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Trends in High Nature Value Farmland and Ecosystem Services Valuation: A Bibliometric Review

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Abstract: High Nature Value farmland (HNVf) represents a rural landscape characterized by extensive farming practices. These lands not only deliver vital ecosystem services (ES) but also serve as significant harbors of biodiversity, underscoring their critical conservation status. Consequently, European Union countries have prioritized the identification, monitoring, and enhancement of HNVf systems in their policies. As governments and international organizations increasingly lean on green subsidies to promote sustainable environmental practices, the valuation of ecosystem services (VES) emerges as a crucial tool. This valuation offers both an economic rationale for conservation and aids in determining the optimal allocation of these subsidies for maximum environmental and economic return on investment. Given the potential for such valuations to shape and justify conservation subsidies, there is a growing imperative to understand the research trends and knowledge gaps in this realm. This article, through a bibliometric review, seeks to illuminate the size, growth trajectory, and thematic tendencies within HNVf and VES literature. Bibliometric analysis is recognized as promising in identifying research trends; thus, this article consists of a bibliometric review of HNVf and VES research. The objective is to identify the size, growth trajectory, and geographic distribution of HNVf and VES literature between the first publication until 2022, while assessing the critical publishing journals, authors, documents, and conceptual structure of the research fields (e.g., economic, social, and environmental). The analysis revealed a predominant concentration of research on HNVf in Europe, with limited studies conducted outside this continent. The primary focus of these studies revolved around subject areas such as environmental science, agriculture, and biological sciences. Conversely, regarding research on VES, there was no clear regional concentration. VES research publications mainly covered the interdisciplinary fields of economics, biology, and policymaking. As the fields of HNVf and VES have evolved, it is evident that there has been a stronger push towards data-driven approaches, emphasizing the need for tangible assessments and precise understanding. In examining the overlap between topics, the analysis revealed a gap between methodologies for HNVf monitoring and conservation and VES, highlighting the need for further development in crafting an integrated approach encompassing both areas.

Keywords: high nature value farmland; valuing ecosystem services; bibliometric review; science mapping

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1. Introduction

Historically, a considerable proportion of agricultural and forestry activities in Europe were considered to have high natural value [1]. However, technological advances in the twentieth century—including advances in mechanization, fertilizers, and pesticides—effectively eliminated barriers to the intense exploitation of soil's productive potential [2]. Unsustainable agricultural practices are frequently identified as the primary instigators of numerous

environmental disruptions. The repercussions of such activities extend far beyond immediate regional impacts, leading to irreversible loss of extensive, ecologically significant agricultural areas. On a global scale, the intensification of these practices has exerted considerable influence on habitats, biodiversity, and the provision of ES [3–6]. The detriments manifest in varied forms, including landscape homogenization and biodiversity loss, underscoring the vital importance of shifting towards more sustainable agricultural techniques. Such techniques, mindful of ecological equilibrium and long-term resource conservation, offer the potential to mitigate these detrimental effects and promote more harmonious interactions between agriculture and the environment [7–11].

High Nature Value farmland (HNVf) is a concept coined in the early 1990s as a strategic instrument to typify and aid in protecting European farming systems with high biodiversity value. HNVf embodies critical ecosystem services essential to environmental sustainability and human welfare. These landscapes, characterized by their biodiversity, facilitate ecosystem functions ranging from maintaining soil fertility and carbon sequestration to crucial services like water purification and pollination [12–16]. However, comprehensive evaluation of these functions surpasses mere ecological parameters. They encompass considerable economic, social, and cultural implications, impacting both localized economies and broader global frameworks, shaping community livelihoods and resonating with cultural values [17–25].

Despite the acknowledged importance of HNVf and VES research and the research efforts made, there remains a need for continued exploration. The current literature often misses an integrated approach for HNVf identification, qualification, and monitoring. A lack of standardized frameworks leads to varied identifications and protections across regions. Although the ecological importance of HNVf is documented [26–44], there is a need to understand the relationships between communities, land management, and conservation. Furthermore, many critical ecosystem services of HNVf are either undervalued or ignored in economic evaluations [45–65].

To analyze the rapid growth and complexity associated with research on HNVf and VES, bibliometric analysis provides a systematic and unbiased way to map out the vast domain of knowledge. It not only captures the most influential works and emerging themes but also enables identification of potential gaps and trends in the research community [66,67]. The technique unveils pivotal intersections across diverse research areas, highlighting collaborative patterns and setting the stage for future interdisciplinary research [68–70]. By employing this approach, our study aims to present a thorough overview of the existing body of knowledge on HNVf and VES [54,71,72].

2. Review Framework

Bibliometric techniques, recognized for their strengths in citation analysis and data mining, were employed in our study [73]. Utilizing tools like VOSviewer, NetDraw, and BibExcel, we processed data from renowned sources that allowed us to pinpoint dominant research trends and provide a holistic overview of the subject's evolution [74,75]. Thus, such a review provided a comprehensive view of the network and structure of the field of interest. The methodological approach is shown in Figure 1.

Essentially, the article reviewed state-of-the-art research in HNV, specifically, HNVf and VES.

The review applied science mapping techniques to produce a bibliometric synthesis of research trends identified in Scopus-indexed publications [76,77]. To correctly analyze the body of literature, the review considered four dimensions [78]:

- Size: Quantity of gathered knowledge.
- Time: Publication evolution within the research field.
- Space: Geographic source of publications within the domain.
- Composition: Intellectual composition of the knowledge base.

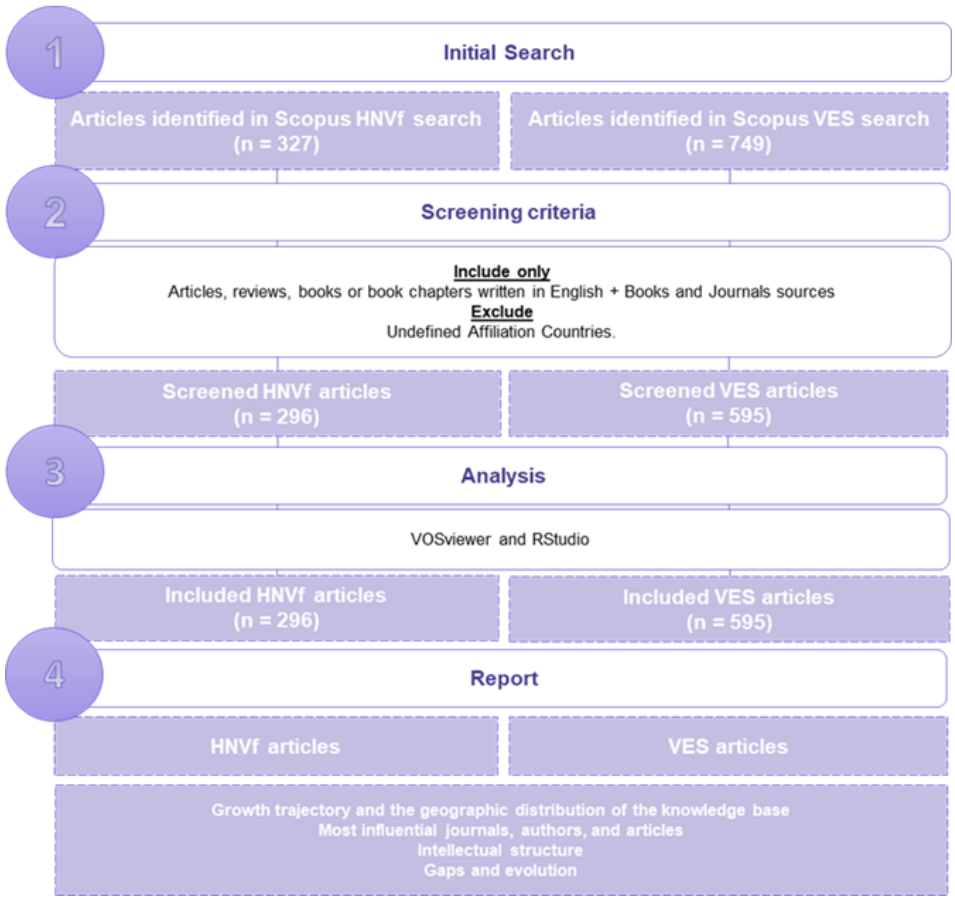

Figure 1. Methodological approach.

The first step consisted of ascertaining the search criteria. For this purpose, PRISMA guidelines were applied to ensure the scientific quality and transparent selection of the articles for analysis [79]. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 provides a framework for reporting systematic reviews and meta-analyses to ensure comprehensive and transparent presentation. One of the crucial steps in a review is the literature search, and PRISMA 2020 offers specific recommendations regarding the search process, such as the reporting of information sources, search criteria used, and study selection process. Secondly, Boolean operators were used to extract data from the selected scientific literature platform, Scopus. The choice of only using Scopus was based on the fact that it is the largest database of peer-reviewed literature and widely used to create datasets for reviews. The Elsevier Scopus database is also considered to be more comprehensive in representing research in social sciences, thus incorporating the social and cultural facets of VES and HNVf [80]. Moreover, there has been increasing overlap between Scopus and the Thompson Reuter Web of Science [81]. The third step involved data analysis through bibliometric methods and finally, the fourth and last step, consisted of interpreting and visualizing the results.

2.1. Search Criteria and Data Extraction

Initially, two separate searches were conducted: one delving into the scientific domain of HNVf, and the other examining VES. After the initial review, it became evident that only one article connected HNV and VES, while no articles bridged HNVf and VES. Prompted by this revelation, a further more targeted search was conducted to investigate connections between these research areas, particularly focusing on articles that might weave together HNVf and ES. While our main goal was to map out the principal research themes, this

third exploration was vital to understand, highlight, and navigate apparent gaps when considering the confluence of both subjects.

