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Review

Grassland Ecosystem Services: Their Economic Evaluation through a Systematic Review

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Abstract: Grasslands provide a wide range of provision, support, regulation, and cultural ecosystem services (ESs), whose valuation methods can be grouped into three categories (ecological, sociocultural, and economic). The present manuscript aims to provide an overview of academic studies on grassland ESs and of the most used economic evaluation methods. To this end, a systematic and bibliometric review was conducted using the scientific database Scopus and the VOSviewer software. The results highlighted that China and the USA were the main countries with the highest number of publications regarding ESs provided by grasslands. The number of publications began to grow starting in 2005, thanks, perhaps, to the publication of influential documents, such as the Millennium Ecosystem Assessment, and the general increase in interest in ecological policy issues. The year 2023 had the highest number of documents in absolute (646), demonstrating the timeliness, importance, and relevance of this research topic. The most studied grassland ES has been carbon storage; however, a central role was played also by biodiversity. In this context, papers that estimated grassland ESs from an economic perspective represented only 3% of all papers that Scopus has returned. More than half of these referred to the use of equivalent coefficients to calculate the ES value of different land uses/land cover categories or, at most, of 11 types of ES. All this highlights the difficulty in estimating individual ESs provided by grasslands from an economic point of view and the greater propensity to use physical, chemical, and biological indicators. Consequently, the sustainable management of grasslands requires more studies on the economic evaluation of their ES, as well as environmental aspects in the economic accounting of governments, or to implement a support system for farms in delivering various ecosystem services.

Keywords: pasturelands; economic assessment; bibliometric and systematic analysis; ecosystem functions; accounting

Citation: Pergola, M.; De Falco, E.; Cerrato, M. Grassland Ecosystem Services: Their Economic Evaluation through a Systematic Review. *Land* **2024**, *13*, 1143. https://doi.org/10.3390/land13081143

Academic Editors: Dingde Xu, Michael Vrahnakis and Yannis (Ioannis) Kazoglou

Received: 30 May 2024
Revised: 11 July 2024
Accepted: 24 July 2024
Published: 26 July 2024

1. Introduction

According to FAO, grasslands account for 28% of the world's land area, 63% of which is concentrated in the Russian Federation, Australia, the United States of America (USA), Canada, China, Kazakhstan, and Brazil [1]. The definitions given of grassland are different depending on the aspects that are taken into consideration. Indeed, FAO [2] defined grassland as "land covered with grass and with less than 2% tree or shrub cover". The International Vegetation Classification [3] and Dixon et al. [4] identified four different grassland types: tropical grasslands, Mediterranean grasslands, temperate grasslands, and semidesert grasslands. Allen et al. [5], instead, with the aim of developing a consensus on terms and definitions to ensure clear international communication regarding grasslands, defined many grazing land terms at a global level. Among these, pastureland is defined as "land (and the vegetation growing on it) devoted to the production of introduced or indigenous forage for harvest by grazing, cutting, or both" and "is synonymous with grassland when referring to an imposed grazing-land ecosystem with a vegetation broadly interpreted to include grasses, legumes, and other forbs, and at times woody species may

be present". Among other definitions, that of rangeland is also interesting, which the authors defined as "a land on which the indigenous vegetation is predominantly grasses, grass-like plants, forbs or shrubs that are grazed or have the potential to be grazed, and which is used as a natural ecosystem to produce grazing livestock and wildlife". The latter include natural grasslands, savannas, shrublands, many deserts, steppes, tundras, alpine communities, and swamps. Table 1 reports the different types of grasslands identified by Allen et al. [5].

Table 1. The main typologies of grasslands.

Type of Grasslands	Description
Annual	The forage is established annually
Cultivated	The forage is established with domesticated species that receive periodic agricultural treatments
Permanent	With perennial or self-seeding annual forage species that may survive indefinitely or often due to limiting factors that prevent other uses (excessive slope, shallow soil depth, outcropping rockiness, stoniness)
Temporary	The vegetation is composed of annual, biennial, or perennial forage species kept for only a few years
Naturalized	The forage species are mainly introduced from other geographical places that have established themselves and have persisted for a long time in existing environmental and management conditions
Semi-natural	A managed ecosystem dominated by native or naturally occurring herbs and other herbaceous species

Referring to natural grasslands, in the world, there are 42 zonal natural grassland types [6], where the characteristic vegetation is determined by climatic and soil conditions, grazing animals, and fire. For example, in Uruguay, southern Brazil, and north-eastern Argentina, the sub-tropical climate favors the presence of "campos" [7]; in central Brazil, the tropical climate allows the presence of "cerrado" [8]; in eastern and central Argentina, the climate humid to arid ensures the presence of "pampa" (treeless grasslands on flat and fertile plains) [9]; in North America, prairies are widespread, and in south-eastern Europe, Asia, and North America are the steppes [5].

In Europe, natural grasslands cover limited areas, which according to Peeters et al. [10] are alpine and boreal tundra grasslands (beyond the tree line); rocky Pannonian grasslands (in Hungary); the Macaronesian mesophilic pasturelands of the Atlantic islands (e.g., Azores); sub-desert meadows (in Romania, Russia, and Ukraine); Mediterranean xeric grasslands (e.g., the main Mediterranean islands and Stipa grasslands in south-eastern Spain). On the contrary, in most parts of Europe, grasslands are semi-natural, which is the result of centuries or millennia of low-intensity human land use from forests as potential natural vegetation [11].

Each of these grassland types provides important provision, support, regulation, and cultural ecosystem services (ES) [12,13], namely, the benefits humans obtain from grassland functions [14]. In the past, grasslands have played an important role in people's livelihoods as areas producing fodder for animals. Today, instead, the increasing demand for animal products is being met by the production of fodder on cropland and improved grasslands [13]. Consequently, the conversion to arable land [15] and the lack of management/increased abandonment [16,17] have led to the decline of grasslands worldwide during the last century. Anyway, grass remains the most natural forage for various herbivores, providing minerals, vitamins, and other active substances supporting living processes and providing healthy meat and milk for people [18]. It is largely recognized that grasslands have not only a local importance, for the maintenance of biodiversity, pollination, and food production but also at regional (water and erosion regulation, recreation, inspiration) and global scales (climate regulation) [13]. Nowadays, grassland plants may be used for energy production needs or as natural dyes for coloring clothes, and various medical plants can be found in pastureland, especially if natural [18]. Thus, a complete picture of the ES provided by grasslands can be found in Richter et al. [12], Bengtsson et al. [13], O'Mara [19], Erb et al. [20], Veen et al. [21], Habel et al. [22], and Dengler et al. [11].

Referring to Europe, Table 2 reports the functions and the relative ecosystem services provided by the main typologies of European grasslands.

Table 2. The ESs provided by the main typologies of European grasslands.

