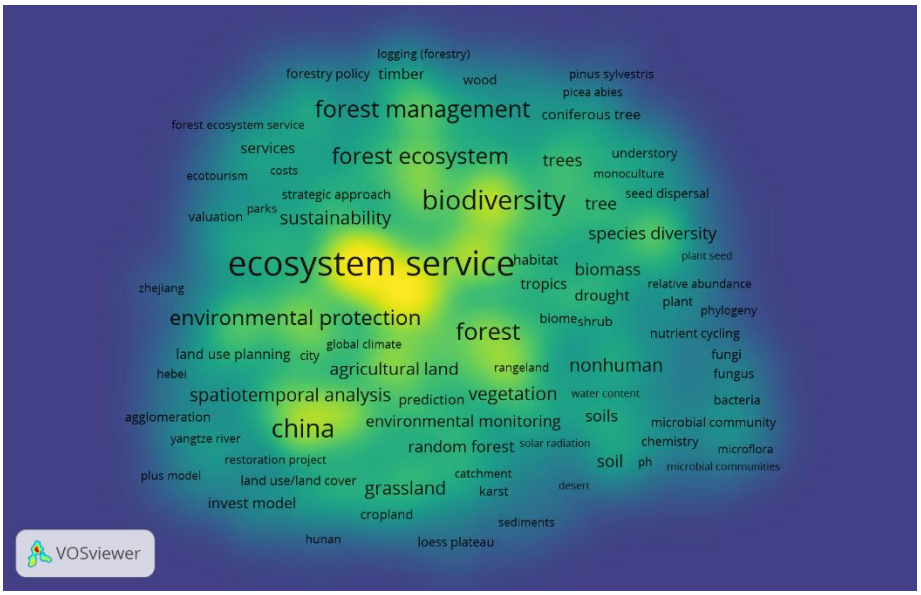


***Figure 1.*** *– Keyword density map*

*Source: Own elaboration.*

Regarding citation distribution, a group of highly cited articles was identified that addressed topics such as the role of forests as carbon sinks, the relationship between biodiversity and the provision of ecosystem services, and the impacts of deforestation on water regulation. The total citation frequency was 107,521 and peaked in 2024 with approximately 2,300 citations to articles on the topic. Likewise, a concentration of citations in a small number of studies was detected, suggesting the need to diversify knowledge sources and promote research in less-represented regions, such as Africa and Latin America.

The analysis of the main areas of disciplinary interrelation revealed that research on forest ecosystem services was inherently interdisciplinary (83.5%). Disciplines such as ecology, environmental science, ecological economics, and sociology stood out for their contributions to the field. This interdisciplinarity reflected the complexity of ecosystem services, which depended on ecological processes and social, economic, and cultural factors. However, less integration of disciplines such as engineering and technology was observed, which represented an opportunity to strengthen innovative approaches to forest management.

Keyword analysis and cross-country co-authorship allowed us to identify the most recurring themes and patterns of international collaboration. Terms such as "biodiversity," "climate change," "forest management," and "economic valuation" were the most frequent, confirming the relevance of these topics on the scientific agenda. Regarding co-authorship, strong collaboration was detected between countries in Europe, North America, and Asia, while developing regions showed more limited participation.

The study identified the main lines of research, which were grouped around the four types of ecosystem services: provision, regulation, support, and cultural. It was observed that regulating services, especially those related to climate and the hydrological cycle, received the most attention in the literature.

On the other hand, cultural services, such as tourism and spiritual values, were the least studied. The study's results reflected a dynamic and growing field of research, but one with significant challenges. The concentration of studies in certain regions and topics, the lack of integration of key disciplines, and the underrepresentation of cultural services were aspects that required future attention.

The findings of the "Forest Ecosystem Services" study revealed significant trends in scientific research between 2020 and 2025, reflecting both advances and challenges in understanding and valuing these ecosystems. The exponential growth in the number of publications demonstrated that forest ecosystem services have established themselves as a priority topic on the global scientific agenda, driven by the urgent need to address issues such as climate change, biodiversity loss, and environmental degradation. This growth was not uniform, as a thematic and geographic concentration was observed, leaving significant gaps to be addressed.