The initial search encompassed a comprehensive review of all documents published until December 2022. The search was carried out using the Boolean operator "OR" since we wanted to include all documents that used specific terms. These terms were used to search all records that mentioned them in either their title, abstract, or keywords:

- TITLE-ABS-KEY ("high nature value" OR "hnv farmland" OR "hnv farming" OR "high nature value farmland" OR "high nature value farming").
- TITLE-ABS-KEY ("valuing ecosystem services" OR "valuation ecosystem services" OR "ecosystem services valuation" OR "ecosystem services valuing" OR "modeling ecosystem services" OR "ecosystem services modeling").
- TITLE-ABS-KEY ("hnv farmland" OR "hnv farming" OR "high nature value farmland" OR "high nature value farming") AND TITLE-ABS-KEY ("ecosystem services").

Following a brief analysis of the initial search results, the screening criteria were defined, as shown in Figure 1. Originally, only particular subject areas were considered; however, after several search attempts, all subject areas were included since the corresponding featured articles offered valuable insight for this bibliometric review.

Finally, the dataset was extracted from Scopus as a comma-separated values file (.csv) for use in VOSviewer software 1.6.16 and a BibTeX Bibliographical Database file (.bib) for use in the Bibliometrix package in R [81]. The extracted data included the author name(s), author affiliation(s), article title, keywords, abstract, and multiple citation data.

2.2. Data Analysis

The data analysis in this review relied on descriptive statistics and bibliometric analysis. The descriptive statistics were obtained using Bibliometrix in R. The software used to carry out the bibliometric analysis and visualization of the results was VOSviewer, a tool for visualizing data in network maps [74]. VOSviewer was used because it allowed us to map the knowledge present in the selected materials (Table 1).

Table 1. Types of VOSviewer analysis of bibliographic data [70].

Type of Analysis	Description
Co-authorship	Established based on the number of co-authored documents.
Citation	Established based on the number of times the articles cite each other.
Co-citation	Established based on the number of times the articles are cited together.
Bibliographic coupling	Established based on the number of shared references.

VOSviewer was used since it can provide information such as the affiliation of authors working in these matters; the journals that publish more articles on the subject; the most cited authors or documents; which authors work together; and the essential concepts in each research field. Network maps were created utilizing bibliographic and text data to enable visualization and a more simplified examination of the linkages that existed between authors, documents, and study fields. For the bibliographic data, co-authorship and citation analyses were applied, and for text data, the most mentioned terms were extracted. R software's 4.2.1 Bibliometrix package was used to enhance the exploration of the findings obtained from VOSviewer and employ different visualization techniques. Also, a methodology proposed by Pagani et al. [82] was used regarding the most influential documents in order to rank them. This methodology sorted the articles using the InOrdinatio (*IO*) equation to find the rank index, as follows:

$$IO = (IF/1000) + (\alpha * (10 - (Y_r - Y_p))) + (\sum C_i),$$

where *IF* refers to the journal impact factor, Y_r is the year when the data was collected, Y_p is the publication year of the article, and $\sum C_i$ is the total citations of an article between Y_p and, Y_r. Finally, α is a weighting element, ranging between 1 and 10. For a value of α closer

to 1, lower importance is given to the year criterion. Considering recent publications, the year criterion was most important for subjects such as HNVf and VES. Therefore, $\alpha = 10$ was used. In addition, IF is accounted for as a ratio of 1000, to be normalized concerning the other criteria.

Finally, to gain a deeper understanding of the relationship between the two research topics, articles that addressed both realms were thoroughly analyzed.

3. Results and Discussion

The data extraction yielded 296 documents related to HNVf research from 131 sources, with the first document published in 1997. The VES search generated 595 documents from 160 sources, with the earliest dating back to 1998 (Table 2). The most common types of documents were articles followed by book chapters in HNVf research and reviews in VES research. Despite the difference in the number of documents between the two research fields, they both showcased a similar number of authors. This indicated potential interest from scientists across various subject areas in HNVf research.

Table 2. Main information about the two research topics.

	HNVf Research	**VES Research**
Period	1997–2022	1998–2022
Documents	296	595
Articles	269	492
Reviews	8	50
Books	2	10
Book Chapters	17	43
Authors	160	159
Sources	131	160

3.1. Growth Trajectory and Geographic Distribution

The foundation stages for the exploration of HNVf and VES research originated in 1992 (Figure 2), highlighted by the Convention on Biological Diversity [83], which underscored the value of preserving biological diversity, making sustainable use of its elements, and distributing benefits resulting from the exploitation of genetic resources fairly and equally. In subsequent years, vital reports, particularly from the IEEP [84,85], emphasized the importance of conserving European farmlands known for their biodiversity richness. From 1997 to 2010, regarded as the foundation phase, both realms of research experienced a modest but steady increase in publications, with only 7% of documents produced during this period. Also, it was during this period that new and already existent frameworks and policies laid the groundwork for understanding and preserving biodiversity on agricultural land. The term HNVf, introduced by Baldock et al. [86], gained traction during this phase, with an emphasis on conservation value in Europe, especially through the continuation of low-intensity farming systems [87,88]. During the same period, the domain of VES research was boosted by key frameworks such as the Millennium Ecosystem Assessment (MEA) [89], which elucidated the economic and societal value of ecosystems. The Economics of Ecosystems and Biodiversity (TEEB) [20] report further anchored the significance of VES, emphasizing the need to integrate ecological and economic dimensions in assessing biodiversity and ecosystem services.

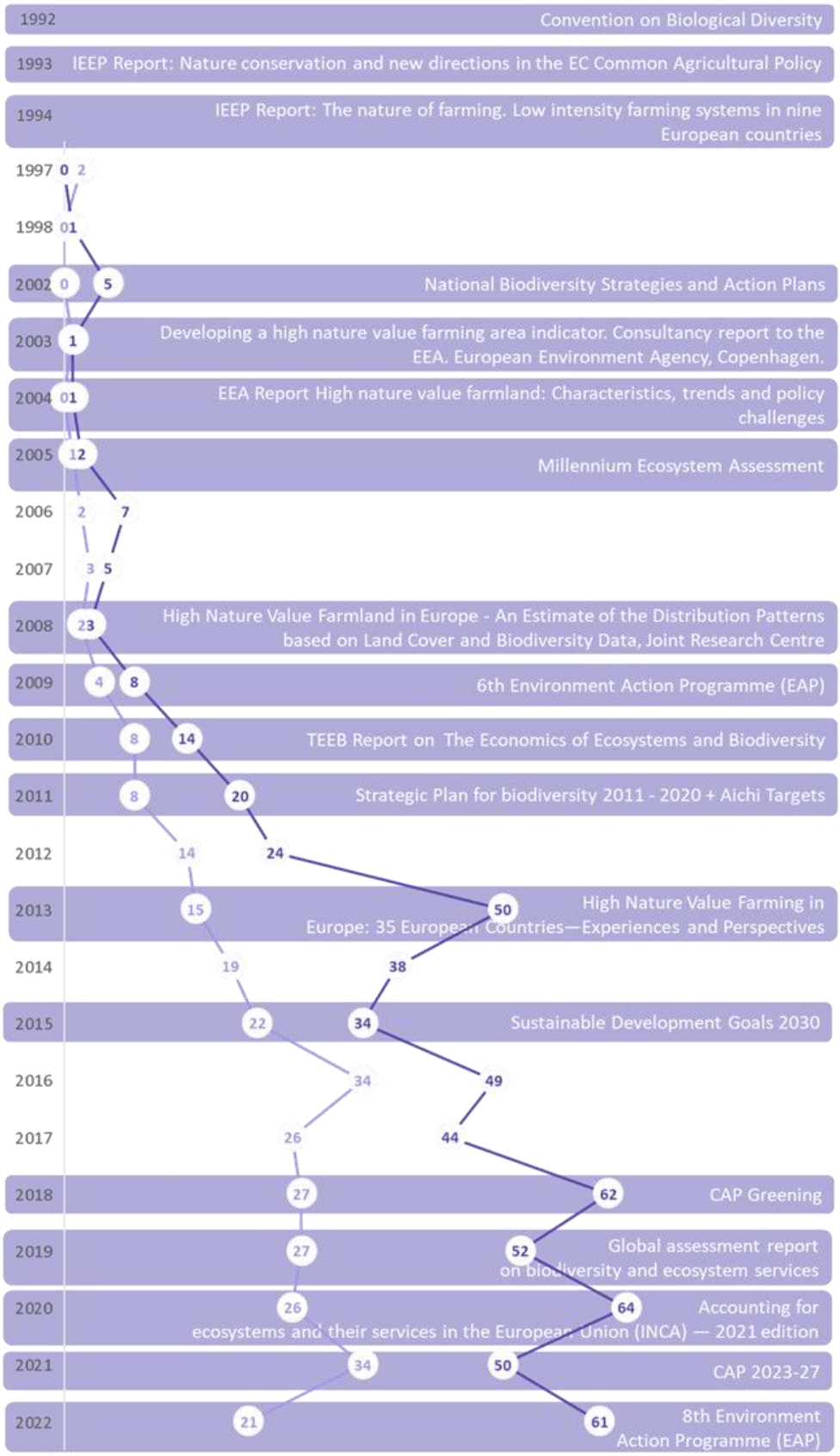

Figure 2. Publication trajectory by year and important developments, 1997–2022.