European Area	Grasslands Type	Main Functions Provided	Ecosystem Services Category
Nordic countries (Denmark, Finland, Iceland, Norway and Sweden)	Natural	livestock production	Provisioning
	Semi-natural	grazing maintaining biodiversity maintaining landscape	Provisioning Supporting
	Cultivated	winter fodder milk in summer	Provisioning
Temperate regions (such as Ireland, the UK, France, the Benelux, Germany, Czech Republic, Slovakia, and Poland)	Permanent	feed production maintaining biodiversity soil erosion control	Provisioning Supporting Regulating
	Temporary	feed production maintaining biodiversity	Provisioning Supporting
Mediterranean basin	Natural/ Semi-natural	livestock production soil erosion control carbon sequestration biodiversity conservation maintaining landscape	Multiple

In particular, in Nordic countries, grasslands are very heterogeneous, and their importance varies greatly from country to country. In fact, natural pasturelands are very large in Iceland and play a notable function in livestock production, while they are much less relevant in other countries [23]. In temperate regions of Europe, both permanent and temporary grasslands are used, including a varying proportion of forage legumes, playing a key role in feed production (above all for cattle and sheep) and, in some areas, in the preservation of the environment [24]. Moreover, referring to soil erosion, permanent grassland is strongly recommended, and since, in this region, we are witnessing their reduction, Huyghe et al. [24] said that this important function should be valorized. Finally, in the Mediterranean basin (a global biodiversity hotspot with an extremely high number of endemic plant species) [25], grasslands and rangelands are important ecosystems that have traditionally played a significant role in the evolution of human societies [26]. In particular, here, livestock grazing (characterized by small ruminants and beef cattle belonging to local races) affects the quantity and quality of forage, vegetation dynamics, species, and landscape diversity [27]. Thus, in this context, grassland systems are not only important for livestock production but they also perform multiple ecosystem functions [25].

Although most grasslands provide the same set of ecosystem services, their values are different [18]. Ecosystem service valuation methods can be grouped into three categories: ecological, sociocultural, and economic [28]. Of these three, as noted by Richter et al. [12], the economic evaluation of ES has been recognized as an important tool for developing strategies for the sustainable management of ecosystems. To our knowledge, there are few systematic literature review studies on the economic evaluation methods of grassland ESs. Indeed, Kang et al. [29] used 61 research studies in their evaluation of grassland ecosystem services' value in China, including 564 value observations to establish a value transfer database and to construct a value model. Richter et al. [12] provided an overview of available methods for the economic valuation of ES through a review of 85 plot-scale methods to assess 29 different ES indicators for 21 provisioning, regulating, supporting, or cultural ESs. Liu et al. [30,31] provided a comprehensive evaluation of the economic value of grassland ESs: on one hand, via a meta-regression analysis of 69 studies; on the other hand, via a meta-analysis of 702 observations from 134 primary studies. Thus, the present manuscript aimed to provide a critical overview of academic studies on the ES supplied by grasslands and wanted to contribute to the research of the most commonly used economic evaluation methods.

2. Materials and Methods

According to the aim of the paper, a bibliometric and systematic review of the literature on grassland ecosystem services was carried out to highlight the geographical focus of the literature, as well as how academia approaches the study of grassland ESs and what the main economic evaluation methods are to assess such ESs. As stated by Merli et al. [32] and Denyer and Tranfield [33], systematic analysis enables one to implement a clear and reproducible process of selection, analysis, and reporting on research about a specific topic. As in Pergola et al. [34], the review process followed some phases: definition of the research question; choice of the software to use; collection of documents; systematic and bibliometric analysis of documents; selection of the documents; qualitative analysis and groupings; and evaluation of the documents (Figure 1).

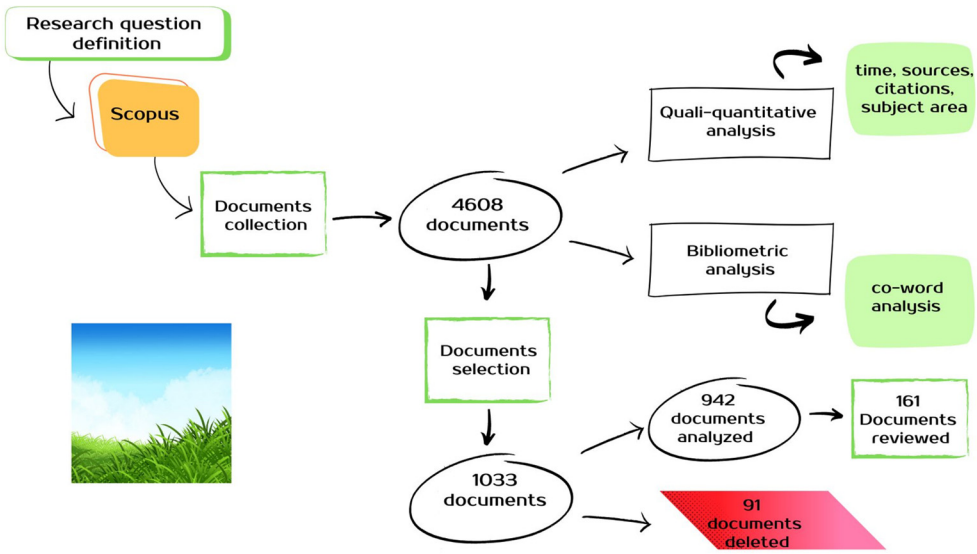

Figure 1. The review process scheme.

2.1. The Science Mapping

For the bibliometric analysis science mapping was used, a technique that examines the relationships between research components [35]. In particular, co-word analysis was used to understand the existing relationships between issues by focusing on the written content of the documents analyzed. VOSviewer software (version 1.6.20) was utilized to extract and analyze the semantic contents of titles, abstracts, and keywords of publications, correlating them to citation count data and creating network maps to visualize the results [36]. As in Muley and Medithi [37], default parameters were used for the analysis and the construction of the network maps. In particular, in the network map, the font size of words states their frequency of occurrence; if two words occurred more frequently in the analyzed documents, they were nearest to each other. Only words that had a minimum of 10 occurrences were analyzed and shown. To create the maps, two units of analysis were used ("all keywords" and "author keywords"), and the full count method was adopted, meaning that each co-occurrence link had the same weight. The default "associative strength method", with default values of attraction and repulsion, was used for the normalization of the co-occurrence matrix [35].

As detailed in Donthu et al. [35], in the network maps constructed using the VOSviewer software, each knot represented a keyword, wherein: (1) the size of the knot indicated the number of times that the keyword occurred, (2) the connection between the knots represented the co-occurrence among keywords (i.e., keywords that co-occurred or occurred together), (3) the thickness of the connection indicated the occurrence of co-occurrences among keywords (i.e., the number of times that the keywords co-occurred or occurred together), (4) the bigger the knot, the greater the occurrence of the keyword, and (5) the

thicker the connection between knot, the higher the occurrence of the co-occurrences among keywords. Each cluster was highlighted with a different color.