One of the most notable trends was the predominant focus on regulating services, particularly those linked to climate and the hydrological cycle. This was not surprising, given the critical role forests play in mitigating climate change through carbon sequestration and regulating water through watershed protection. However, this focus neglected other equally important services, such as cultural and support services, which are fundamental to human well-being and ecosystem resilience.

Another relevant aspect was the interdisciplinary nature of research in this field. The integration of disciplines such as ecology, ecological economics, and sociology allowed for a holistic approach to ecosystem services, recognizing their multidimensionality. The lower participation of areas such as engineering and technology suggested a missed opportunity to incorporate innovative solutions in forest management. For example, the use of emerging technologies, such as artificial intelligence and remote monitoring systems, could improve the efficiency of assessing and conserving ecosystem services, especially in hard-to-reach regions.

The geographic distribution of publications and co-authorship patterns were also topics of discussion. While strong collaboration among developed countries was observed, participation from regions such as Africa and Latin America was limited, despite being home to some of the most biodiverse forests on the planet. This disparity reflected inequalities in research capacity and the need to strengthen collaborative networks that include scientists and local communities in these regions. Incorporating traditional and local knowledge into scientific research could enrich the understanding of ecosystem services and promote more inclusive and effective conservation strategies. The following figure shows that the largest number of publications on the topic came from authors and institutions in China (n=2,697), and their highest frequency was reached in 2022 (Figure 2).

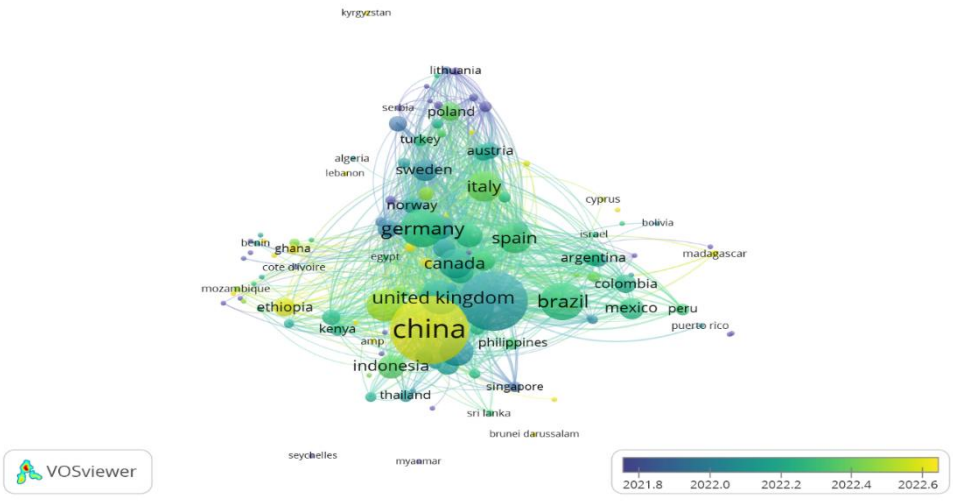


***Figure 2.*** *– Country density map*

*Source: Own elaboration.*

The study highlighted the importance of moving toward a comprehensive valuation of ecosystem services, which considers their economic dimension and their ecological, social, and cultural value. The lack of studies on cultural and support services represented a significant gap, as these services are essential for human well-being and ecosystem sustainability. Furthermore, the study emphasized the need to address research gaps in regions with high biological diversity but less scientific representation, which would allow for the generation of more balanced and representative knowledge.

The study's findings provided a comprehensive overview of the state of knowledge regarding forest ecosystem services and presented challenges and opportunities for future research. In a context of growing environmental and social pressure, scientific research has emerged as a fundamental pillar for promoting the conservation and sustainable use of these ecosystems, contributing to building a more resilient and equitable future.

The results obtained reflect an increase in scientific production related to forest ecosystem services, which is related to the global trend toward revaluing natural resources from an ecosystemic and interdisciplinary perspective. Now, the increase in knowledge production between 2020 and 2024 reflects greater academic interest in the subject at hand. Specifically, Costanza et al. (1997, 2014) highlighted the importance of internalizing ecosystem values in economic and planning decisions.

