Article

A Scientometrics Review on Land Ecosystem Service Research

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Abstract: Humans can derive the benefits from the ecosystem to satisfy human needs as well-being. Therefore, good ecosystem management is the intermediary between ecosystems and human well-being. The ecosystem services depend on the supply of nature, and also reflect the value orientation of human beings, as the basis for the realization of human survival and cultural development. Land ecosystem services are the core and hot topic of ecological research. Under the current severe depletion of land use, this research evaluates the sustainable governance on the natural resource shortage, serious environmental pollution and ecosystem degradation. Based on the Web of Science database, this paper analyzes the development characteristics and trends of global land ecosystem services research using the Bibliometrix software package. The results show that (1) the amount of literature on land ecosystem services research between 2000 and 2019 has generally increased significantly, and entered a stage of rapid development from 2015. (2) Developed countries are the main research force in the field of land ecosystem services, and the United States has the absolute leading position. Developing countries are dominated by China, Argentina, and Brazil. (3) The high-frequency keywords for land ecosystem services are land use change, land use, climate change, urbanization, carbon and water quality. This can be regarded as a research hotspot in the field of land ecosystem services to a certain extent. (4) Through cluster analysis on the big data, the research found the direction for the future land ecosystem services, mainly: (I) the restoration of degraded land and its impact on ecosystem services; (II) the environmental impact assessment of land use planning based on the ecosystem services value; (III) the tradeoff analysis of ecosystem services in sustainable land management; (IV) the impact of land cover change on ecosystem services; (V) through the historical analysis of citied papers, the research history and evolution path of land ecosystem services are explored. Based on all these arguments, a comprehensive study on the diverse facets of land ecosystem services and the practical application of land ecosystem services areas is proposed.

Keywords: land ecosystem services; land use change; bibliometric; historical analysis

1. Introduction

Nature interacts with human society in a complex way. While nature has contributed to people's quality of life, human over-exploitation has caused enormous damage to biodiversity. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) combines the joint efforts of government, academia and civil society to assess and enhance the knowledge of the Earth's biodiversity, ecosystems and its contribution to human society. One of the new key elements of this conceptual framework is the concept of nature's contributions to people (NCP), which is all positive contributions

or benefits that people derive from nature, and sometimes negative contributions, losses or damage [1]. The concept is based on the concept of ecosystem services popularized by the Millennium Ecosystem Assessment (MA) and is considered to be a concept with greater potential than ecosystem services [2]. However, the NCP emphasizes a one-way flow from "nature" to "human" [3], and there is currently no substantial evidence that the NCP framework is more useful than the ecosystem service concept [4]. Therefore, this article still adopts the concept of ecosystem services.

Ecosystem services refer to the environmental conditions and effects formed by ecosystems and ecological processes to maintain human survival and development, and are the benefits directly and indirectly derived by human beings [5,6]. Land is a mosaic of various ecosystems in the region, and a geographical entity formed by the combination of various natural and human factors. Land use links social and economic activities with ecological processes, thus affecting ecosystem services. Land use change during urbanization has a major impact on the ecosystem services' value; changes in land use can change the structure and function of ecosystems, thereby affecting the value of ecosystem services. In addition, unreasonable land use will affect the decline in land use efficiency [7], which is not conducive to sustainable land use and management [8]. Under the ecological security scenario, land use change has a positive impact on ecosystem services, while in rapid urbanization scenarios, ecosystem services are negatively affected by land use change. Different land use/cover types have the ability to provide different types, quantities and quality of ecosystem services. The increase in wasteland and built-up areas will lead to a decline in ecosystem services [9,10], and at least some aspects of ecosystem function can be restored after farmland is abandoned [11]. Forest land plays an important role in climate regulation [12], while the supply of cultivated land is stronger.