From 2011 to 2022, the research trajectory underwent a transformative phase, marked by an accentuated increase in publications (comprising 96% of documents). By 2011, both fields showed a tendency for growth in publications, with VES research showing a more pronounced increase. From 2011 onwards, VES research continued a rapid ascent, with a notable boost that might have been related to the upcoming United Nations summit for adoption of the post-2015 development agenda (the 2030 Agenda for Sustainable Development) [90]. HNVf research, meanwhile, experienced a leap by 2016, possibly spurred by strategic plans for biodiversity, including Aichi biodiversity targets, CAP Greening, and other influential documents [91–93]. From 2018 onwards, VES research maintained its dominant position, with the Global Assessment Report on Biodiversity and Ecosystem Services acting as a potential catalyst [94]. In contrast, growth in HNVf research was more measured. In 2021, while HNVf publications plateaued, VES publications surged, reflecting the drive to integrate ecosystem services into broader policy and economic frameworks, as seen with the release of Accounting for Ecosystems in the European Union by INCA [95]. By 2022, both fields displayed growth, with VES research remaining more prolific, although HNVf research showed signs of resurgence. The trends in 2022 emphasized the ongoing relevance of both areas, informed by the anticipation of policies such as the CAP 2023–27 [96] and the Environment Action Programme to 2030 [97]. In summary, both HNVf and VES research experienced significant growth over the years, shaped by global conventions, reports, and evolving research paradigms. The timeline suggests a maturing field, with opportunities for further exploration, especially in standardizing definitions, criteria, and accurate valuation methods for ecosystem services.

Regarding the geographic distribution of the published documents, 47 countries contributed to HNVf research. European countries were the most productive (97% of all publications). Among European countries, Germany, Portugal, Spain, the United Kingdom, and Italy were the top five publishing countries, contributing 56% of published documents.

Figure 3 also shows the top ten countries by the number of publications and citations. Despite having fewer documents published in the field of HNVf research, the United Kingdom exerted more influence than nations such as Portugal and Spain due to the higher total citation count. Although the latter countries had higher number of publications, they received fewer citations, implying a lower impact in the field.

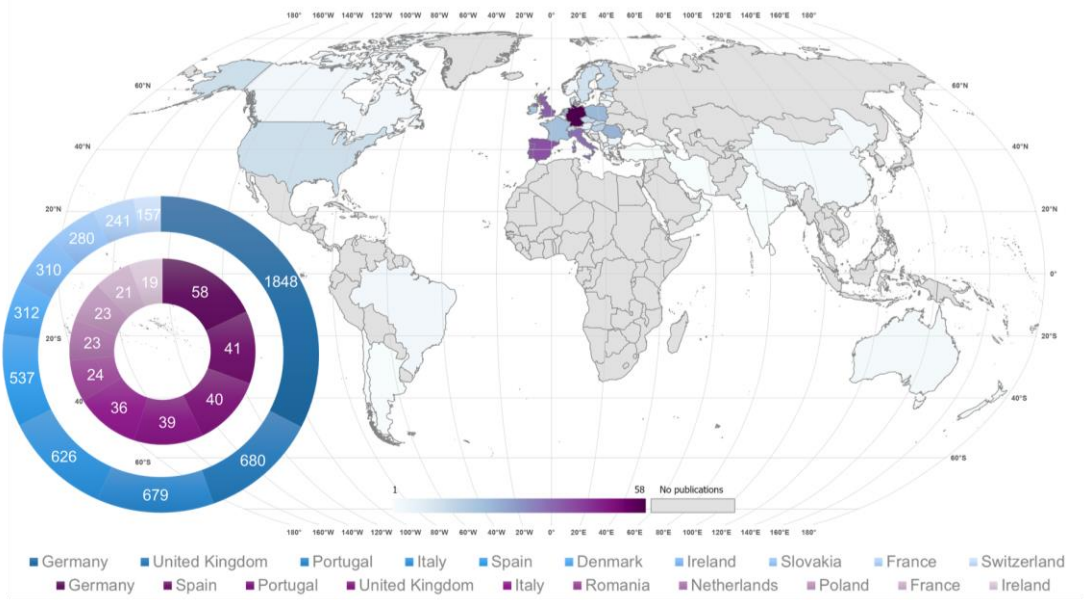

Figure 3. Academic production by country for HNVf research between 1997 and 2022 (inner circle = total of documents; outer circle = total citations).

For VES research, the distribution of published documents was wider, involving a higher number of countries, 78 to be exact. As seen in Figure 4, the most productive countries were the United States (36%), the United Kingdom (17%), China (12%), Australia (11%), and Germany (8%). However, the number of citations received by China's research did not match the highest impact of publications in the Netherlands; despite fewer studies being published than in China, research in the Netherlands received a higher number of citations.

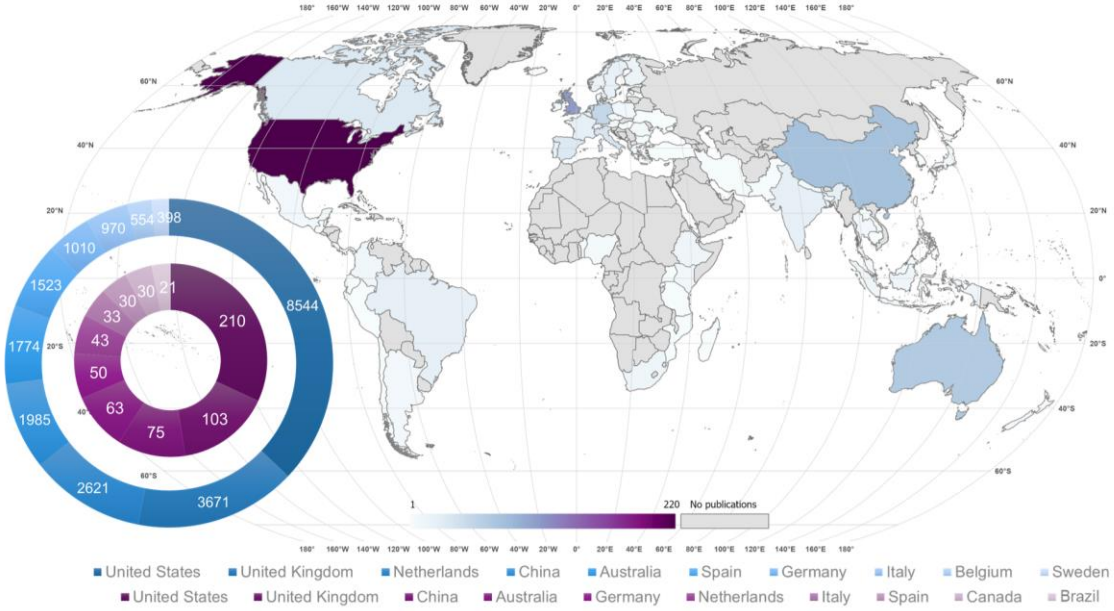

Figure 4. Academic production by country for VES research between 1998 and 2022 (inner circle = total of documents; outer circle = total citations).

Regarding collaboration between countries (Figure 5), HNVf research in Europe emerged as a focal point. Spain, in particular, stood out with consistent high-volume publications. Other consistent European contributors included Portugal, Germany, Italy, France, and Ireland. Outside Europe, the United States demonstrated research interest, particularly around 2013. Recent years also witnessed new interest in countries such as China and India, marking their presence in this research domain. The heatmap hinted at shared research trajectories. For instance, Spain, Portugal, and Germany clustered closely, indicating parallel research interests or collaborations. Similarly, the grouping of Ireland, the UK, and the USA might suggest shared methodologies or research focus. Geographically distant yet ecologically similar countries, like Australia, New Zealand, and Fiji, also clustered together, potentially pointing towards shared ecological challenges or research perspectives.

Regarding VES research (Figure 6), North America, particularly the United States, was consistently at the forefront of VES research, with high publication counts. Canada followed, with a less intense but steady contribution. In Europe, the United Kingdom, Spain, Germany, and the Netherlands displayed significant research output, emphasizing their central role in the European VES research landscape. Notably, countries with emerging economies, like China and India, exhibited a late but rapid surge in publications, indicating their growing research capacity and interest in this research domain. The dendrogram's hierarchical clustering suggested potential research affinities. For instance, Spain, Portugal, and the Netherlands clustered closely, which might signify shared research themes or collaborations. Likewise, countries such as South Korea, Indonesia, and Malaysia formed a distinct cluster, pointing towards potential regional collaborations or similar ecological contexts.

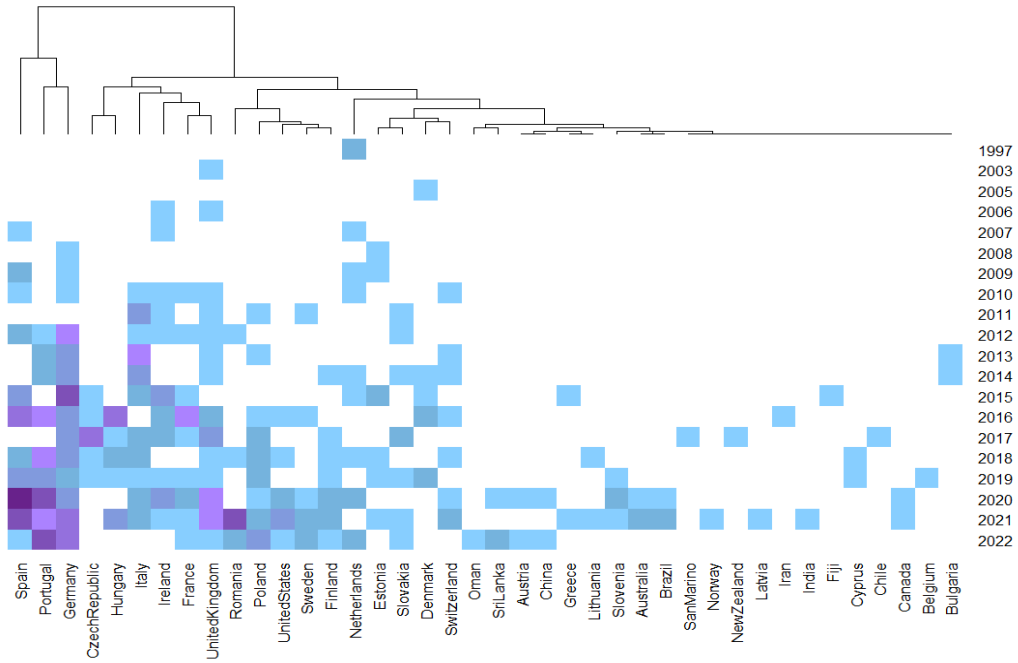

Figure 5. Heatmap and dendrogram for the number of documents per country and year of publication for HNVf research (purple = higher number of publications; light blue = lowest number of publications).