The high frequency of keywords such as “biodiversity” and “climate” " change " highlights the academic alarm surrounding ecological deterioration in relation to the loss of biological diversity and the consequences of climate variability. This is argued by Díaz *et al.* (2015), who assert that ecosystem services should be analyzed considering biodiversity as a functional basis. Similarly, the predominance of the thematic axis over economic valuation demonstrates a growing desire to make visible the intangible benefits of ecosystems, as proposed by Farley and Costanza (2010).

While most studies focused on topics such as climate change mitigation, biodiversity conservation and the sustainable management of forest resources and management with the community, this coincided with the global priorities established in international

agendas such as the Sustainable Development Goals (SDGs) and the Paris Agreement (Arévalo *et al.*, 2023).

Regarding the distribution of citations, it coincides with the study carried out by Faria *et al.,* (2025), who identified a group of highly cited articles that addressed topics such as the role of forests as carbon sinks, the relationship between biodiversity and the provision of ecosystem services, and the impacts of deforestation on water regulation.

Similarly, with what was proposed by Gonzáles Vallejo (2023), who found that research on forest ecosystem services is quite interdisciplinary. This interdisciplinarity reflected the complexity of ecosystem services, which depended on ecological processes and social, economic and cultural factors. However, there was less integration of disciplines such as engineering and technology, which represented an opportunity to strengthen innovative approaches in forest management (Xu *et al.*, 2024; Zhang, 2025).

The exponential growth in the number of publications showed that the ecosystem services of forests were consolidated as a priority issue on the global scientific agenda, driven by the urgency of addressing problems such as climate change, biodiversity loss and environmental degradation (Kassun *et al.*, 2024; 2025). This growth was not homogeneous, as a thematic and geographic concentration was observed, leaving important gaps to be resolved.

However, this focus has left other equally important services, such as cultural and support services, in the background, which are fundamental to human well-being and ecosystem resilience. For example, cultural services, such as tourism and traditional practices, contribute to the economic development of local communities and strengthen the links between people and nature, thus promoting greater environmental awareness (Sánchez Castillo, Gómez Cano *et al.*, 2024).

On the contrary, significant gaps are identified in geographical terms, with sub-Saharan Africa and the Andean-Amazonian regions being the areas with the least academic output on the topic. In this regard, Martínez- Harms and Balvanera (2012) had already indicated the need to broaden the scale of analysis and promote studies based on local ecological knowledge. Along these lines, Berkes *et al.* (2000) argue that it is crucial to

integrate traditional and scientific knowledge into ecosystem management planning, especially in areas rich in biodiversity.

The analysis of co-authorship networks shows a concentration of knowledge in the global north, specifically in universities in the United States, the United Kingdom, China and Germany. This is supported by Liu and Zhang (2020), who state that there is a centralization of scientific production in highly prestigious institutions.

Finally, it is essential to strengthen institutional, scientific, and community capacities to value, conserve, and govern forest ecosystem services from a multi-scale and participatory approach. As Gómez-Baggethun points out, *et al.* (2013), integrating ecological, cultural and economic values into forest management decisions is crucial to moving towards effective sustainability.

## *CONCLUSIONS*

The study identified significant growth in scientific production on forest ecosystem services between 2020 and 2025, reflecting the relevance of this topic on the global agenda. This is closely related to the contemporary environmental crisis generated by the modern civilization model, centered on the idea of progress, which has brought consequences such as climate change, biodiversity loss, pollution, and ecosystem degradation.

Likewise, a thematic concentration was observed in studies of regulating ecosystem services, such as climate change mitigation and water regulation; the opposite was true for cultural and supporting ecosystem services, which received less attention. This situation is due, on the one hand, to the urgency of addressing the ecological crisis and the need to measure and quantify services in a standardized manner. This, in the case of cultural and regulating services, is quite complex, as they involve intangible and symbolic dimensions that are more difficult to measure. In addition, there are two other elements: the payment for environmental services scheme, which is also easier to implement in regulating services, as the latter provides greater visibility of the benefits.

Finally, there is the subjectivity that is often involved in qualitative work with communities, which often generates bias in the scientific information generated.