The concept of land ecosystem services is not directly proposed internationally. Land ecosystem services can be summarized as products and services that are directly or indirectly obtained through ecosystem services based on land. They include not only the physical products such as food, medicinal materials and industrial raw materials necessary for human production and life, but also non-physical ecological services such as soil and water conservation, purification of the environment, regulation of climate, and maintenance of biodiversity. Since the 1980s, the international community has performed many studies and discussions on the value, driving factors and research methods of ecosystem services. At present, the core research contents of land ecosystem services are land ecosystem services valuation, trade-off and synergy analysis and spatial flow study. Land ecosystem services valuation mainly evaluates the land ecosystem services' value from different use types, scales and evaluation methods. Sannigrahi [13] assessed the global land ecosystem services' value between 1995 and 2015 and found that ecosystem services' value lost $1.21 trillion per year due to depletion of forest vegetation and wetland/water surface. Chen [14] used the coefficient of ecosystem services' value to calculate the ecosystem services' value of the Ganjiang upstream watershed, analyzing the relationship between ecosystem services' value and potential factors using the boosted regression tree method, found that the Grain for Green program, population, GDP, urbanization level, investment in fixed assets, the proportion of secondary industry and tertiary industry proportion would affect ecosystem services' value. The specific interactions between different ecosystem services are complex and can be roughly summarized into two main relationships: trade-offs and synergies. Arowolo [15] found that land ecosystem services' value in Nigeria increased between 2000 and 2010 due to the expansion of cultivated land, but the economic loss caused by the continued loss of services such as climate and water regulation provided by natural ecosystems may exceed the benefits of cultivated land development. So, the trade-off between ecosystem services is becoming increasingly prominent. Lin [16] analyzed the spatial trade-offs and synergies among eight ecosystem services of the Three Parallel Rivers Region in Southwest China. It has been found that most provisioning services (such as food production, livestock production, etc.) had trade-offs with other services, while regulating services (such as carbon sequestration and carbon storage) showed synergies with other services. Inter-regional mobility of ecosystem services has also been a hot topic in academic circles in recent years. Balzan [17] assessed spatial changes in ecosystem services' capacity and flows in the Mediterranean small island state of

Malta. The study found that the generation and transmission of ecosystem services was determined by the intensity of land use. The study found that the generation and transmission of ecosystem services is determined by the land use intensity. In rural landscapes characterized by agricultural and semi-natural LULC types, there is a significant synergy between ES capacity and flow, while major urban areas tend to have low ecosystem capacity and ecosystem services flows.

Bibliometrics uses mathematical and statistical methods to quantitatively analyze literatures. It enables researchers to quickly master the current basic information and development status in the research field, explain the relationship between analysis units more intuitively through graphics and visualization [18], so as to clearly understand the research status, research hotspots and development trend in this field. At present, scholars have conducted bibliometric analysis of relevant research on land ecosystem services and achieved certain results. Zhang [19] conducted a bibliometric analysis of the SCI-E and SSCI databases of Web of Science, introducing the global research trends of highly cited papers on ecosystem services from 1981 to 2017. The existing bibliometric analysis is mainly based on publications, journals, keywords, countries, institutions and authors, and lacks the research on the evolution trend of hot topics and the analysis of citation historical veins. The current research on land ecosystem services is still rare and not comprehensive, but there are many reviews on land ecosystem services research. For example, Van den Belt [20] reviewed and commented on 58 new articles about agroecosystem in New Zealand, concluding that the concept of ecosystem services has a diverse interpretation and application, and the scope and characteristics of the research system are still fragmented and diverse. Zheng [21] systematically reviewed 47 related studies in 2005–2018, recording 70 actual or potential trade-offs, and analyzing more than half of the trade-offs caused by land use/cover changes. Although the literature review can analyze the research status and existing problems of existing research results in a certain period, the method is subjective and has a limited number of articles analyzed. As the research scope is mainly at a regional scale, the research space and time scale are restricted, and the global trend of land ecosystem services cannot be accurately grasped. So, this paper aims to fill this gap by studying global trends and academic networks involving land ecosystem services research. In this paper, the bibliometric analysis method and Bibliometrix Software Package will continue to be used to analyze and evaluate the relevant literature on land ecosystem services collected in the Web of Science database from 2000 to 2019, in order to directly and objectively identify the research trend of land ecosystem services, and provide a scientific reference for the research direction of land ecosystem services in the future. The research purposes of this paper include (see Table 1):

Table 1. Research questions, method and analysis in this paper.