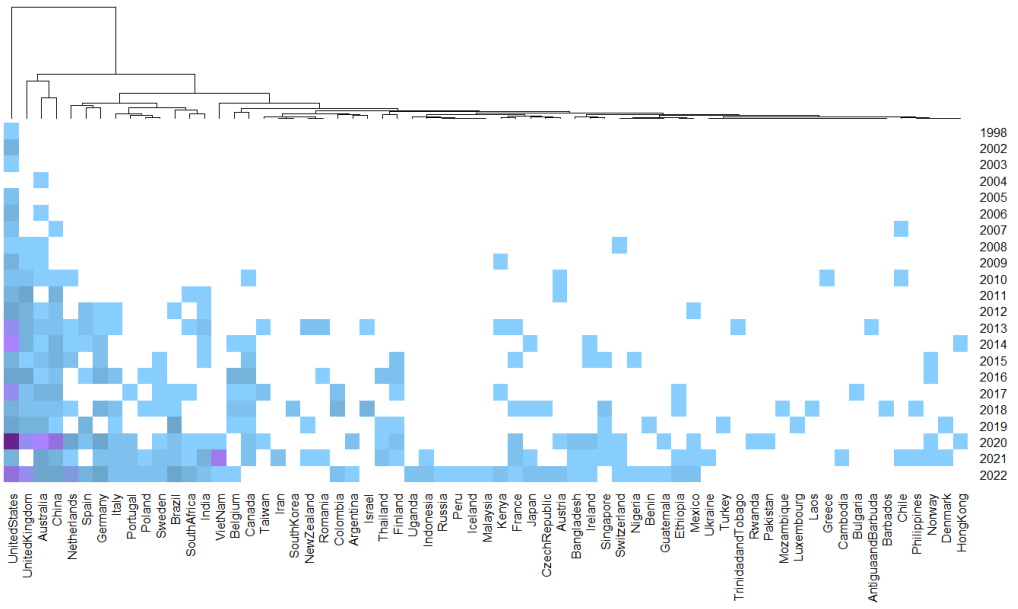

Figure 6. Heatmap and dendrogram for the number of documents per country and year of publication for VES research (purple = higher number of publications; light blue = lower number of publications).

A broad range of countries, including Mexico, South Africa, and Saudi Arabia, showed sporadic but relevant contributions over the years, highlighting the global appeal and significance of VES research.

Finally, a simple examination of publications by affiliation in both disciplines of research was carried out (Figure 7). While German institutions held greater influence in HNVf research based on the number of published documents and citations, Portuguese universities such as Évora and Lisbon Universities exhibited a higher frequency in overall studies. In the field of VES research, Stanford University stood out as the foremost insti-

tution, while Beijing Normal University and other institutions displayed a comparable frequency of contributions.

Figure 7. Institutions with the highest presence (frequency) in HNVf (**right**) and VES (**left**) research.

3.2. Intellectual Structure: Influential Authors, Publications, and Journals

This section analyses the most influential authors, publications, and journals in both HNVf and VES literature.

3.2.1. HNVf Research

The top ten productive and cited authors in HNVf research are listed in Table A1 (Appendix A). To qualify, authors needed to contribute to at least five documents. This ensured that regular contributors to HNVf research were recognized, while one-time participants in highly cited papers were excluded [98,99]. After assessment, only 13 met this criterion. The most productive authors were Plieninger T., Hartel T., and Lomba A., while the most cited were McCracken D., Plieninger T., and Dengler J.

The co-citation network (Figure 8) highlighted Beaufoy G., Plieninger T., and Baldock D. as central figures, frequently cited and anchoring the core HNVf research themes found predominantly in the red cluster. This dense cluster represented a well-established research foundation. In contrast, the isolated purple cluster pointed to niche areas or differing theoretical perspectives. Also, it is notable that some authors, the standouts in co-citations analysis, were not as prominent among the most productive or cited authors, suggesting that their broader contributions focused on the HNV knowledge base. Overall, the HNVf literature landscape appeared to be led by influential voices, enriched by diverse topics, and marked by a dynamic, interconnected research community.

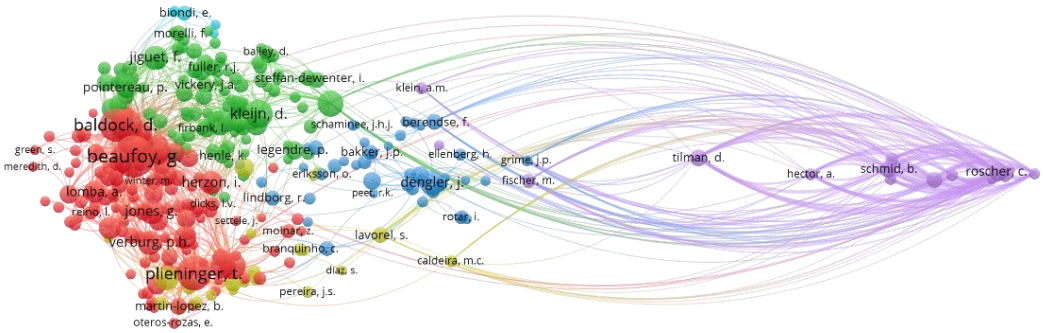

Figure 8. Author co-citation network for HNVf literature, 1997–2022 (threshold of 50 citations).

During the first period, one of the most influential publications was published [38]. In this case, the article reviewed conflicts between conservation and agricultural activities

and evaluated strategies to resolve such disputes. Also, the authors approached the relationship between low-intensity agriculture and high bird species levels. In [38], the authors reviewed in which circumstances agricultural activities and interests towards economic gains clashed with conservation of biodiversity in agricultural landscapes. They identified and described three major processes responsible for creating biodiversity-related conflicts: (i) intensification of agriculture; (ii) abandonment of marginally productive HNVf; and (iii) scale of agricultural operations. Between 2011 and 2022, the rest of the top ten most cited publications in HNVf research were published. Dengle et al. [29] explored the biodiversity in a specific type of high nature value grassland and synthesized the current knowledge on the topic. This article did not explore HNVf-related topics but helped to characterize and better understand the relationship between the ES of grasslands and biodiversity. Renwick et al. [100] analyzed the potential impact of agricultural and trade policy reform on land use, focusing on land abandonment. A key finding of the article's research was that reforms widely differed in spatial impact, meaning that neglect of HNV systems occurred within the same farming systems depending on the specificity of each environment throughout Europe. The authors also pointed out that these impacts reflected the inadequacy of policies, such as the CAP's first pillar. Biondi [101] recognized the importance of HNVf for the methodological and conceptual evolution of phytosociology since the introduction of the concept praised the interactions of vegetation communities as a critical element for biodiversity levels. The article reviewed and discussed the fundamental aspects and ideas of phytosociology. Although relevant to the study of plant community sociology in HNVf areas, it did not approach HNVf-related topics in a considerable measure. The objective of the article by Halada et al. [102] was to identify the habitat types listed in the Habitats Directive Annex I that required low-intensity agricultural management. The authors identified 63 habitat types of European importance that depended on agriculture and considered delineating areas such as HNVf as a vital policy tool, leading to better-targeted application of measures to maintain habitats and species.

Next, using co-citation analysis, Figure A1 (Appendix A) depicts the influential sources with over 100 citations. The sparse connections between these sources suggested that they were rarely co-cited, possibly indicating limited interdisciplinary dialogue. The clear division between ecology and biology journals (green cluster) and those focused on environmental management and conservation (red cluster) further accentuated this observation. This distinction might signal missed opportunities for integrating biological insights with practical conservation strategies, underscoring a potential need for more holistic discussions in the literature.

3.2.2. VES Research

The most productive authors, in terms of published documents and citations in VES research, can be found in Table A3 (Appendix A). The selection criteria involved authors featured in at least five published documents. After careful evaluation, only 19 authors were found to meet the specific criteria. Hein L. stood out for significant impact with 2084 citations across five publications, indicating the profound influence of his work. Conversely, Costanza R. presented an extensive body of 16 publications but garnered fewer citations per document, suggesting specialized contributions. Barton D.N. and Bagstad K.J. struck a balance between publication frequency and impact.

Figure 9 offers a detailed visualization of the co-citation dynamics within the VES research landscape. Five distinct clusters were representative of the varied thematic concentrations within VES studies. Unlike the patterns observed in HNVf research, the top-tier authors in VES research demonstrated a balanced presence across the network, reinforcing the idea of a well-integrated research community. The notable scholars were Costanza, De Groot, and Polasky. Their prominence not only highlighted their individual contributions but also established these authors as foundational pillars in VES research.