The analysis of co-authorship among countries revealed strong scientific collaboration in regions such as Europe, North America, and Asia, while developing regions, such as Africa and Latin America, showed more limited participation. This situation reflects the Eurocentrism of science, where the information generated is concentrated precisely in developed countries, neglecting approaches to highly diverse tropical ecosystems, as well as local experiences and knowledge of community-based forest management. This situation has broader consequences, such as the low impact on public policies in these countries and, consequently, unequal access to the benefits that forest services can generate.

While the study's findings demonstrate an interest in an interdisciplinary approach, there is a clear lack of studies that consider a comprehensive assessment of ecosystem services, taking into account their economic dimension and their ecological, social, and cultural value. This would undoubtedly allow this field of knowledge to recognize the value of forests beyond the economic.

## *REFERENCES*

ARÉVALO ZURITA, M., EXPÓSITO GARCÍA, E. y APEZ ARÉVALO, I., 2023. Gestión empresarial y prácticas de equidad e igualdad de género: el caso de la empresa Agroforestal Cafetalera Tercer Frente. Región Científica [en línea], vol. 2, no. 2, [consulta: 28 abril 2025]. ISSN 2954-6168. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=9839638.

AUBIN, I., DESCHÊNES, É., SANTALA, K.R., EMILSON, E.J.S., SCHOONMAKER, A.L., MCINTOSH, A.C.S., BOURGEOIS, B., CARDOU, F., DUPUCH, A., HANDA, I.T., LAPOINTE, M., LAVIGNE, J., MAHEU, A., NADEAU, S., NAETH, M.Anne., NEILSON, E.W. y WIEBE, P.A., 2024. Restoring forest ecosystem services through trait-based ecology. Environmental Reviews, [en

línea] vol. 32, no. 4, pp. 498-524. ISSN 1181-8700. DOI 10.1139/er-2023-0130. Disponible en: https://cdnsciencepub.com/doi/full/10.1139/er-2023-0130

BEKELE, B., WEI, W., TSEGAYE, L., TILAHUN, M., GIRMA, T. y KETEMA, H., 2025. Urban expansion-induced land use land cover changes and the subsequent changes in ecosystem service and land surface temperature in the central highland of Ethiopia. Environmental and Sustainability Indicators, [en línea] vol. 26, pp. 100626. ISSN 2665-9727. DOI 10.1016/j.indic.2025.100626. Disponible en: https://www.sciencedirect.com/science/article/pii/S2665972725000479

BRUNO, I., MANIA, I., LOVERA, M., BRONDINO, L. y PEANO, C., 2025. Vegetation-based Ecological Functions Sustainability Index (VEFSI) for optimizing ecosystem services in orchards. Agricultural Systems, [en línea] vol. 223, pp. 104186. ISSN 0308-521X. DOI 10.1016/j.agsy.2024.104186. Disponible en: https://www.sciencedirect.com/science/article/pii/S0308521X24003366

CAMASTRA, F.D. y GONZÁLEZ VALLEJO, R., 2025. Inteligencia artificial, sostenibilidad e impacto ambiental. Un estudio narrativo y bibliométrico. Región Científica, [en línea] vol. 4, no. 1, pp. 2. ISSN 2954-6168. Disponible en: https://rc.cienciasas.org/index.php/rc/article/view/355/397

DU, X., LEI, X., HE, X., LAN, J., GUO, H. y XU, Q., 2024. Ecosystem service multifunctionality of mixed conifer-broad-leaved forests under climate change and forest management based on matrix growth modelling. Forest Ecosystems, [en línea] vol. 11, pp. 100231. ISSN 2197-5620. DOI 10.1016/j.fecs.2024.100231. Disponible en: https://www.sciencedirect.com/science/article/pii/S2197562024000678

DUQUE RAMOS, A.P., 2024. Estudio sistemático de la participación del marketing ambiental, como método para fomentar la conciencia ambiental de estudiantes universitarios. Región Científica [en línea], vol. 3, no. 2, Disponible en: https://dialnet.unirioja.es/descarga/articulo/9839694.pdf. Disponible en:

DUŞCU, D.-M. y RÎŞNOVEANU, G., 2025. Understanding visitor preferences: Perceived importance of anthropogenic and natural forest features in supplying cultural ecosystem services. Forest Ecosystems, [en línea] vol. 13, pp. 100306. ISSN 2197-5620. DOI 10.1016/j.fecs.2025.100306. Disponible en: https://www.sciencedirect.com/science/article/pii/S2197562025000156