Research Questions	Method	Analysis
What is the current research status of land ecosystem services?	Literature timing analysis	The law of document growth counts the number of documents related to land ecosystem services by year in order to grasp the trend of scholars' attention to land ecosystem services as a whole.
What is the distribution of the main research forces in the field of land ecosystem services?	Main research author analysis	The papers of major research scholars can well reflect the development of disciplines and provide effective solutions for solving complex problems.
	Main research country analysis	The publication of papers in different countries can, to some extent, reflect the emphasis and influence of country on the field of land ecosystem services.
What are the research hotspots in the field of land ecosystem services?	High-frequency keyword analysis	Keywords provide a high degree of generalization and refinement of articles. Refined high-frequency keywords in multiple articles can represent research hotspots in this field to a certain extent. Cluster analysis uses statistical methods to simplify the complex keyword network relationships into several relatively few clusters. This method can determine several key points that scholars pay attention to in a certain period of time.
	High-frequency keyword clustering analysis	

<div align="center">**Table 1.** *Cont.*</div>

Research Questions	Method	Analysis
How does the land ecosystem service citation develop?	Historical analysis	Historical citation analysis can graphically show the relationship between different documents in the field of land ecosystem services, quickly map out the development of the field, and locate the most important literature in this field, determine the distribution law of the most cited literature, and construct the development law and future research trends of the discipline.

2. Data Sources and Research Methods

2.1. Data Sources

The Web of Science database is the world's largest comprehensive academic information resource library covering the most disciplines. Its content covers the fields of natural sciences, engineering technology, biomedicine, social sciences, arts and humanities. The data used in the literature analysis of this article were derived from the core collection of Web of Science. It consists of three major citation databases: Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (A&HCI). To analyze the research dynamics and development frontiers of land ecosystem services. In this paper, the search was conducted in October 2019, so the time span ranging from the earliest available date up to October 2019 were taken into consideration in this study (the time retrieval spans from January 2000 to October 2019). The method of document retrieval was to select the search scope as the title, enter TI=(*land AND ecosystem service) in the search term, and obtain 840 papers. In order to eliminate the interference of unrelated literature and ensure the precision and recall rate of research papers on land ecosystem services, this study selected the document type as "Article". The selection criteria for articles were: the four authors read the title and abstract of the literature search carefully. If the title and abstract could not distinguish whether it involved land ecosystem services, the full text was read independently. The four authors then jointly decided whether to include the literature in the study. We finally obtained 728 related articles.

2.2. Research Method

2.2.1. Research Software

Bibliometrics is a quantitative statistical method that uses mathematical and statistical methods to study the growth and distribution of scientific literature [22]. Knowledge map is a method that combines the theory and method of applied mathematics, graphics, information visualization technology, information science and other disciplines with citation analysis and co-occurrence of bibliometrics. Knowledge map is a research method that visualizes the core structure, development history, frontier areas and overall knowledge structure of the subject with visual maps. Therefore, it mainly takes all the research literatures in a certain field for a period of time as a research sample, and visually reflects the overall research and development trend of the field.

Developed in 2017 by Professor Massimo Aria, the Bibliometrix software package is a new R-based bibliometric software package [23]. It can import and process literature information from Scopus and Web of Science databases and statistical analysis of the relevant scientific literature index, the construction of the co-occurrence matrix, co-citation, coupling, cooperative analysis and co-word analysis, subject evolution analysis and other aspects of research and visualization can be performed. Thus, the Bibliometrix software package can independently complete the five-step bibliometric statistical analysis process of study design, data collection, data analysis, data visualization and interpretation (see Figure 1). However, only a small number of scholars have used Bibliometrix for bibliometrics and visualization [24,25]. Based on the outstanding advantages of this analytical tool, this paper attempted to apply it to the research field of land ecosystem services and conduct a