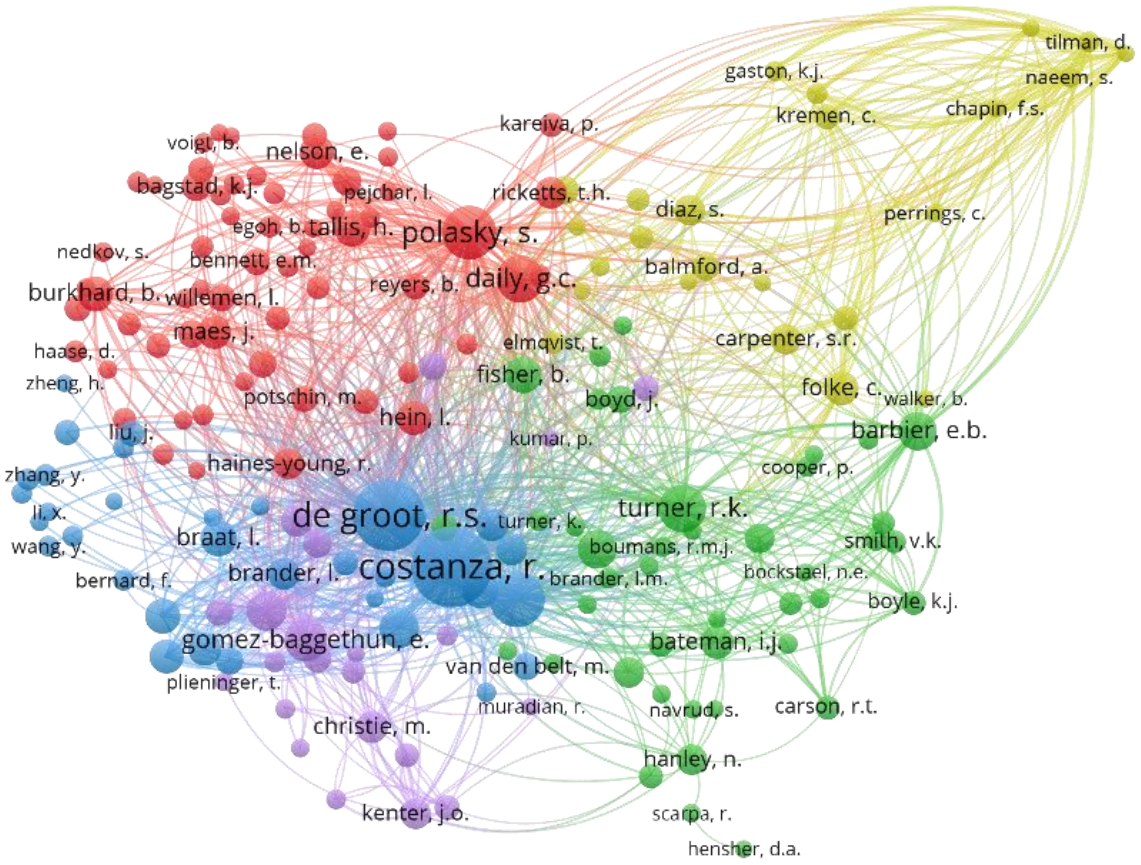

Figure 9. Author co-citation network for VES literature, 1998–2022 (threshold of 50 citations).

Table A4 (Appendix A) showcases the most influential VES literature between 1998 and 2022. The most referenced work was the piece by De Groot R. S. [25] on the challenges of integrating ecosystem services into landscape planning, reflecting the complexities of the field. This was closely followed by the article by Power A.G. [56], which unraveled the juxtaposition between ecosystem services and agriculture, illuminating the trade-offs and synergies. The topics spanned from urban planning insights by Gómez-Baggethun E. [103] to the exploration of cultural ecosystem services by Milcu [50]. Notably, Farber's work [104] remained significant, underscoring its enduring relevance. A tight citation count among the mid-ranked papers suggested thematic overlap or contemporaneous publishing. Practicality was emphasized, with works by Crossman and Troy focusing on tangible VES applications. Daw's research [105] introduced a nuanced, human-centric perspective, highlighting the evolving holistic approach in the field. Collectively, these works illustrate the dynamic interplay between theoretical and practical advancements in VES research.

Figure A2 (Appendix A) illustrates the densely interconnected co-citation network for VES research, signifying its multidisciplinary nature. This contrasts with the simpler network observed for HNVf research. Distinct clusters emerged within the VES field: the green cluster emphasized environmental economics and management, the blue delved into core ecological and biological principles, while the red embodied a transdisciplinary approach, focusing on evaluative strategies for ecosystem services. Notably, even within these clusters, there were discernible gaps, suggesting nuanced thematic variations and sporadic co-citations among closely related sources.

3.3. The Conceptual Structure

A co-occurrence analysis of text data, focusing on titles and abstracts, was employed to identify prominent concepts in HNVf and VES research. Co-word analysis, a technique

used across various domains, is adept at capturing robust associations between textual elements [98,99]. This approach not only discerns prevailing tendencies in a domain [98] but also tracks shifts in dominant themes as new research findings emerge [66]. Temporal word co-occurrence maps offer visual insights, showcasing thematic relationships and their prominence over time [68].

3.3.1. HNVf Research

The network of word co-occurrence showed three generic clusters with very similar sizes and shapes (Figure 10). The separation between the blue and red clusters from the green cluster suggested a weaker correlation. This implied that the green cluster publications delved into distinct topics compared to those in the blue and red clusters. The blue cluster encompassed terms associated with methodologies for identifying and analyzing HNVf. In contrast, the red cluster pertained to the theoretical significance of HNVf and its associated policies. Notably, this cluster incorporated the term ES, underscoring the emphasis on considering these in policy formulation. Meanwhile, the green cluster centered around biodiversity research. Given the terminologies present in this cluster, it can be inferred that species richness served as a prevalent indicator for HNVf identification. However, given the noticeable distance between the red and blue clusters from the green cluster, there was a clear delineation between documents centered on species richness and diversity and those emphasizing HNVf monitoring and identification methodologies.

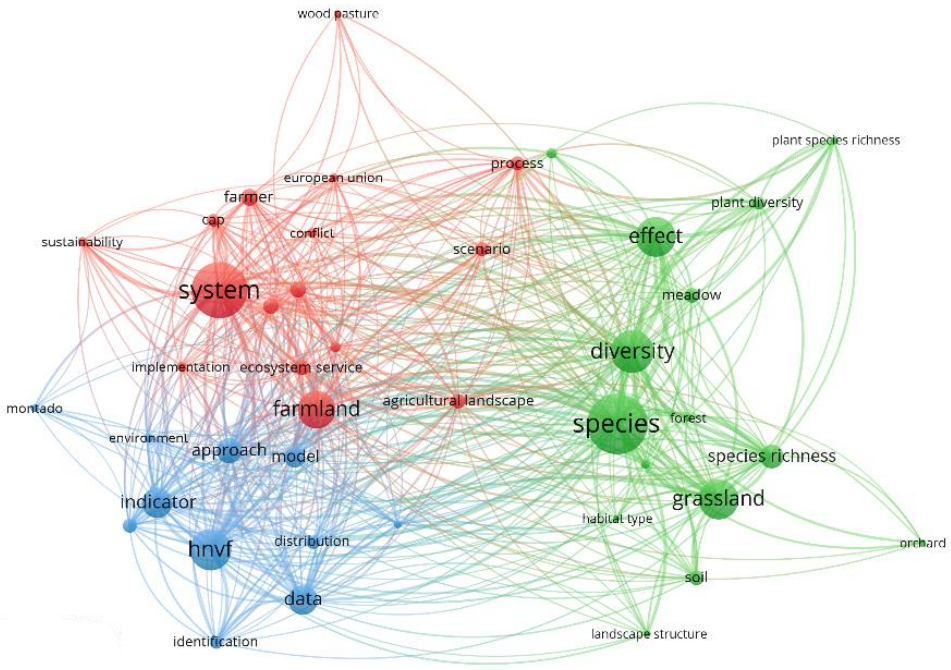

Figure 10. Network of word co-occurrence for HNVf research, 1997–2022 (threshold of 20).

Figure 11 illustrates the evolution of HNVf research from 1997 to 2022. During the initial phase (purple), the predominance of larger nodes associated with terms like "species","system", "effect" and "farmland" suggested that foundational inquiries were oriented towards understanding the very essence of HNVf landscapes—their intrinsic characteristics, the species they harbor, their systematic role in broader agriculture, and the tangible or intangible effects they might have on the surrounding environment. Transitioning into the later phase (yellow), larger nodes associated with terms such as "grassland" "HNVf", "diversity", and "indicator" hinted at the field's progression. The pronounced frequency of "grassland" and, more recently, "montando/wood pastures" and "orchards" suggested that recent research was zooming in on specific ecosystems within the broader HNVf category, reflecting a more granular understanding of these environments. Con-

currently, the emphasis on "diversity" showcased the continuous focus on biodiversity conservation within these farmlands. The heightened frequency of "indicator" underscored a current inclination towards refining tangible, measurable metrics to monitor and evaluate HNVf health, status, and dynamics. This shift from broader concepts to nuanced specifics can be viewed as a natural maturation in many scientific domains. The initial foundational knowledge paved the way for more targeted, detailed exploration. Advanced methodologies in the later phase might have been facilitated by the evolving policy landscape and feedback from implementations like the CAP.