2.2. The Systematic Review Process

In order to conduct a reliable bibliometric and systematic analysis [38], the scientific database Scopus [39,40] was utilized for the collection of the documents, [39]. The first phase of the review process was the collection of all grassland ES publications across the scientific community. Thus, the generic expression "grasslands ecosystem services" was adopted and the research criterion "Article title, Abstract, Keywords" was employed. All types of documents were utilized as units of analysis (articles, reviews, book chapters, conference papers, books, notes, editorials, short surveys, letters, data papers, and conference reviews) and in all languages. No chronological restriction was performed, and the query on the database was carried out on 14 May 2024. From 1980, Scopus returned a total of 4608 documents. Thus, a quantitative analysis of the distribution and evolution of these documents over time, sources, number of citations, and thematic areas was made.

Subsequently, to identify papers that dealt with economic evaluation methodologies of the grassland ecosystem services, the subject areas "Social Science" and "Economics, Econometrics and Finance" were selected. In addition, the strings "grasslands ecosystem services" + "economic evaluation" and "grasslands ecosystem services" + "economic assessment" were used with the research criterion "Article title, Abstract, Keywords" to avoid the risk of leaving out some documents. Consequently, Scopus returned a total of 1033 publications, of which, after removing duplicates (91 documents), 942 papers were evaluated. From the latter, through qualitative analysis (reading of the abstracts and/or full documents), the manuscripts that presented economic methodologies for evaluating the grassland ESs were selected. Therefore, a sample of 161 papers was carefully examined in order to group them into areas of economic assessment methods.

3. Results

3.1. The Descriptive and Bibliometric Analysis of the Literature on Grasslands Ecosystem Services

The first article on grassland ecosystem services dates back to 1980 and refers to the tallgrass prairie version of the ELM Grassland Model, used to evaluate the potential impact of creating a tallgrass prairie National Park in the Flint Hills region of Kansas [41]. In particular, the model was specifically developed to study the effects of levels and types of herbivory, climatic variation, and fertilization upon pastureland ecosystems [41]. In any case, up to 2004, there were only 53 documents. As early as 2005, the number of publications referring to grassland ESs began to increase, and a steady rise in research articles has been observed since then (Figure 2). At the same time, the highest number of publications was recorded in the last five years (n = 2544), representing 55% of the total documents found on Scopus.

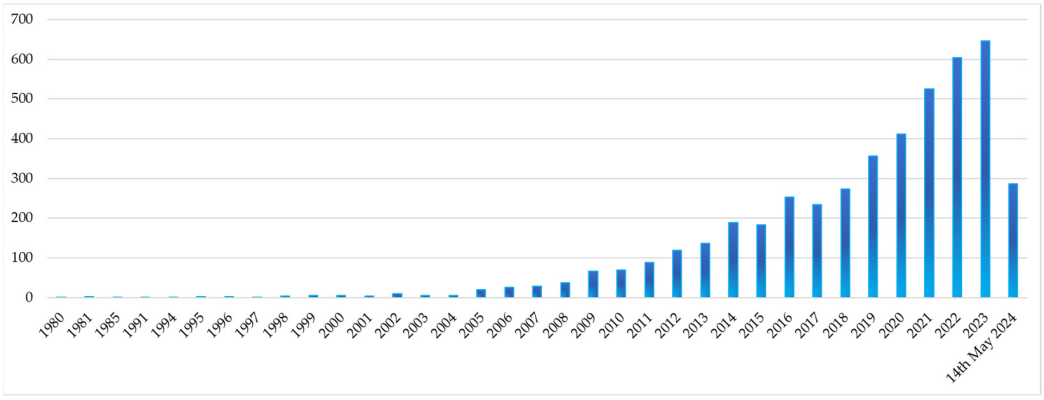

Figure 2. Trends of documents on grassland ecosystem services.

The distribution of all documents by countries shows that more than 50% of them were from China (1129), the United States (985), Germany (455), and the United Kingdom (379), as reported in Figure 3.

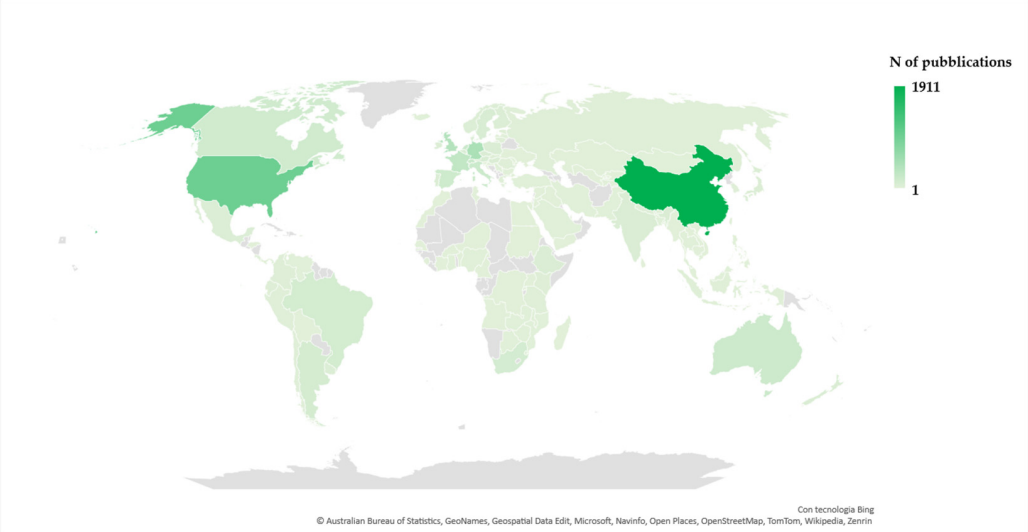

Figure 3. Distribution by countries of the publications on grassland ES (n = 4608) collected with the Scopus database in the period 1980–2024.

Most of the published manuscripts were articles (4024; 87%), followed by review papers (240; 5%), book chapters (152; 3%), and conference papers (128; 3%). About 93% of the documents (4304) were published in journals, and the top ten source types are listed in Table 3. The latter shows that the main research areas were the assessment of ecological and environmental indicators, the ecology, the environment in total (atmosphere, lithosphere, hydrosphere, biosphere, and anthroposphere), the sustainability, and everything that concerns land.

Table 3. The top ten contributor journals collected with the Scopus database in the period 1980–2024.

Source Title	Number of Documents	% of Documents
Ecological indicators	176	4%
Shengtai xuebao	175	4%
Science of the total environment	138	3%
Sustainability Switzerland	131	3%
Land	115	2%
Agriculture ecosystems and environment	110	2%
Journal of Environmental Management	95	2%
Remote sensing	71	2%
Plos one	70	2%
Journal of Applied Ecology	65	1%
Total of the top ten journals	1146	25%
Number of documents published in journals	4304	93%
Number of documents related to grassland ESs	4608	100%

In line with what has been said, the top ten cited articles dealt with the importance of biological diversity for the maintenance of ecosystems; the impact and consequences of biodiversity loss on the functioning of ecosystems, the provision of ecosystem services and human well-being; the importance of biological and microbial communities for ecosystem services and human well-being; the importance of investing in the protection and restoration of natural capital and the implementation of national policies on payments for ES to address devastating environmental crises and improve human well-being (Table 4).