comprehensive bibliometric analysis of the global research results of land ecosystem services. This can be used as a reference for other bibliometric researchers.
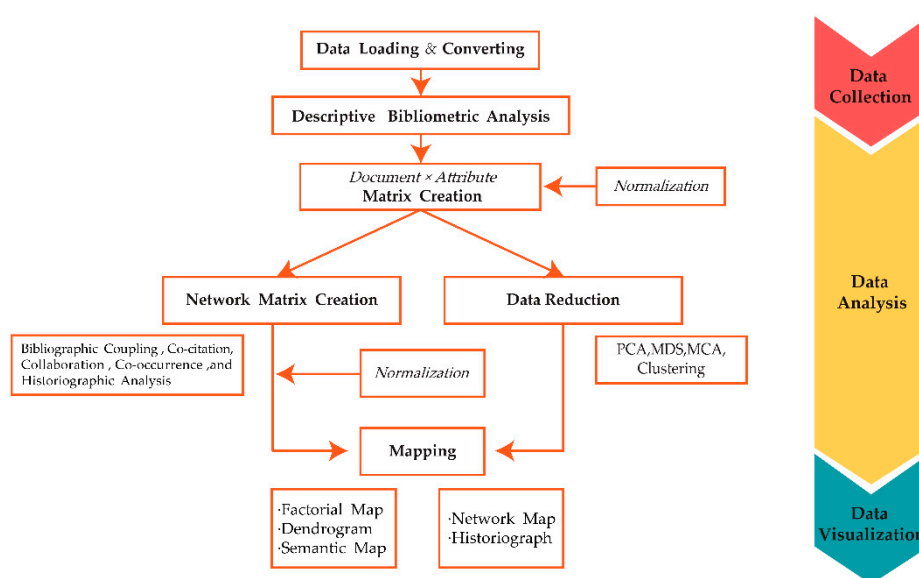

Figure 1. Bibliometrix and the recommended science mapping workflow.

2.2.2. Knowledge Mapping

(1) Lotka's law

The study of the laws of the authors of the literature began with Lotka in the 1920s. Lotka's law is an important law that studies the relationship between the number of documents published by authors in a subject area and the authors who publish them. It believes that the relationship between the number of authors and the number of documents can be expressed as $f(x) = C/x^n$, where x is the number of documents, and $f(x)$ is the ratio of the number of authors who have published x articles to the total number of authors; C is the Lotka constant, which refers to the proportion of authors who have published only one document to all authors. n is the Lotka index, which is usually 2. Lotka's law can more clearly distinguish between high-yield authors and low-yield authors in the field of land ecosystem services, which can further describe the distribution of scientific productivity in this field.

(2) Tree dendrogram

Cluster analysis can quantitatively study the classification and partitioning problems within the discipline, which is the most commonly used method in bibliometrics [26]. The basic principle of cluster analysis is to quantitatively determine the close relationship between samples according to the attributes of sample and mathematical methods according to certain similarity or difference indicators. The samples are clustered according to the degree of such affinity. In the cluster analysis map, if the clustering criteria are different, the clustering results will be different. In this paper, the clustering statistical method was used to calculate the co-word matrix, and the keywords with relatively high co-occurrence frequency were grouped into small groups, and the keywords with relatively low frequency were clustered into large groups. We formed a tree dendrogram of relationships from close to alienated.

(3) Multidimensional scaling analysis

Multidimensional scaling analysis is the assignment of observational data to a specific location in the conceptual space. Conceptual spaces are generally two-dimensional or three-dimensional. The distance of the data points is determined by the calculated dissimilarity, so that similarities and dissimilarities can be described in the low dimension to obtain a spatial understanding of the object relationships.

(4) Historical direct citation network

The historical citation analysis can graphically display the relationship between different documents in the field of land ecosystem services, and can quickly help scholars to draw a history of development in the field, and to locate important documents and the latest important documents in the field.