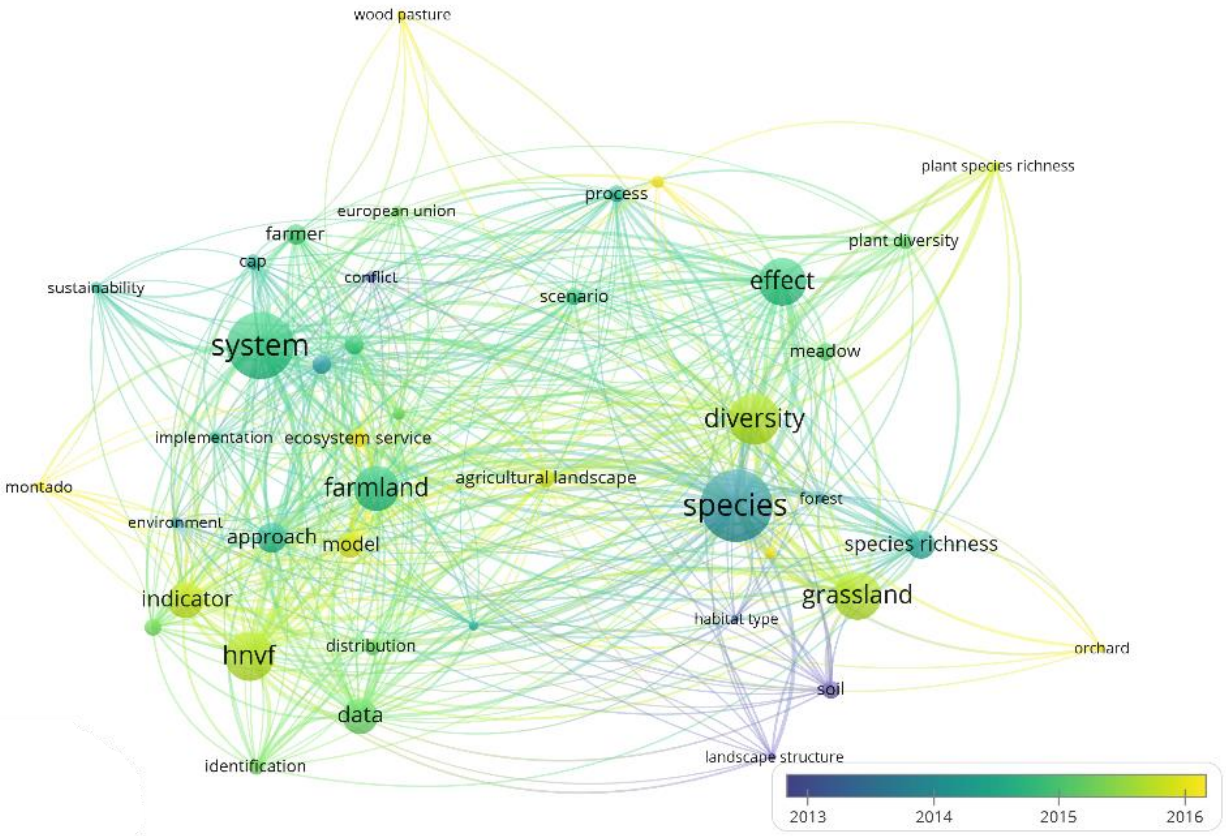

Figure 11. Temporal network overlayed on word co-occurrence map for HNVf research, 1997–2022 (threshold of 20).

3.3.2. VES Research

In examining the network of word co-occurrence for VES research (Figure 12), the overall shape of the map suggested that most published documents delved into more interconnected topics. The red cluster emphasized analytical rigor, focusing on quantifying and modeling ES using data, estimates, and scenarios. It hinted at the research's predictive and data-driven facet, with foundational terms like "natural capital" as the base of these studies. The blue cluster dove into the environmental context, highlighting how ES manifest in and impact specific landscapes, especially regions like wetlands. It underscored the dynamic nature of these services and their tangible environmental effects. The yellow cluster corresponded to the economic dimension of the research. Here, the interplay between weighing the trade-offs of VES and integrating it into policy decisions was evident, emphasizing the monetization and economic implications of these services. Finally, the green cluster, rooted around the core term, offered a holistic view. It explored the challenges in understanding and conserving ES, the intrinsic link to biodiversity, and the pivotal human-stakeholder interactions that shape their existence and restoration.

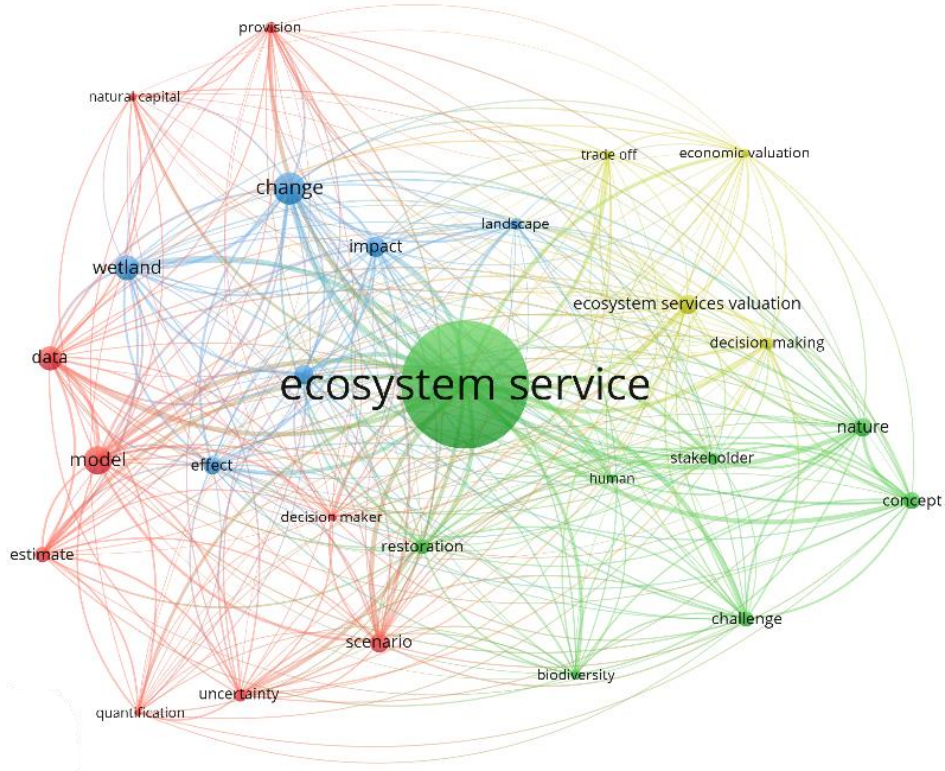

Figure 12. Network of word co-occurrence for VES research, 1998–2022 (threshold of 20).

In Figure 13, the color and size of the term "ecosystem services" suggested that the term was consistently a focal point, bridging earlier concepts with more recent discussions.

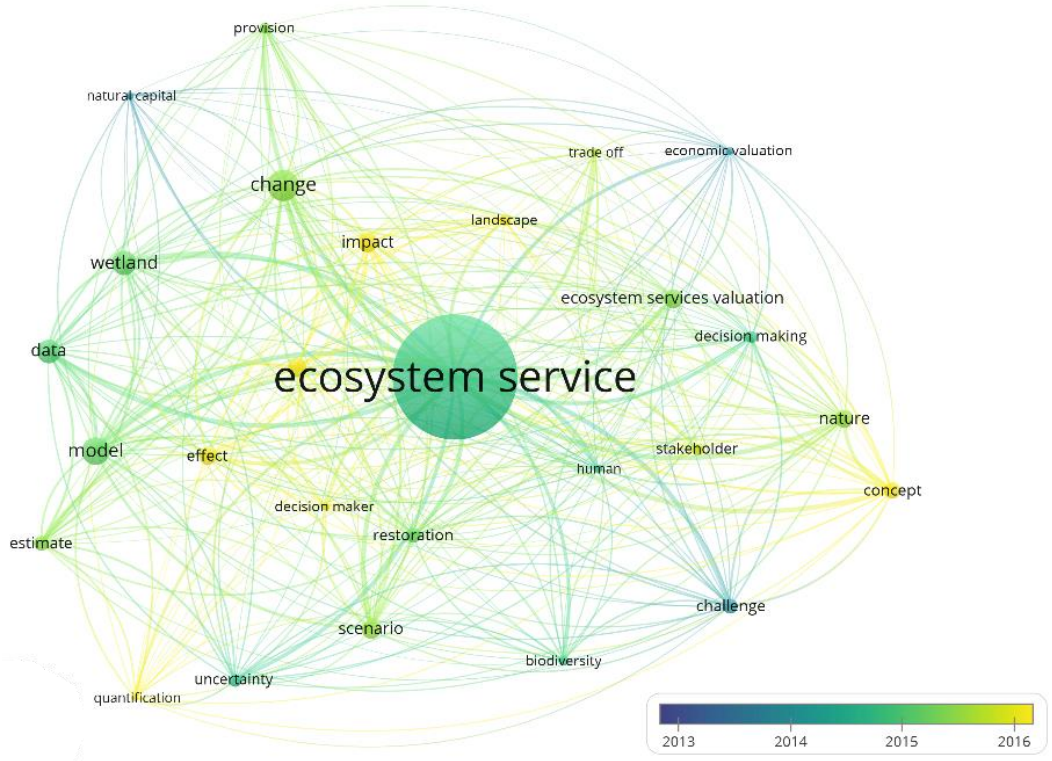

Figure 13. Temporal network overlayed on word co-occurrence map for VES research, 1998–2022 (threshold 20).

More recent terms, such as "effect", "impact", "concept", and "quantification" indicated a shift in research towards understanding the direct implications of ES in various environmental and socio-economic dimensions. There was growing interest in not only conceiving but also quantifying these services' tangible and intangible consequences and effects. Also, somewhat recent terms like "data", "change", "ecosystem services valuation," "model," and "uncertainty" suggested that as the field evolved, there was a growing emphasis on collecting empirical data, observing, and predicting changes in ES and attempting to value them. The presence of "model" hinted at efforts to create predictive or interpretive frameworks, while "uncertainty" underscored the challenges or ambiguities researchers grappled with during this phase.

Among the earlier terms, we found "natural capital," "economic valuation," and "challenge". This implied that initial forays into ES research were grounded in tying the environment ("natural capital") to economic paradigms. There was a clear endeavor to economically value the environment, underpinning the early days of ES as a concept. The term "challenge" suggested that these early efforts were fraught with complexities, both conceptual and methodological.

Despite the temporal shifts in thematic priorities, most terms maintained a similar node size, suggesting that while the focal points of research evolved, many of these themes remained consistently relevant, each contributing a pivotal piece to the holistic understanding of ES.

4. Connections between Research Topics

HNVf represents a critical intersection of agriculture and biodiversity conservation, emphasizing farming practices that maintain and enhance a diverse array of species and habitats. On the other hand, VES provides a framework for understanding and quantifying the benefits, both tangible and intangible, that ecosystems, including HNVf, deliver to humanity. As HNVf promotes sustainable agricultural practices that safeguard biodiversity, it invariably contributes to the maintenance and enhancement of ES. Valuating these services not only underscores the economic implications of sustainable farming but also offers a persuasive argument for the preservation of HNVf landscapes [19,106].