Table 4. The top ten cited manuscripts collected with the Scopus database in the period 1980–2024.

Title of the Top Ten Cited Manuscripts	Journal's Name	Year of Publication	Number of Citations
Partitioning selection and complementarity in biodiversity experiments [42]	Nature	2001	2242
Quantifying the evidence for biodiversity effects on ecosystem functioning and services [43]	Ecology letters	2006	2006
Biodiversity and ecosystem stability in a decade-long grassland experiment [44]	Nature	2006	1611
Soil biodiversity and soil community composition determine ecosystem multifunctionality [45]	Proc. Natl. Acad. Sci.	2014	1495
Confronting a biome crisis: Global disparities of habitat loss and protection [46]	Ecology letters	2004	1321
Microbial diversity drives multifunctionality in terrestrial ecosystems [47]	Nature Communications	2016	1306
Incorporating plant functional diversity effects in ecosystem service assessments [48]	Proc. Natl. Acad. Sci.	2007	1250
Improvements in ecosystem services from investments in natural capital [49]	Science	2016	1228
High plant diversity is needed to maintain ecosystem services [50]	Nature	2011	1150
Ecological and socioeconomic effects of China's policies for ecosystem services [51]	Proc. Natl. Acad. Sci.	2008	1125

Referring to subject areas, those most represented were environmental science and agricultural and biological sciences (Figure 4), confirming the importance of studying grassland ESs from an environmental and agricultural management perspective. At the same time, it is interesting to note that the area of social sciences occupied the third place, absorbing 7% of the research returned by Scopus.

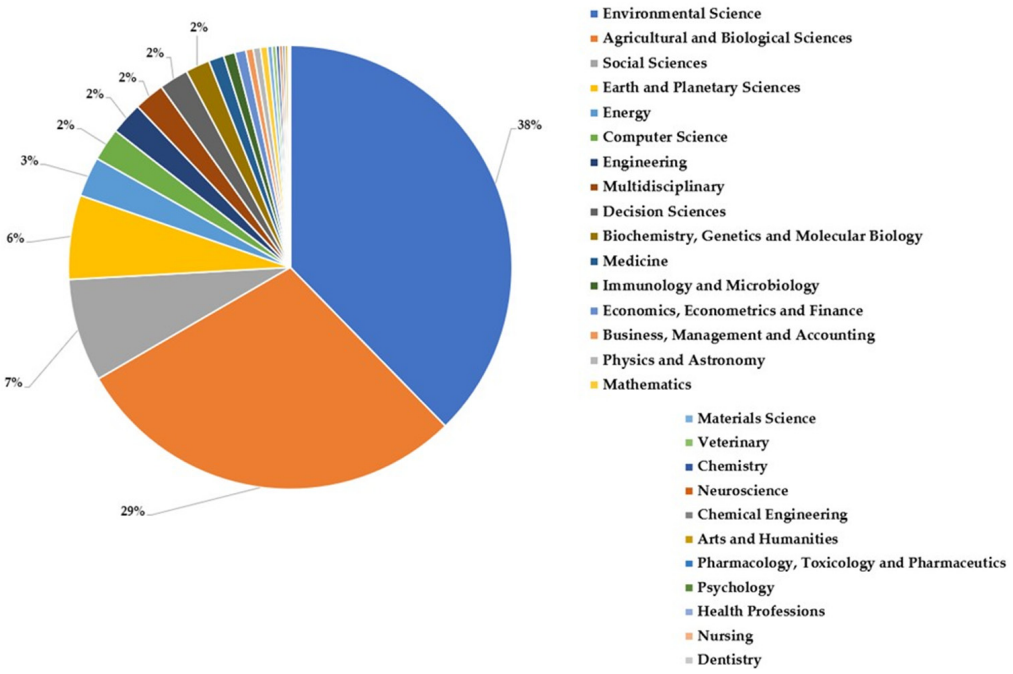

Figure 4. Distribution of documents, collected with the Scopus database in the period 1980–2024, by subject area.

The co-word analysis of all keywords of the 4608 collected documents aggregated the terms with a minimum number of occurrences of 10 into 5 clusters, easily visible in Figure 5 because they are highlighted by different colors (cluster 1 red; cluster 2 bright green; cluster 3 blue; cluster 4 light green; cluster 5 purple) (Figure 5). The top five most recurring words were grassland (occurrences: 1890), ecosystem service (occurrences: 1813), ecosystem services (occurrences: 1120), ecosystems (occurrences: 1105), and China (occurrences: 1059). The keyword "grassland" belonged to cluster 3, and the other most frequently occurring words were agricultural land, agriculture, and biodiversity. Instead, the keywords "ecosystem service", "ecosystem services", "ecosystems", and "China" belonged to cluster 1, where the other most frequently occurring words were environmental protection, forestry, land use, land use change, and sustainable development (Figure 5).

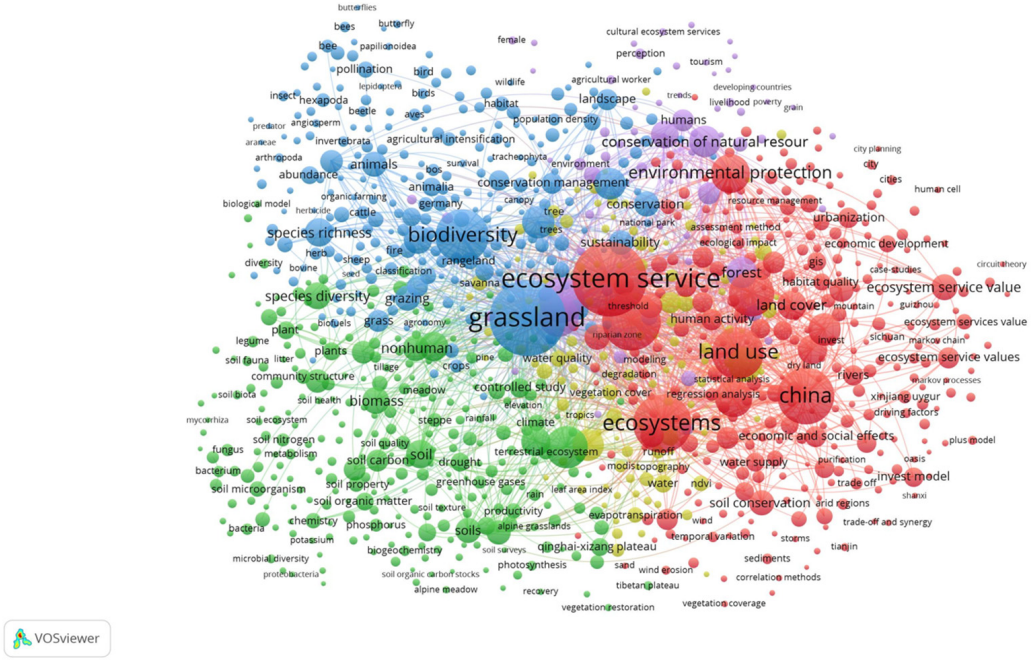

Figure 5. Co-word (all keywords co-occurrence) network map of the 4608 documents collected with the Scopus database in the period 1980–2024.