FARIA, B., NUNES, J.P., BAARTMAN, J.E.M., DIAS, L., WU, J. y PRATS, S.A., 2025. Assessing cost-effectiveness of land management measures to restore forest ecosystem services after fire using hydrological modelling and multi-criteria decision analysis. CATENA, [en línea] vol. 251, pp. 108808. ISSN 0341-8162. DOI 10.1016/j.catena.2025.108808. Disponible en: https://www.sciencedirect.com/science/article/pii/S0341816225001109

FORSMAN, A., SUNDE, J., SALIS, R. y FRANZÉN, M., 2024. Latitudinal gradients of biodiversity and ecosystem services in protected and non-protected oak forest areas can inform climate smart conservation. Geography and Sustainability, [en línea] vol. 5, no. 4, pp. 647-659. ISSN 2666-6839. DOI 10.1016/j.geosus.2024.09.002. Disponible en: https://www.sciencedirect.com/science/article/pii/S2666683924000841

HALLAJ, Z., BIJANI, M., KARAMIDEHKORDI, E., YOUSEFPOUR, R. y YOUSEFZADEH, H., 2024. Forest land use change effects on biodiversity ecosystem services and human well-being: A systematic analysis. Environmental and Sustainability Indicators, [en línea] vol. 23, pp. 100445. ISSN 2665-9727. DOI 10.1016/j.indic.2024.100445. Disponible en: https://www.sciencedirect.com/science/article/pii/S2665972724001132

HELSETH, E.V., VEDELD, P. y GÓMEZ-BAGGETHUN, E., 2024. Balancing investments in ecosystem services for sustainable forest governance. Forest Policy and Economics, [en línea] vol. 169, pp. 103364. ISSN 1389-9341. DOI 10.1016/j.forpol.2024.103364. Disponible en: https://www.sciencedirect.com/science/article/pii/S1389934124002181

HERTEGÅRD, E. y WIDMARK, C., 2025. Policy integration of forest ecosystem services-Cases of Catalonia, Estonia, Grisons, and Hesse and Thuringia. Land Use Policy, [en línea] vol. 151, pp. 107478. ISSN 0264-8377. DOI 10.1016/j.landusepol.2025.107478. Disponible en: https://www.sciencedirect.com/science/article/pii/S0264837725000110

HUANG, Z., LI, S., PENG, J., MA, X., DING, H., CHENG, F. y BI, R., 2024. Assessing ecosystem service dynamics and drivers for sustainable management in the Agro-pastoral ecotone of northern China: A spatiotemporal analysis. Ecological Indicators, [en línea] vol. 165, pp. 112213. ISSN 1470-160X. DOI 10.1016/j.ecolind.2024.112213. Disponible en: https://www.sciencedirect.com/science/article/pii/S1470160X24006708

JO, J.-H., CHOI, M., KWEON, D., SON, Y.-G. y LIM, E.M., 2024. Regulating ecosystem services in a local forest: Navigating supply, trade-offs, and synergies. Trees, Forests and People, [en línea] vol. 15, pp. 100466. ISSN 2666-7193. DOI 10.1016/j.tfp.2023.100466. Disponible en: https://www.sciencedirect.com/science/article/pii/S2666719323000985

KASSUN, B.W., KALLIO, M., TRØMBORG, E. y RANNESTAD, M.M., 2025. Land use and land cover change, trade-offs, and synergies between ecosystem services in a dry Afromontane Forest. Journal for Nature Conservation, [en línea] vol. 85, pp. 126874. ISSN 1617-1381. DOI 10.1016/j.jnc.2025.126874. Disponible en: https://www.sciencedirect.com/science/article/pii/S1617138125000512

KASSUN, B.W., MAARIT I. KALLIO, A., TRØMBORG, E. y MEKONEN RANNESTAD, M., 2024. Vegetation density and altitude determine the supply of dry Afromontane forest ecosystem services: Evidence from Ethiopia. Forest Ecology and Management, [en línea] vol. 552, pp. 121561. ISSN 0378-1127. DOI 10.1016/j.foreco.2023.121561. Disponible en: https://www.sciencedirect.com/science/article/pii/S0378112723007958