3. Results Analysis

3.1. Literature Timing Analysis

It can be seen from Figure 2 that although the number of articles issued in individual years has decreased, the number of documents has generally increased year by year, and the research can be roughly divided into three stages. (1) Initial stage (2000–2008): the study of land ecosystem services was in its infancy, with fewer publications per year, but maintaining a basic growth. (2) Volatility growth stage (2009–2014): the number of documents began to fluctuate in growth. The global study of land ecosystem services began roughly during this period. The reason for this is that in the context of rapid urbanization in the world, economic development and population growth brought tremendous pressure on the ecological environment. Among them, the changes in land use brought about by human activities had most direct impact on regional ecosystem services. Bateman [27] argued that land use change affects the structure, processes, and functions of ecosystems by changing the type of surface cover. Using the UK as a research area, Bateman demonstrated that land use change has a negative impact on agricultural production, greenhouse gas emissions and storage, open leisure activities, urban green space and biodiversity. Therefore, Bateman proposed that restrictive development policies have a significant positive effect on improving the value of ecosystem services. (3) Rapid development stage (2015–present): the number of documents has grown rapidly. As the theory of sustainable development is increasingly recognized by scholars and the theory of strong sustainability is proposed [28], the global research on land ecosystem services is further deepened. This shows that while the economy is growing rapidly, people are beginning to pay attention to the assessment and recovery of ecosystem services.
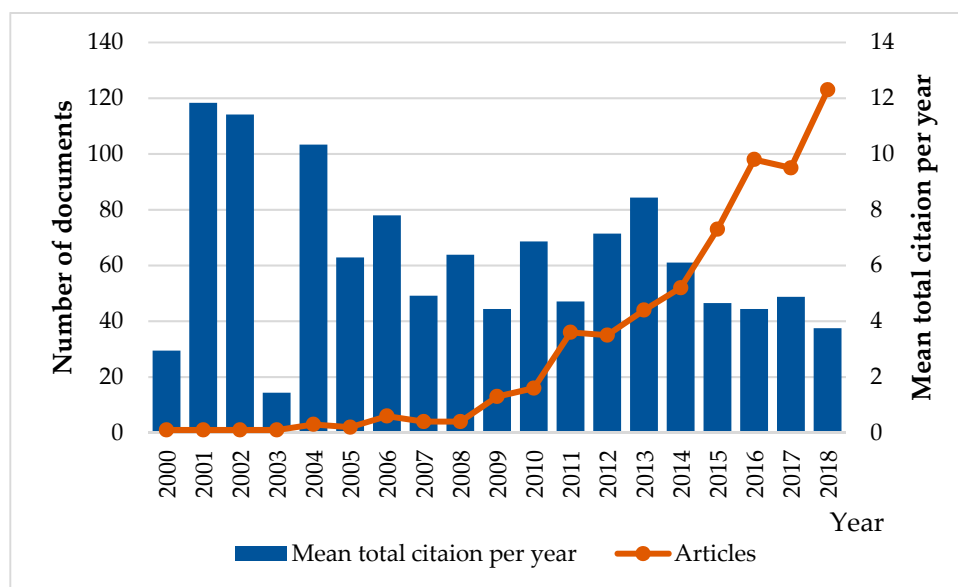
Figure 2. Number of articles and average citations per item in each year in the field of land ecosystem services.

Judging from the average citations per item, there was only one paper on land ecosystem service research in the Web of Science database in 2001 and 2002, but the citations were as high as 11.83 and 11.41 respectively. The papers during this period focused on the relationship between species richness and ecosystem services. For example, Engelhardt [28] believed that wetlands provide many important

ecosystem services for humans, such as ecological health, entertainment function, and water supply. It was also suggested that the increase in the richness of vascular plant species can increase the biomass of algae plants by 25% and retain 30% of potential polluting nutrients, thus increasing the value of wetland ecosystem services to a certain extent. However, after 2004, the annual average citations per item showed a trend of decreasing volatility, with a total citation frequency of only 190. It can be seen that the average quality of the literature on land ecosystem services research is not high and the comprehensive influence is insufficient. This indicates that the research level of land ecosystem services needs to be further improved.