At the same time, to better outline the situation, the unit of analysis "author keywords" was used, and the corresponding density map (Figure 6) showed that the most recurring keywords were ecosystem services (825 occurrences); grassland (288 occurrences); biodiversity (274 occurrences); climate change (234 occurrences); and ecosystem service value (203 occurrences) (Figure 6).

In this analysis, 6 clusters have been identified and the terms "ecosystem services" and "ecosystem service value" belonged to cluster 1, where the other most frequently occurring words were carbon storage, ecosystem service, land use, and land use change. The keywords "grassland" belonged to cluster 6, which includes the following most frequently occurring terms: agroecology, land management, landscape, livestock, and vegetation. The keywords "biodiversity" and "climate change" belonged to cluster 2, with the words drought, ecosystem function, functional diversity, grazing, multifunctionality, soil organic carbon, and species richness.

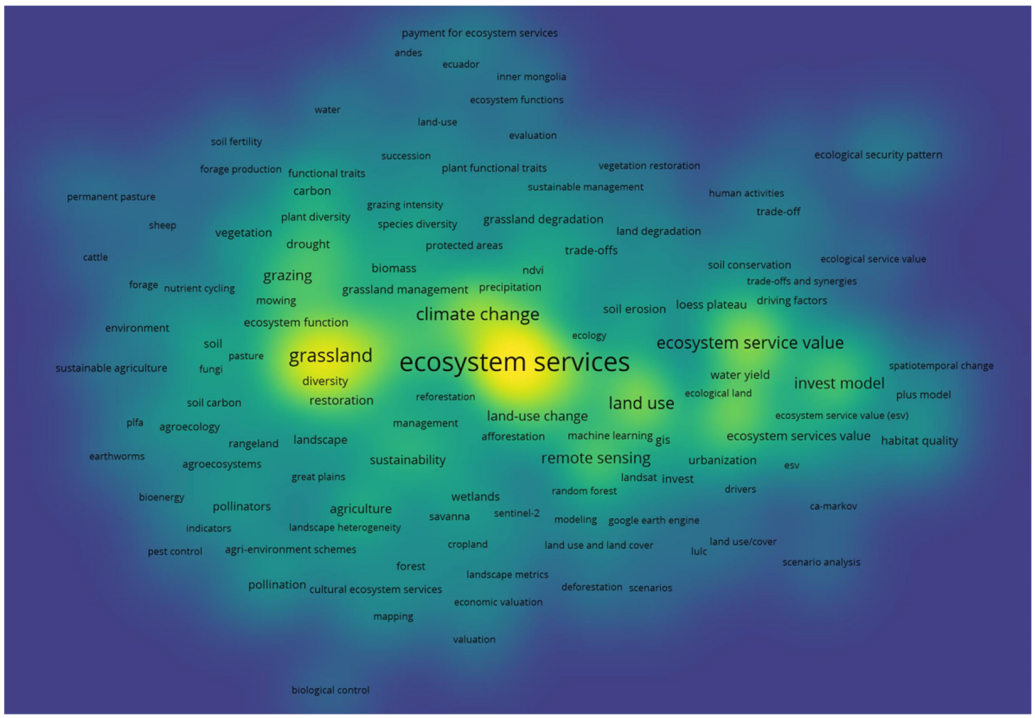

Figure 6. Density map displaying words from author keywords of the 4608 documents collected with the Scopus database in the period 1980–2024.

3.2. The Analysis of the Documents Referring to the Economic Evaluation Methodologies of the Grassland ES

To try to skim the 1033 documents that Scopus returned in reference to the economic methodologies for estimating grassland ESs, co-occurrence analysis was used. The latter, carried out considering "all keywords", was not very significant for the purpose of the research given that it identified five very varied clusters and the following five most recurring words: ecosystem service (457 occurrences), grassland (324 occurrences), China (321 occurrences), ecosystem services (258 occurrences), ecosystems (221 occurrences) (Figure 7), namely, the same ones displayed before.

At the same time, this analysis made it possible to verify the presence of terms relating to the economic evaluation of the ES. Thus, the following keywords were identified: economics (67 occurrences); economic analysis (21 occurrences); willingness to pay (14 occurrences); payment for ecosystem services (10 occurrences); and ecological economics (11 occurrences). As shown in Figure 8, which shows the links of these economic terms, only the words "economics", "ecological economics", and "willingness to pay" were simultaneously linked to the two main research terms (ecosystem services and grasslands)—among other things, the most recurring terms. On the contrary, the keyword "economic analysis" was found to be linked to ecosystem services/service, ecosystems, and land use, while "payment for ecosystem services" was found to be far from all the other keywords and not linked to any other term.

This analysis was followed by the selection of manuscripts that had the economic evaluation of ESs as their subject of study. The selected sample (161 papers) was carefully studied and divided into 15 groups of adopted methodologies, as reported in Table 5.

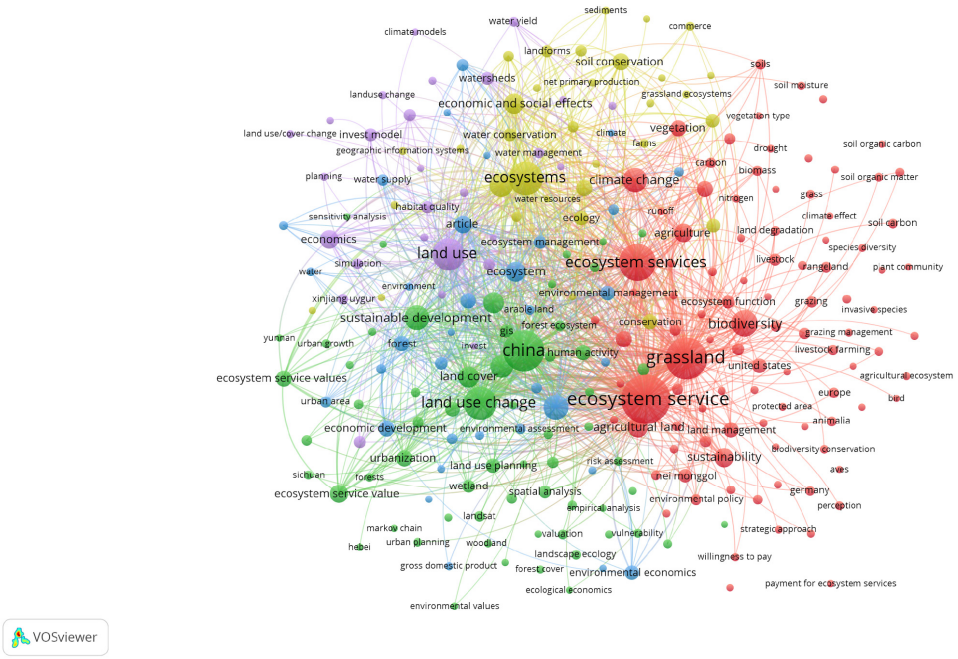

Figure 7. Co-word (all keywords co-occurrence) network map of the 1033 documents collected with the Scopus database in the period 1980–2024.