4.1. HNVf Ecosystem Services

HNVf provides a diverse array of provisioning services, ranging from a variety of crops and livestock, which are characterized by unique nutritional, cultural, and ecological attributes. Notably, traditional breeds demonstrate adaptability and resilience, often flourishing without intensive chemical interventions. Beyond providing sustenance, HNVf yields products such as fibers and regional medicinal herbs, all integral to local traditions and yet possessing global commercial significance. In terms of regulating services, HNVf systems offer numerous benefits. Their diverse cropping patterns and reduced reliance on chemicals contribute to soil health, thereby promoting fertility and controlling erosion. The dense vegetation inherent to these landscapes acts as a natural filter, enhancing water quality. Furthermore, the biodiversity they support is essential for pollinators vital to various crops. Intrinsic practices like agroforestry not only regulate local climates but also contribute to carbon sequestration and broader climate change mitigation strategies. Culturally, HNVf stands as a repository of local traditions and practices, encapsulating generational knowledge. The biodiversity and scenic beauty of these landscapes facilitate recreational activities and promote ecotourism, marking them as centers of cultural heritage and regional identity. From a support perspective, HNVf landscapes are biodiversity hotspots, offering habitats for numerous species and underlining their significance in conservation efforts. These ecosystems, replete with myriad symbiotic interactions, are pivotal in nutrient cycling, a service often underappreciated due to its intricate and multifaceted nature [107–112].

4.2. Bibliometric Insights

The synergy between HNVf and VES is an intricate subject. When it comes to research in both topics, the only bridging article found was "Valuation of Ecosystem Services for Implementing Innovative Clean Technology" [113]. The article emphasized the potential harmony between HNV areas, not specifying farmland, and VES, while retaining ecological integrity. Also, it is worth mentioning that one of the most cited articles in VES research was related to ecosystem services and agriculture [56].

Regarding consistent contributors in both fields, authors such as Plieninger T., Pinto-Correia T., Lomba A., Regos A., Moreno G., and Azeda, C. demonstrated a pronounced interest in HNVf and ES. Yet their focus was not on valuation. Both Lomba A. and Plieninger T. emerged prominently, with each having authored four pieces, one of which they co-authored.

When analyzing the dataset on HNVf and ES research (33 documents), two articles, surpassing 70 citations each, deserve particular attention. The first [19] investigated the varying perceptions of farmers and nonfarmers towards ES. It unveiled farmers' profound awareness of these services and their agricultural implications, whereas nonfarmers were more inclined towards quality food production and the cultural essence of ecosystems. The subsequent article [107] investigated HNVf's adaptability amid socioeconomic flux, proposing possible futures and accentuating the crucial nature of sustainable farming methods for these precious lands. Table A5 (Appendix A) shows the remaining articles that correspond to the top 10 most cited articles in HNVf and ES research.

On a geographical note, Portugal stood out with the highest number of publications, narrowly outpacing Germany. These studies were comprehensive, discussing topics from ecosystem metamorphosis, differential farming strategies to ES, and intricate HNVf management practices, to the employment of advanced high-resolution data techniques throughout Europe. Some also explored fire-resilient farming approaches, geocaching as a cultural ecosystem metric, psychographic-driven willingness-to-pay evaluations for ES, and a specific probe into soil organic carbon dynamics across European HNVf.

However, it is essential to note a discernible gap: collaboration between HNVf and ES research remained sparse, often narrowed down to niche subjects without delving deeper into HNVf's holistic qualities and the encompassing ES. This disparity widened when juxtaposed against VES studies.

4.3. Challenges and Pathways

Despite its significant ecological and societal importance, integrating HNVf and its ES into policy and practice still presents a multitude of challenges. Firstly, many regions suffer from a lack of formal recognition of HNVf, as evidenced by the geographic distribution of relevant research. This absence of official acknowledgment can hinder these areas from receiving the necessary targeted support or protection. Concurrently, there is a frequent deficiency in the collection of comprehensive and consistent data on HNVf. This gap makes it difficult to craft tailored policies or evaluate the effectiveness of existing ones.

For a long time, many existing agricultural policies, driven by economic motivations, tended to favor high-intensity and industrial agriculture. These often offered subsidies that might inadvertently undermine HNVf. However, there is an emerging trend of policies providing incentives for environmentally friendly practices [63]. Another concern is the fragmented approach towards HNVf conservation, wherein related policies are dispersed across various sectors like agriculture, environment, and rural development. This dispersion can result in a lack of coordination and at times, even lead to conflicting goals.

On the ground, local communities, indigenous groups, and farmers are pivotal in managing these ecosystems. Yet there is a noticeable gap in the effective involvement of these stakeholders in decision-making processes19]. Additionally, while HNVf can contribute to broader environmental goals, such as climate change mitigation, water management, and soil conservation, current policies often overlook such integrative approaches [114]. Financial constraints also present a barrier [115]. The conservation and promotion of HNVf

demand financial backing, especially to remunerate farmers for the ecosystem services they offer. The absence of clear frameworks for dedicated funding can deter the preservation and promotion of these vital lands. Furthermore, in specific regions, challenges arise due to unclear land ownership or tenure, complicating the initiation of conservation and management strategies. There is also a discernible gap in the transfer of knowledge. Mechanisms or platforms to disseminate best practices, research outcomes, or innovations for these systems are often lacking. At a broader level, the scale at which policies are crafted might not always align with the unique needs of localized systems. Lastly, external factors such as global market demand and price oscillations can exert economic pressures on farmers, potentially deterring them from adopting HNV practices [116–118].

Addressing these challenges requires an integrated approach, focusing on collaboration among stakeholders, improved data collection, and alignment of economic incentives with conservation objectives. Moreover, acknowledging the multifunctional role of HNVf, not only in biodiversity but also in cultural, societal, and economic terms, is crucial for its effective integration into policy frameworks. Nevertheless, numerous mechanisms and policies are currently being implemented to address these challenges. The European Union's Common Agricultural Policy (CAP) stands out as a significant shaper of agricultural practices. A pivot in the CAP towards conservation [96], especially through the environmentally aligned initiatives in its second pillar, can serve HNVf's cause. In parallel, the EU Biodiversity Strategy [94], formulated under the European Green Deal with a 2030 horizon, encapsulates objectives that are harmonious with conserving HNVf [93]. Moreover, the expansive EU initiative for nature conservation, the Natura 2000 Network [119], offers an ideal setting for HNVf to be a strong conservation focus. The Water Framework Directive (WFD), which acknowledges HNVf's integral role in water management, is another policy conduit through which integrating HNVf management can amplify water quality and support aquatic ecosystems [120]. On a similar note, rural development programs, both at national and regional levels, can be utilized to extend financial and technical support for the stewards of HNVf [121]. Countries can leverage national biodiversity strategies and action plans (NBSAPs) to define specific goals tailored for HNVf. Regarding climate, it is crucial to weave HNVf into overarching strategies like the EU's Climate Law, given its contribution to carbon sequestration and fostering climate resilience. The agri-environment-climate measures (AECM), part of the CAP's second pillar, provide incentives for eco-friendly farming and can be refined to spotlight HNVf systems. Instruments such as the European Landscape Convention can serve to accentuate HNVf's cultural and landscape significance [87]. Lastly, the UN's Sustainable Development Goals, particularly goals 2, 13, and 15, can provide the backbone of national policies, championing the ideals and protection of HNVf [90].

Moving to mechanisms and approaches, the payment for ecosystem services (PES) system provides direct recompense for those enhancing ecosystem services from their lands [122]. Tailoring these incentives to accentuate HNVf-centric practices can further fortify crucial ecosystem services. Natural capital accounting offers a lens to monetize and appreciate the ES of HNVf, steering policymakers towards informed decisions. Ecosystem-based adaptation strategies, acknowledging escalating climate challenges, can be designed around HNVf to bolster resilience. Finally, biodiversity offsets, meant to offset biodiversity deficits, can rejuvenate both biodiversity and the accompanying ES if shaped with HNVf as a priority, especially in areas marred by intensive farming or development [123].

4.4. Future Directions

Recent advancements have broadened the monitoring and quality assessment of HNVf and its ES with a multidimensional approach, emphasizing the importance of blending ecological, economic, and socio-cultural insights [48,108,124–127]. A pivotal challenge lies in harmonizing localized, hands-on knowledge of HNVf with expansive global metrics. Climate change adds further to this challenge, demanding predictive modeling to discern the potential impacts on HNVf and VES [128–130]. Technological developments, especially

in artificial intelligence and remote sensing, promise transformative capacities in HNVf monitoring, but they need to be anchored by solid methodologies [119,131–143]. Concurrently, an in-depth exploration of policy efficacy, legislative structures, and market-based mechanisms is still needed to align conservation with economic objectives [143]. In essence, the future of HNVf research calls for an integrated, technologically informed and culturally attuned approach to address the complexities of these landscapes [100,115].

5. Conclusions

Our bibliometric review revealed a dominant preference for VES over HNVf research. This preference was evident across a variety of disciplines and geographical regions. As research into VES flourishes, HNVf has attained a plateau in interest. The reasons for this may include the shift in research methodologies that prioritize ES for characterizing landscapes and assessing their ecological health. Additionally, the concept of HNVf has become ingrained in policymaking, which could account for a perceived decrease in novel research.