3.2. Main Research Author Analysis

In this study, the Lotka's law distribution map is drawn. The ordinate indicates the proportion of authors of different literatures to all authors, and the abscissa indicates the number of documents. The dotted line in the figure is a general image description of Lotka's law. As can be seen from Figure 3, there are 2424 scholars who published a paper, accounting for 85.9% of the total. The number of scholars who published more than two papers was 399, accounting for 14.1% of the total (see Table 2). It can be seen that the authors of the land ecosystem service research field and the number of documents are similar to the dotted line in the figure, which basically conforms to the general law of Lotka's law. This can indicate that the number of authors who have written only one or two papers in the field of land ecosystem services is relatively large. Most scholars in this field have just entered, and the research has not been in-depth.
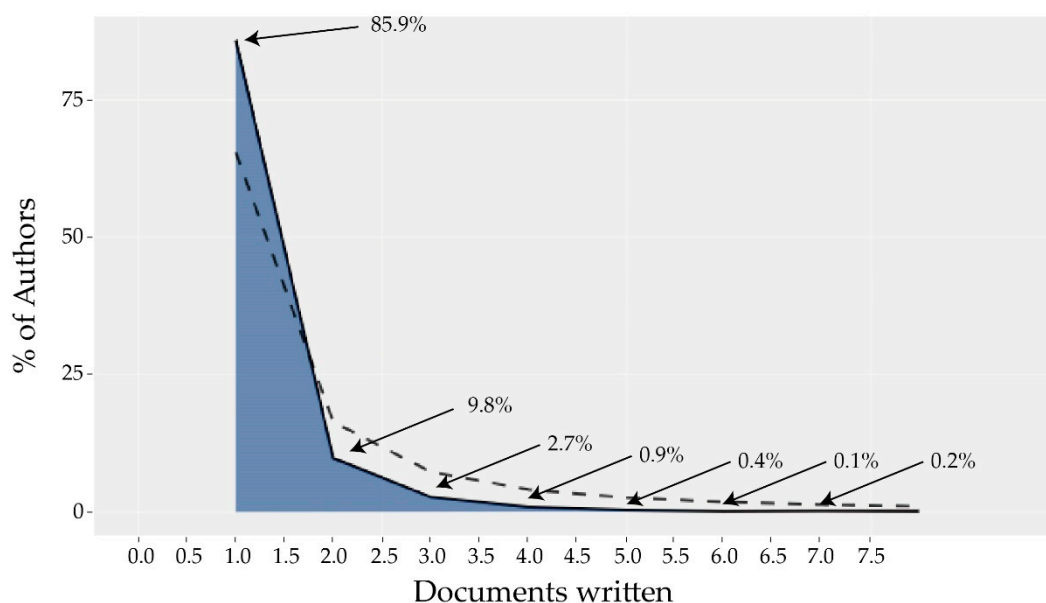

Figure 3. The frequency distribution of scientific productivity.

Table 2. Distribution of authors and their publications.

Documents written	N. of Authors	Proportion of Authors
1	2424	0.858661
2	276	0.0977683
3	76	0.0269217
4	25	0.0088558
5	10	0.0035423
6	3	0.0010627
7	5	0.0017712
8	4	0.0014169

Figure 4 (the shade of the color indicates the citation of the author, and the size of the circle indicates the amount of paper published. The specific values are shown in Appendix A) and Table 3 list the top 10 high-yield authors in the field of land ecosystem services. The author with the largest number of papers published and the highest number of citations is Frust C. Furst has published papers in the field of land ecosystem services since 2012. His main research direction is to evaluate the value of ecosystem services. Frust C's paper 'Assessment of the Effects of Forest Land Use Strategies on the Provision of Ecosystem Services at Regional Scale', published in *Journal of Environmental Management* in 2012, was cited 18 times [29]. Fürst [29] believes that combining spatial explicit analysis based on land use scenarios with more detailed classifications of land use and assessing land use patterns can provide a good basis for forest management planners and regional planners to develop strategies. In view of this, Frust used spatial explicit methods to measure the impact of unstructured agriculture and short rotation coppice on ecosystem services. The results of the study indicate that the use of short rotation coppice instead of afforestation areas will reduce the total amount of biological resources and cause economic losses.
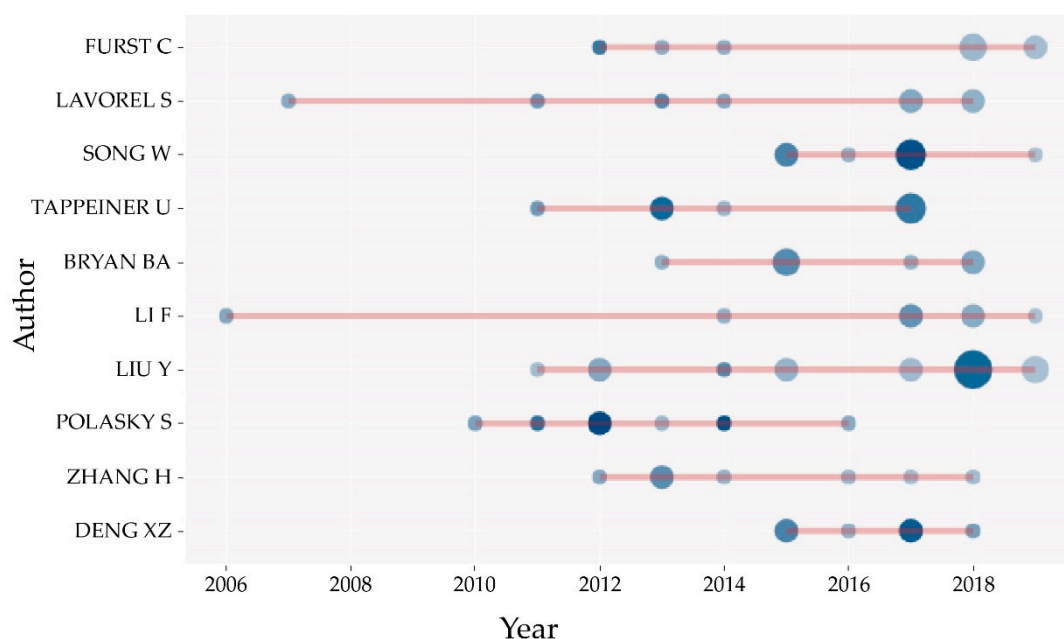
Figure 4. Authors' production over time in the field of land ecosystem services.