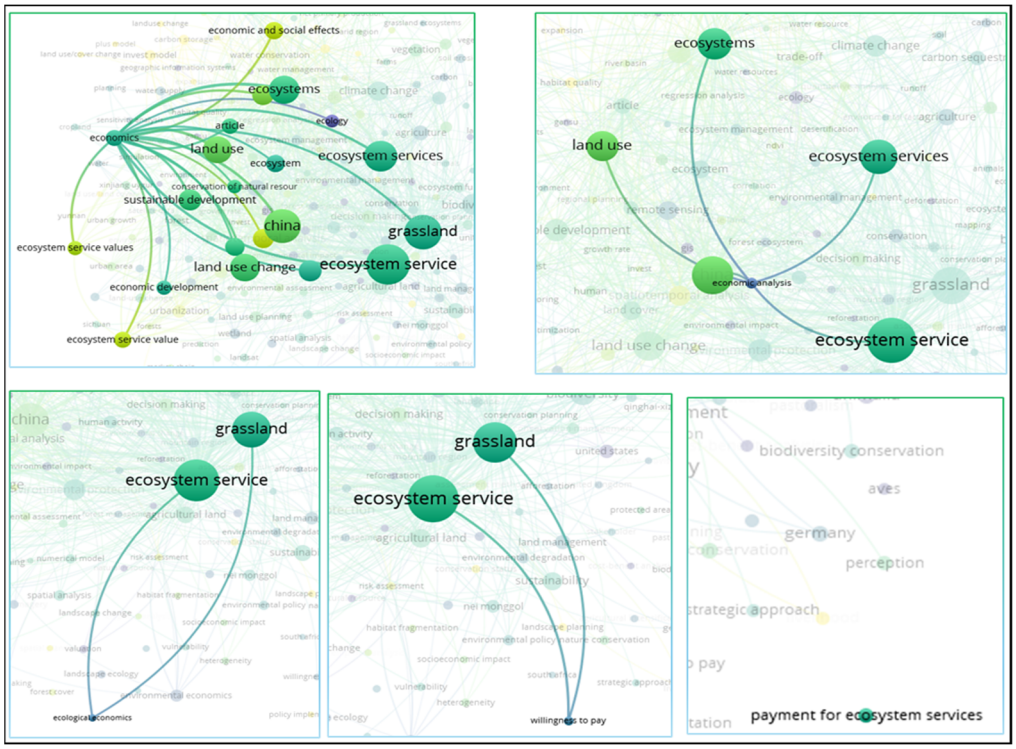

Figure 8. Co-word (all keywords co-occurrence) network map of the 1033 documents collected with the Scopus database in the period 1980–2024.: focus on the keywords "economics", "ecological economics", "willingness to pay", "economic analysis", "payment for ecosystem services".

Table 5. The groups of ES grassland economic evaluation methodologies identified, the number of publications for each group, and the relevant bibliographical references (our elaboration).

Methodologies	Number of Documents	References
Ecosystem Service Value (ESV) Assessment	91	[52–71] *
Resource Equivalency Approach	22	[72–92]
Econometric Models	11	[12,93–101]
Benefit Transfer Method	7	[102–108]
Contingent Valuation Method (CVM)	7	[109–115]
Gross Ecosystem Product (GEP)	4	[116–119]
Emergy Value Method	4	[120–122]
Focus Groups, Perception/Social Preference Method	4	[123–126]
Net Present Value	3	[127–129]
Replacement Cost Method	3	[115,130–132]
Market and Shadow Price Method	2	[133,134]
Life Cycle Assessment Approach	1	[135]
Social Cost	1	[136]
Theory of Value and Random Utility	1	[137]
Cost–Benefit Analysis	1	[138]

* For reasons of space, only publications from the last year are reported.

The most widespread economic estimation methodology for grassland ES was the ESV assessment, which, for each land-use category (per unit area) assigns an equivalent coefficient, as reported by Xie et al. [139] and Costanza et al. [14]. "Indirect" estimation methods then follow, namely, the resource equivalency approach, according to which the economic estimates of ES occur through the quantification of compensation to farmers for the loss of the environmental resource [140]. This category includes the payments for ecosystem services (PESs), the agri-environment schemes (AESs), and the eco-compensations. We define these methodologies indirectly given that the estimation of the ES in these cases occurred through the quantification of the amount for the ecological compensation received by farmers who implemented measures to increase the ES or avoid their decrease.

Econometric models, useful for carrying out meta-regression analyses when there are multiple variables to consider simultaneously, were found in only 11 papers (Table 5). At the same time, the benefit transfer method, used to estimate the economic values of ES by transferring available data from studies already completed in another location and/or context, was applied in seven manuscripts, as well as the contingent valuation method. In particular, the latter was used to estimate landowner/farmer willingness to accept (WTA) monetary compensation in exchange for implementing management practices preserving grassland ecosystems or to assess the willingness to pay (WTP) for ES.

Other economic methodologies were the estimation of ES through the computation of the gross ecosystem product (based on the calculation of the functional quantity of each ecological element and then its conversion into value quantity) [141]; the energy value method (which refers to the available energy required directly and indirectly to make a service or good [142] and measures natural capital and ESV by assessing the costs of their generation from a donor-side perspective [122]); the use of focus groups to understand the perceptions and social preferences of interviewees; and the use of the net present value (Table 5).

The use of the market and shadow price method and the replacement cost approach were less frequent (only in two research in the first and in three in the second). Finally, the life cycle assessment approach, the use of the social cost, the cost theory of value and the random utility, and the cost–benefit analysis were decidedly rare.

Referring to the type of data used for the economic evaluation of grassland ES, the analysis of the 161 selected papers showed that land use/cover change (LUCC) data were the most used data (in 37% of cases), followed by direct data acquired through structured and semi-structured interviews (SSI) (14%) (Table 6).

Table 6. Typologies of data used for the economic analysis of grassland ES.