While tremendous progress has been made in understanding HNVf and VES, notable gaps remain in both research domains. In HNVf research, a critical step is the expansion of its geographical scope. A more comprehensive, global perspective offers insights into the challenges and opportunities that different regions present. Additionally, as we delve deeper into HNVf assessment, there is a need to include diverse metrics that not only quantify but also qualify the conditions found in this type of ecosystem; methodologies should be designed to integrate and prioritize ES, ensuring that we capture the essence of HNVf's potential. On the other hand, when considering VES research, we must acknowledge the limitations of traditional assessment methods. These methods often miss the nuances necessary for informed policymaking that genuinely values ecosystems. A solution lies in blending biophysical knowledge with economic valuation techniques, which would provide a clearer and more actionable understanding of ES.

Science mapping, while offering quantitative insights, is not without limitations. It often demands prior domain expertise and may not always deliver in-depth findings analogous to traditional reviews. Our bibliometric approach is a starting point, a foundation upon which deeper, more intricate analyses can be built. This research sets the stage for comprehensive studies that dissect the complex relationship between HNVf and VES, with a focus on standardized links. Future investigations should delve deeper into spatial modeling of HNVf and valuation of respective ES methodologies, which will further elucidate their practical implications.

Author Contributions: Conceptualization, I.G. and J.R.; methodology and software, I.G. and J.R.; data curation I.G.; validation, I.G., E.G., P.P. and J.R.; formal analysis, I.G.; investigation, I.G.; writing—original draft preparation, I.G.; writing—review and editing, I.G., E.G., P.P. and J.R. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: No new data was created in this study. The bibliographic datasets can be downloaded through Scopus by using the search criteria mentioned in this study.

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

Appendix A

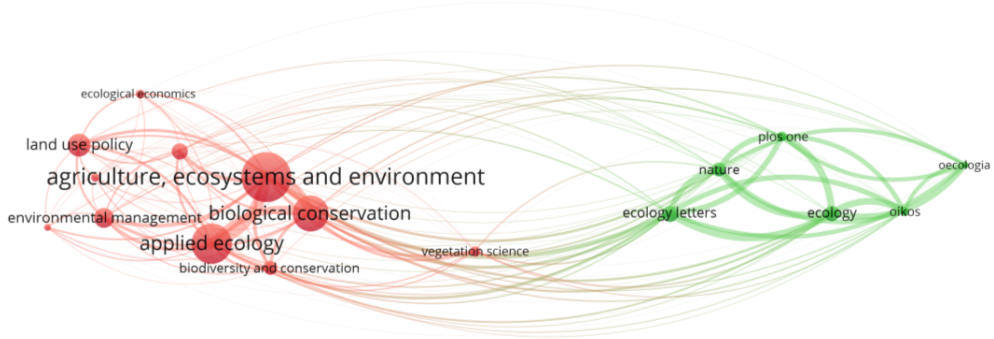

Figure A1. Source co-citation network for HNVf research from 1997 to 2022.

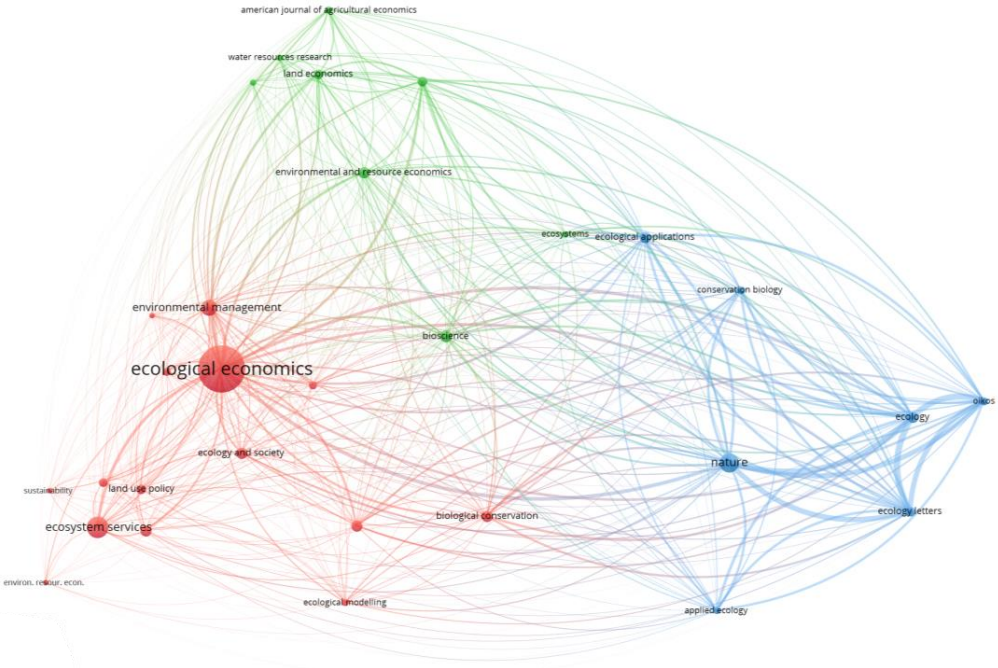

Figure A2. Source co-citation network for VES research from 1997 to 2022 (threshold of 100 citations).

Table A1. Ten most productive and influential authors in HNVf research, 1997–2022 (>5 documents).

Author	Nº of Documents	Nº of Citations
McCracken D.	5	914
Plieninger T.	11	548
Dengler J.	5	501
Hartel T.	10	383
Lomba A.	9	298
Moran J.	8	205
Moreira F.	7	203
Pinto-Correia T.	7	180
Finn J.A.	7	163
Sullivan C.A.	6	155

Table A2. Ten most influential documents in HNVf literature, 1997–2022.

1st Author (Year)	Document Title	Nº of Citations	*IO* Rank	Reference
Henle K. (2008)	Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe-A review	500	460	[38]
Dengler J. (2014)	Biodiversity of Palearctic grasslands: A synthesis	380	400	[29]
Renwick A. (2013)	Policy reform and agricultural land abandonment in the EU	304	314	[100]
Biondi E. (2011)	Phytosociology today: Methodological and conceptual evolution	223	213	[101]
Halada L. (2011)	Which habitats of European importance depend on agricultural practices?	219	209	[102]
Weisser W. (2017)	Biodiversity effects on ecosystem functioning in a 15-year grassland experiment: Patterns, mechanisms, and open questions	219	269	[144]
Plieninger T. (2015)	Wood-pastures of Europe: Geographic coverage, social-ecological values, conservation management, and policy implications	191	221	[145]
Wesche K. (2012)	Fifty years of change in Central European grassland vegetation: large losses in species richness and animal-pollinated plants	181	181	[146]
Sutcliffe L. (2015)	Harnessing the biodiversity value of Central and Eastern European farmland	176	206	[32]
Levers C. (2018)	Spatial variation in determinants of agricultural land abandonment in Europe	142	202	[147]

Table A3. Ten most cited authors in VES research, 1997–2022 (>5 documents).

Author	Nº of Documents	Nº of Citations
Hein L.	5	2084
Barton D.N.	7	1285
Bagstad K.J.	8	776
Barbier E.B.	5	639
Brander L.	10	626
Sutton P.C.	6	500
Costanza R.	16	344
Fisher B.	7	207
Polasky S.	6	148
Gómez-Baggethun E.	6	89

Table A4. Ten most influential documents in VES literature, 1998–2022.

1st Author (Year)	Document Title	Nº of Citations	*IO* Rank	Reference
De Groot R. S. (2010)	Challenges in integrating the concept of ecosystem services and values in landscape planning, management, and decision making	1524	1504	[25]
Power A. G. (2010)	Ecosystem services and agriculture: tradeoffs and synergies	619	599	[56]
Gómez-Baggethun E. (2013)	Classifying and valuing ecosystem services for urban planning	527	537	[103]
Farber (2002)	Economic and Ecological concepts for valuing ecosystem service	439	339	[104]

Table A4. *Cont.*

1st Author (Year)	Document Title	Nº of Citations	*IO* Rank	Reference
Bullock (2011)	Restoration of ecosystem services and biodiversity: Conflicts and opportunities	361	351	[58]
Milcu (2013)	Cultural ecosystem services: A literature review and prospects for future research	359	369	[50]
Crossman (2013)	A blueprint for mapping and modeling ecosystem services	295	305	[52]
Bagstad J. K. (2013)	A comparative assessment of decision-support tools for ecosystem services quantification and valuation	284	294	[23]
Troy (2006)	Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer	280	220	[24]
Daw (2011)	Applying the ecosystem services concept to poverty alleviation: The need to disaggregate human well-being	278	268	[105]

Table A5. Ten most cited articles that approach HNVf and ecosystem services as the research topic, 2011–2022.

1st Author (Year)	Document Title	Nº of Citations	Reference
Bernués A. (2016)	Agricultural practices, ecosystem services and sustainability in High Nature Value farmland: Unraveling the perceptions of farmers and nonfarmers	78	[19]
Lomba A. (2020)	Back to the future: rethinking socioecological systems underlying high nature value farmlands	72	[107]
Plieninger T. (2019)	Perceived ecosystem services synergies, trade-offs, and bundles in European high nature value farming landscapes	59	[106]
O'Rourke E. (2016)	High nature value mountain farming systems in Europe: Case studies from the Atlantic Pyrenees, France and the Kerry Uplands, Ireland	53	[148]
Ferraz-de-Oliveira M.I. (2016)	Management of Montados and Dehesas for High Nature Value: an interdisciplinary pathway	44	[149]
Lomba A. (2017)	Making the best of both worlds: Can high-resolution agricultural administrative data support the assessment of High Nature Value farmlands across Europe?	36	[150]
Pais S. (2020)	Mountain farmland protection and fire-smart management jointly reduce fire hazard and enhance biodiversity and carbon sequestration	33	[151]
Rodríguez-Ortega T. (2016)	Psychographic profile affects willingness to pay for ecosystem services provided by Mediterranean high nature value farmland	32	[152]
Varela E. (2020)	Targeted policy proposals for managing spontaneous forest expansion in the Mediterranean	30	[153]
Gardi C. (2016)	High nature value farmland: Assessment of soil organic carbon in Europe	26	[109]

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