Table 3. Top 10 influential authors in land ecosystem services.

Authors	Articles	Total Citation	Production Year_Start
FURST C	8	182	2012
LAVOREL S	8	124	2007
SONG W	8	108	2015
TAPPEINER U	8	112	2011
BRYAN BA	7	83	2013
LI F	7	114	2006
LIU Y	7	104	2011
POLASKY S	7	95	2010
ZHANG H	7	111	2012
DENG XZ	6	98	2015

The number of articles issued by Lavorel S is also eight, and the total number of citations is 124. Lavorel has published an article since 2007, with their main research direction being the evaluation and research of grassland ecosystem service functions and values. Lavorel [30] believes that few scholars

currently study the simultaneous changes in land use change and ecosystem services. Therefore, Lavorel developed the original indicators to explore the relationship between alpine grassland landscape and ecosystem services. The results show that in the initial stage, the land use change causes the landscape heterogeneity to be improved to some extent, and then gradually homogenizes. Moreover, it was proposed that future landscape planning and policy research should pay attention to the management of landscape and regional scale versatility. At the same time, it is necessary to coordinate social needs and reduce the contradiction between cultural ecosystem services and regulatory ecosystem services.

### 3.3. Main Research Country Analysis

The relevant information of the top 20 countries with the number of published documents is shown in Table 4. It can be seen from Table 4 that: (1) the research strength of developed countries is significantly stronger than that of developing countries. Among the top 20 countries, only China, Argentina, Brazil and Thailand are developing countries. (2) The number of European and American countries is significantly higher than that of Asia, Africa and Oceania (as shown in Figure 5). The United States is far ahead of the world in terms of its number of publications, and its publications account for about 14.6% of the sample. (3) On the whole, the influence of countries with a small amount of publications is not necessarily weak, such as Finland and the Netherlands. Their total citation frequency is significantly higher than countries with more publications.

Table 4. Paper status of the main countries engaged in land ecosystem services from 2000 to 2019.

Country	Articles	Freq	SCP	MCP	Total Citations	Average Article Citations
CHINA	187	0.25793	138	49	2722	14.56
USA	107	0.14759	82	25	3406	31.83
UNITED KINGDOM	65	0.08966	36	29	1783	27.43
GERMANY	42	0.05793	24	18	965	22.98
AUSTRALIA	23	0.03172	8	15	573	24.91
SPAIN	23	0.03172	11	12	462	20.09
FINLAND	22	0.03034	17	5	548	24.91
ITALY	17	0.02345	13	4	255	15.00
NETHERLANDS	17	0.02345	4	13	732	43.06
CANADA	16	0.02207	10	6	115	7.19
FRANCE	15	0.02069	9	6	417	27.80
SWITZERLAND	14	0.01931	7	7	59	4.21
SWEDEN	13	0.01793	6	7	388	29.85
POLAND	12	0.01655	10	2	44	3.67
NEW ZEALAND	11	0.01517	7	4	267	24.27
ARGENTINA	10	0.01379	7	3	405	40.50
BRAZIL	10	0.01379	5	5	42	4.20
JAPAN	10	0.01379	5	5	126	12.60
BELGIUM	9	0.01241	7	2	113	12.56
THAILAND	9	0.01241	5	4	61	6.78

Note: SCP stands for single-country publication. MCP stands for multiple-country publication.