Type of Data	Number of Documents
Land use/cover change (LUCC)	60
Data from structured and semi-structured interviews (SSIs)	22
Land cover data, net primary productivity, precipitation, and soil erosion data (LNPS)	21
Multi-source data (MS)	14
Bio-economic modeling approach (BEM)	12
Data from others research (R)	12
Land use data and socio-economic data (LSE)	9
LUCC, climatic, socioeconomic, and biophysical data (LCSEB)	7
Socio-economic data (SE)	4
Total	161

In 57% of the documents, the four categories of ES (provisioning, regulating, supporting, cultural) were estimated and, for each category, the following ecosystem services were accounted: food production, raw material production, and water supply (as regards provisioning services); gas regulation, climate regulation, environment purification, and hydrological regulation (with regards to regulating services); soil conservation, nutrient cycle maintenance, and biodiversity (as supporting services); aesthetic landscape, regarding cultural services. In 22% of the papers, the overall value of the ES offered by the grasslands was calculated (ESV), without any differentiation in the different ES offered; in 13% a single ES was estimated, and, in 8%, there were multiple ecosystem services (Figure 9).

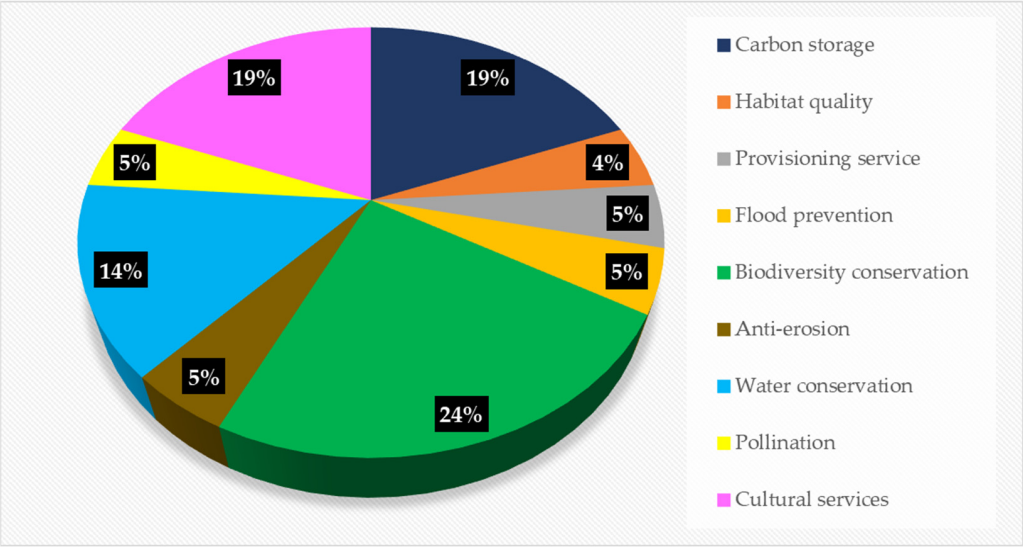

Figure 9. The individual ecosystem services estimated from an economic point of view.

Biodiversity conservation (in five papers), cultural services (in four manuscripts), carbon storage (in four documents), and water conservation (in three papers) were the most estimated single ES (Figure 9).

Among the ecosystem services that have been economically estimated in combination with other ES, carbon sequestration stands out, followed by forage provision and soil protection (Figure 10).

In conclusion, the evaluation of the 161 selected papers showed that individual ESs were evaluated from an economic point of view mainly through bio-economic modeling approaches and data coming from structured and semi-structured interviews. The economic estimate of multiple ES was carried out with data from different sources depending on the ES to be estimated, while the accounting of the ESV and the main ES falling into the four

macro categories of ES was carried out essentially through land use/cover change data more or less combined with environmental, climatic, and socio-economic data (Figure 11).

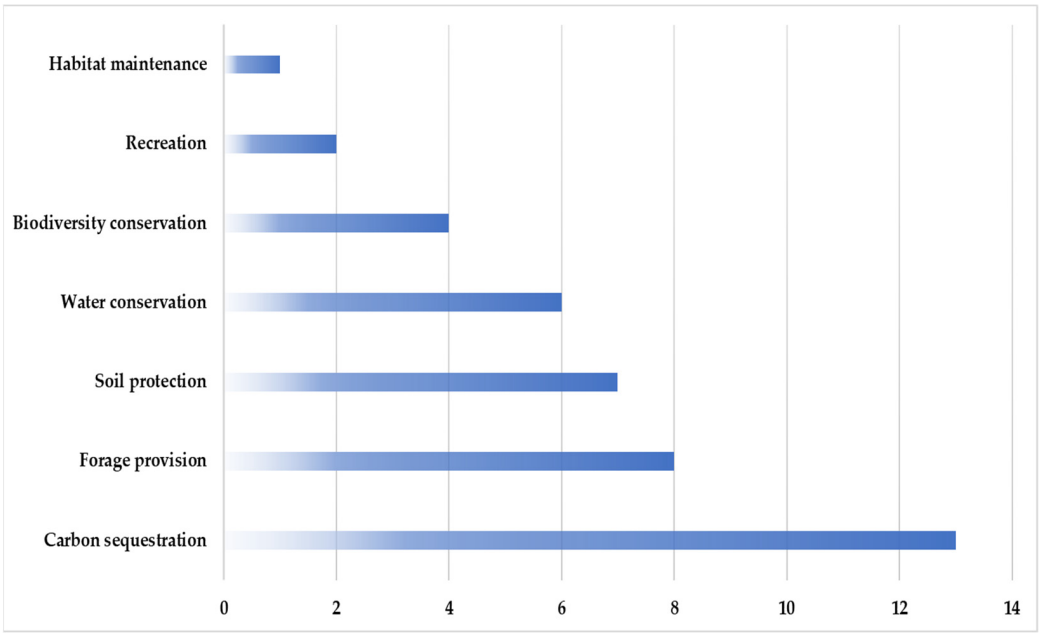

Figure 10. Multiple ecosystem services estimated from an economic point of view.