KRSNIK, G., REYNOLDS, K., MURPHY, P., PAPLANUS, S., GARCIA-GONZALO, J. y OLABARRIA, J.R.G., 2023. Forest use suitability: Towards decision-making-oriented sustainable management of forest ecosystem services. Geography and

Sustainability, [en línea] vol. 4, no. 4, pp. 414-427. DOI 10.1016/j.geosus.2023.09.002. Disponible en: https://www.researchgate.net/publication/373877283_Forest_use_suitability_Towards_decision-making-oriented_sustainable_management_of_forest_ecosystem_services

LI, X., CHEN, Y., LIU, Q. y LIU, Y., 2025. Forest management interventions affect the trade-offs of multiple vegetation and soil ecosystem services in walnut forests in the Taihang Mountains, China. Global Ecology and Conservation [en línea], vol. 57, [consulta: 28 abril 2025]. ISSN 2351-9894. DOI 10.1016/j.gecco.2025.e03420. Disponible en: https://www.sciencedirect.com/science/article/pii/S2351989425000216.

LI, X. y WU, C., 2025. Sensitivity assessment and simulation of ecosystem services in response to land use change in arid regions: Empirical evidence from Xinjiang, China. Ecological Indicators, [en línea] vol. 171, pp. 113150. ISSN 1470-160X. DOI 10.1016/j.ecolind.2025.113150. Disponible en: https://www.sciencedirect.com/science/article/pii/S1470160X25000792

MOGES, A., DIBABA, A. y WOLDEAREGAY, M., 2024. Anthropogenic effects and ecosystem services of tropical highland forests in Ethiopia. Global Ecology and Conservation [en línea], vol. 55, [consulta: 28 abril 2025]. ISSN 2351-9894. DOI 10.1016/j.gecco.2024.e03237. Disponible en: https://www.sciencedirect.com/science/article/pii/S2351989424004414.

MOREIRA, A. de J. y REIS FONSECA, R.M., 2024. La inserción de los movimientos sociales en la protección del medio ambiente: cuerpos y aprendizajes en el Recôncavo da Bahia. Región Científica, [en línea] vol. 3, no. 1, pp. 9. ISSN 2954-6168. Disponible en: https://rc.cienciasas.org/index.php/rc/article/view/208

SAILO, R.L., SARKAR, B.C., APSHAHANA, K., DABRAL, A., JILEN, A., MARAK, A.D., SHUKLA, G., SURESH, C.P. y CHAKRAVARTHY, S., 2025. Perceptions of ecosystem services and disservices of bamboo by indigenous communities in Northeast India. Advances in Bamboo Science, [en línea] vol. 10, pp. 100135. ISSN

2773-1391. DOI 10.1016/j.bamboo.2025.100135. Disponible en: https://www.sciencedirect.com/science/article/pii/S277313912500014X

SANABRIA MARTÍNEZ, M.J., 2022. Construir nuevos espacios sostenibles respetando la diversidad cultural desde el nivel local. Región Científica, [en línea] vol. 1, no. 1, pp. 1. ISSN 2954-6168. Disponible en: https://rc.cienciasas.org/index.php/rc/article/view/2

SÁNCHEZ CASTILLO, V., GÓMEZ CANO, C.A. y PÉREZ GAMBOA, A.J., 2025. La Economía Azul en el contexto de los objetivos del desarrollo sostenible: una revisión mixta e integrada de la literatura en la base de datos Scopus. Aibi revista de investigación administración e ingeniería, [en línea] vol. 12, no. 2, pp. 215-230. ISSN 2346-030X. Disponible en: https://revistas.udes.edu.co/aibi/article/view/4028

SÁNCHEZ CASTILLO, V., PÉREZ GAMBOA, A.J. y GÓMEZ CANO, C.A., 2024. Trends and evolution of scientometric and bibliometric research in the Scopus database. Revista Bibliotecas. Anales de Investigación [en línea], vol. 20, no. 1, Disponible en: https://dialnet.unirioja.es/descarga/articulo/9740327.pdf. Disponible en: https://dialnet.unirioja.es/descarga/articulo/9740327.pdf