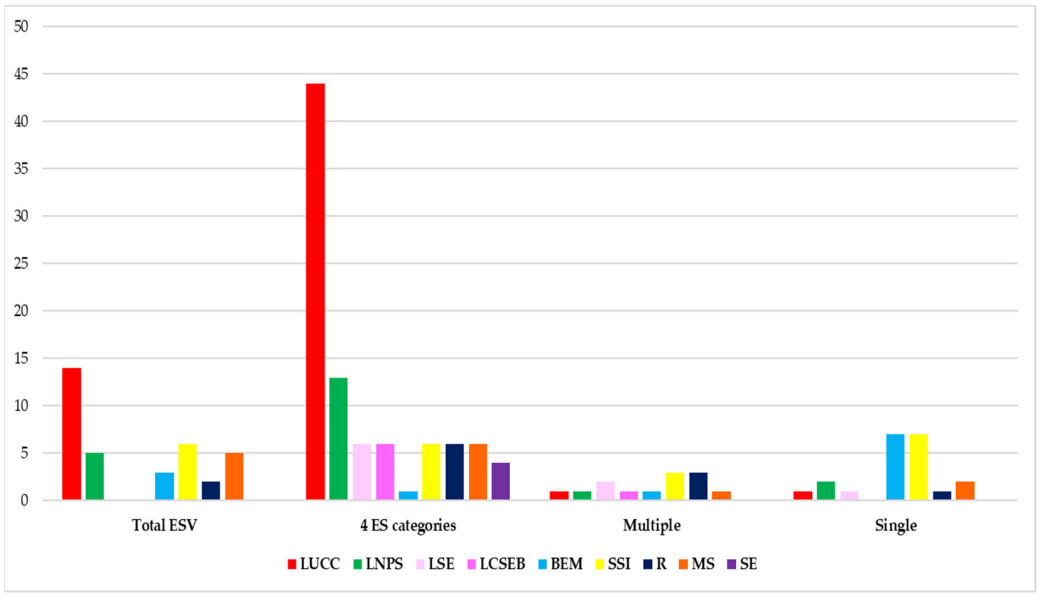

Figure 11. Types of data used to estimate the different ES grasslands from an economic point of view (ESV: ecosystem service value; 4 ES categories: provisioning, regulating, supporting, cultural services; LUCC: land use/cover change; LNPS: land cover data, net primary productivity, precipitation, and soil erosion data; LSE: land use data and socio-economic data; LCSEB: LUCC, climatic, socioeconomic, and biophysical data; BEM: bio-economic modeling approach; SSI: data from structured and semi-structured interviews; R: data from others research; MS: multi-source data; SE: Socio-economic data).

4. Discussion

4.1. Main Findings

As a first step, the present review attempted to provide a critical overview of academic studies on grassland ESs. Thus, it highlighted that China and the USA were both some of the countries with the highest percentage of grasslands (in terms of land area) and the main countries with the highest number of publications regarding ESs provided by grasslands, followed by Germany and the United Kingdom. The number of publications began to grow starting in 2005 thanks perhaps to the publication of the Millennium Ecosystem Assessment, an important document that aimed to evaluate the consequences of ecosystem change for human well-being and to establish the scientific basis for actions necessary to improve the conservation and sustainable use of ecosystems and their contribution to human well-being [143]. The increase in the number of publications on this topic is also the result of the general increase in interest in ecological policy issues that has occurred especially in the last two decades, which has led to state policies being more attentive to concerns about the condition of the environment and to an increase in scope to protect various valuable ecosystems. The main instrument of the European Union policy for the conservation of biodiversity is, undoubtedly, Natura 2000: an ecological network spread across the entire territory of the EU, established pursuant to Habitats Directive 92/43/EEC to guarantee the long-term maintenance of threatened or rare natural habitats and flora and fauna species at a community level.

At the same time, 55% of the documents found in Scopus referred to the last five years, in which 2023 represented the year with the highest number of documents ever (646). These data demonstrate the timeliness, importance, and relevance of this research topic.

The most represented subject areas of study were environmental science and agricultural and biological sciences (Figure 4), in which a central role was played by biodiversity as an important provision service. At the same time, however, among the most cited articles, in addition to those on the importance of biodiversity for the maintenance of ecosystems and on the impact and consequences of its loss for human well-being, not negligible were those that dealt with ES payments to address devastating environmental crises and improve human well-being.

The use of science mapping for bibliometric analysis has highlighted the correlation between the ecosystem services provided by grasslands with carbon storage, land use, and its change. This points out, on the one hand, that the most studied grassland ES in absolute has been the carbon storage, especially in quantitative terms, and how pasturelands act as an important soil carbon sink, and, on the other hand, how land use and its change over time can influence the provision of ES. However, the same analysis applied to the 1033 documents, selected for the subsequent screening to identify the most used methodology for the economic evaluation of grassland ESs, did not produce significant results. In our opinion, this was due to the fact that the science mapping was based on the analysis of the semantic contents of publications' titles, keywords, and abstracts, which very often were unclear (especially the latter) and did not contain the searched words. Hence, there is a need in the future to use software that analyzes entire manuscripts.

Papers that estimated grassland ESs from an economic perspective represented only 3% of all papers that Scopus returned, demonstrating that economic research, as such, is secondary to the study of environmental functions. In fact, to evaluate an ecosystem function, it is necessary to establish that this function exists and what effects its variation has. Only then it can also be valorized from an economic point of view. Moreover, more than half of these publications referred to the methodology of Costanza et al. [14], namely, the use of equivalent coefficients to calculate the ecosystem service value of different land uses/land cover categories. In this case, some studies (about 20) have estimated the total ESV provided by grasslands, highlighting the difficulty in estimating individual ecosystem services provided by pasturelands from an economic point of view (especially those that do not have a market) and the greater propensity to use physical, chemical, and biological indicators. Other research (about 70) has identified and evaluated a maximum of

11 ecosystem services in precise economic terms: food production, raw material production, water supply, gas regulation, climate regulation, environment purification, hydrological regulation, soil conservation, nutrient cycle maintenance, biodiversity, aesthetic landscape, indicating that the latter is the most important ES offered by grasslands. This was also confirmed by studies that analyzed single or multiple ESs, in which carbon storage and biodiversity conservation took precedence.

As pointed out by Liu et al. [30], the evaluation methods commonly used for valuing ecosystem services are different depending on the ES to be evaluated. For example, direct market methods are usually used for services that can be directly traded in the market, and the price is used to reflect the value of the ES. The avoided or replacement cost method uses the cost of actions taken to avoid damages as a measure of the benefits provided by an ecosystem or ES. At the same time, the travel cost method is normally used to estimate the economic use values of recreational ecosystems or sites, and the stated preference methods (the choice experiment method and the contingent valuation method) are used to assess the economic value of various ecosystems and ESs based on a hypothetical scenario. The benefit transfer method is a unit value-based method used to evaluate economic values by transferring existing benefit estimates from completed research to other sites or ES. Thus, with Table 5, which shows, for each methodology identified, the different references in which the methodology is applied, we wanted to indicate to researchers who wanted to estimate grassland ESs in economic terms where to find the most appropriate methodologies to do so.

4.2. Limitations of the Study

The present results are influenced by the use of only one database extraction (Scopus), which includes only publications with CiteScore and not many other documents where the economic valuation of grassland ESs may have been estimated.

5. Conclusions

The results of the present systematic and bibliometric literature review highlighted the importance of grassland ESs and their estimation over time, above all in quantitative, ecological, and sociocultural terms. Economic evaluation studies were few compared to the total academic publications and mainly linked to the quantification of ecosystem service values per unit area for each land-use category or, referring to grasslands, of only 11 types of ES. Consequently, the sustainable management of grasslands requires more studies on the economic evaluation of their ES. Furthermore, such research can be the basis for including environmental aspects in the economic accounting of governments or to implement a support system for farms in delivering various ecosystem services.

Author Contributions: M.P.: Conceptualization, methodology, software, validation, formal analysis, investigation, data curation, writing—original draft preparation, writing—review and editing; M.C.: visualization, writing—review and editing; E.D.F.: supervision, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: No new data were created.

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

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