SHARMA, G., MORGENROTH, J., RICHARDS, D.R. y YE, N., 2025. Advancing urban forest and ecosystem service assessment through the integration of remote sensing and i-Tree Eco: A systematic review. Urban Forestry & Urban Greening, [en línea] vol. 104, pp. 128659. ISSN 1618-8667. DOI 10.1016/j.ufug.2024.128659. Disponible en: https://www.sciencedirect.com/science/article/pii/S1618866724004576

SPRINZ, D.F., SCHAEFERS, T.V., LENK, F. y KROTT, M., 2024. Forecasting forest-related political decisions in a climate-constrained world – The remuneration of forest ecosystem services in Germany. Forest Policy and Economics, [en línea] vol. 169, pp. 103231. ISSN 1389-9341. DOI 10.1016/j.forpol.2024.103231. Disponible en: https://www.sciencedirect.com/science/article/pii/S1389934124000844

SULLIVAN, M.K., VLEMINCKX, J., BISSIEMOU, P.A.M., NIANGADOUMA, R., MAYOUNGOU, M.I., TEMBA, J.L., BÉNÉDET, F., ABERNETHY, K., QUEENBOROUGH, S.A. y COMITA, L.S., 2024. Low-intensity logging alters species and functional composition, but does not negatively impact key ecosystem services in a Central African tropical forest. Global Ecology and Conservation [en línea], vol. 53, [consulta: 29 abril 2025]. ISSN 2351-9894. DOI 10.1016/j.gecco.2024.e02996. Disponible en: https://www.sciencedirect.com/science/article/pii/S2351989424002002.

TORIYAMA, J., HASHIMOTO, S., NAKAO, K., SAITOH, T.M., NISHIZONO, T., UCHIYAMA, K., ARAKI, M.G., MURAKAMI, W. y HIRATA, Y., 2025. Management strategies for shrinking and aging tree plantations are constrained by the synergies and trade-offs between carbon sequestration and other forest ecosystem services. Journal of Environmental Management, [en línea] vol. 373, pp. 123762. ISSN 0301-4797. DOI 10.1016/j.jenvman.2024.123762. Disponible en: https://www.sciencedirect.com/science/article/pii/S0301479724037484

XU, L., HE, Y., ZHANG, L., BAO, G. y XU, H., 2024. Spatial variation in ecosystem service relationships in alpine ecosystems: A case study of the Daxing'anling forest area, Inner Mongolia. Ecological Indicators, [en línea] vol. 166, pp. 112351. ISSN 1470-160X. DOI 10.1016/j.ecolind.2024.112351. Disponible en: https://doaj.org/article/75b9b5ee11a44e01a992abd2d59a6008

YOU, C., QU, H. y GUO, L., 2024. A framework of composite factors for assessing ecosystem service supply drivers: A sustainable socio-ecological perspective. Ecological Indicators, [en línea] vol. 169, pp. 112811. ISSN 1470-160X. DOI 10.1016/j.ecolind.2024.112811. Disponible en: https://www.sciencedirect.com/science/article/pii/S1470160X24012688

ZHAI, T., MA, Y., HUANG, L., LU, Y., LI, L., CHEN, Y., CHANG, M. y MA, Z., 2025. Research on the spatiotemporal evolution characteristics and driving mechanisms of supply–demand risks of ecosystem services in the yellow river basin integrating the hierarchy of needs theory. Ecological Indicators, [en línea] vol. 171, pp. 113229. ISSN 1470-160X. DOI 10.1016/j.ecolind.2025.113229.

Disponible en: https://www.sciencedirect.com/science/article/pii/S1470160X2500158X

ZHANG, B., 2025. Perceptions of trade-offs between urban forest ecosystem services and disservices: A case study of Canberra, Australia. Urban Forestry & Urban Greening, [en línea] vol. 105, pp. 128711. ISSN 1618-8667. DOI 10.1016/j.ufug.2025.128711. Disponible en: https://www.sciencedirect.com/science/article/pii/S1618866725000457

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The authors declare no conflicts of interest.

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The authors have participated in the writing of the work and analysis of the documents.