The number of documents issued in China is the highest in the world, with a volume of 187 articles. However, the average citations per item in China is only 14.56, which is still a certain gap compared with the citations of other countries. This shows that the overall quality level of China's land ecosystem services literature is not high. Land ecosystem services research of China mainly focuses on the evaluation system and evaluation methods, the value dynamic evaluation model research [31] and the ecosystem service marketization mechanism research. Li [32] used LANDSAT TM image to study the changes in land use and ecosystem service value in the main urban area of Jinan from 1998 to 2002. The results of the study show that forest land and farmland provide 80% of the total value of ecosystem services. However, with the acceleration of the urbanization process, the area of cultivated land has gradually decreased and the area of construction land has increased rapidly. As a result, between 1998 and 2002, the total value of ecosystems fell by 42.86 million yuan, with an average annual decline of 3.06 million yuan.
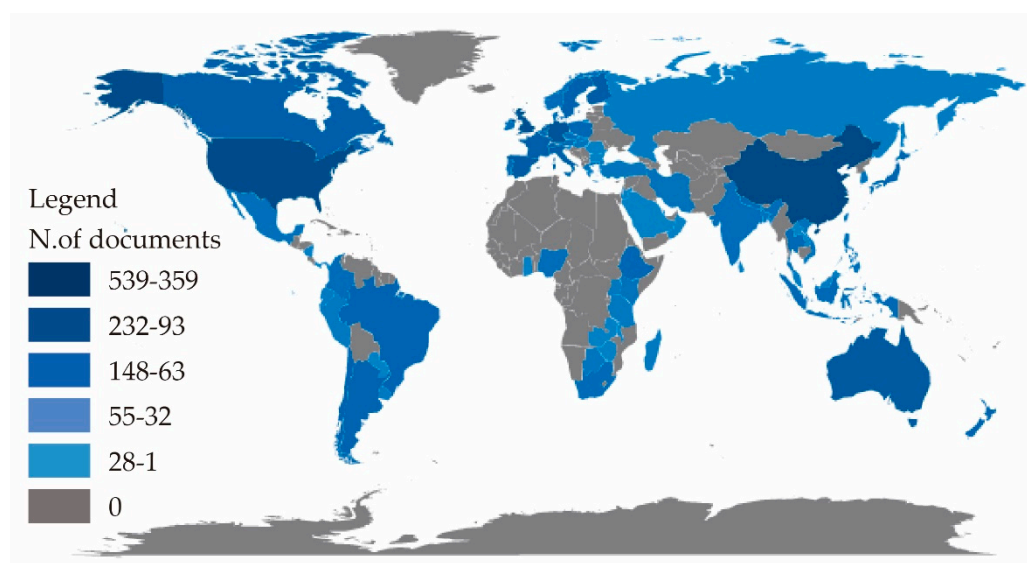
Figure 5. Country scientific production in the field of land ecosystem services.

The command vos.path = "", type = "Vosviewer", size = T, remove. multiple = T was used to call Vosviewer software to generate a collaboration map of 20 countries (see Figure 6). The size of the node is proportional to the number of documents owned by the country. If there is a connection between the nodes, it indicates that there is a cooperative relationship between the two countries. The thickness of the connection indicates the strength of cooperation between the two countries. It can be seen from Figure 6: (1) the United States, China, and the United Kingdom have direct or indirect partnerships with most countries, with MCP values of 25, 49, and 29, respectively. (2) Japan and Italy are at the edge of the cooperative network. Their SCP values are 5 and 4 respectively, and the MCP values are 5 and 13, respectively. (3) This shows that these countries mainly focus on independent research in the field of land ecosystem services, lacking international cooperation and exchanges. Land ecosystem services research of Japan focuses on the response of ecosystem services in different land use scenarios. For example, Hashimoto believes that population decline and underutilization of social and ecological landscapes will lead to the loss and deterioration of biodiversity and ecosystem services. Using Noto Peninsula as a research area, Hashimoto analyzed the land use change between 1997 and 2007 and used the multi-layered perceptual neural network model to simulate the impact of four scenarios on ecosystem services [33]. The results of the study show that ecosystem service functions (such as food production, nitrogen storage, and landscape heterogeneity) will be greatly reduced in the context of reduced natural capital use and large-scale abandonment of agricultural land. Therefore, Hashimoto believes that sound land use and good agricultural policies are critical to maintaining biodiversity and

restoring ecosystem services in the region. (3) From the perspective of the thickness of the connection, international cooperation has been continuously strengthened in recent years.
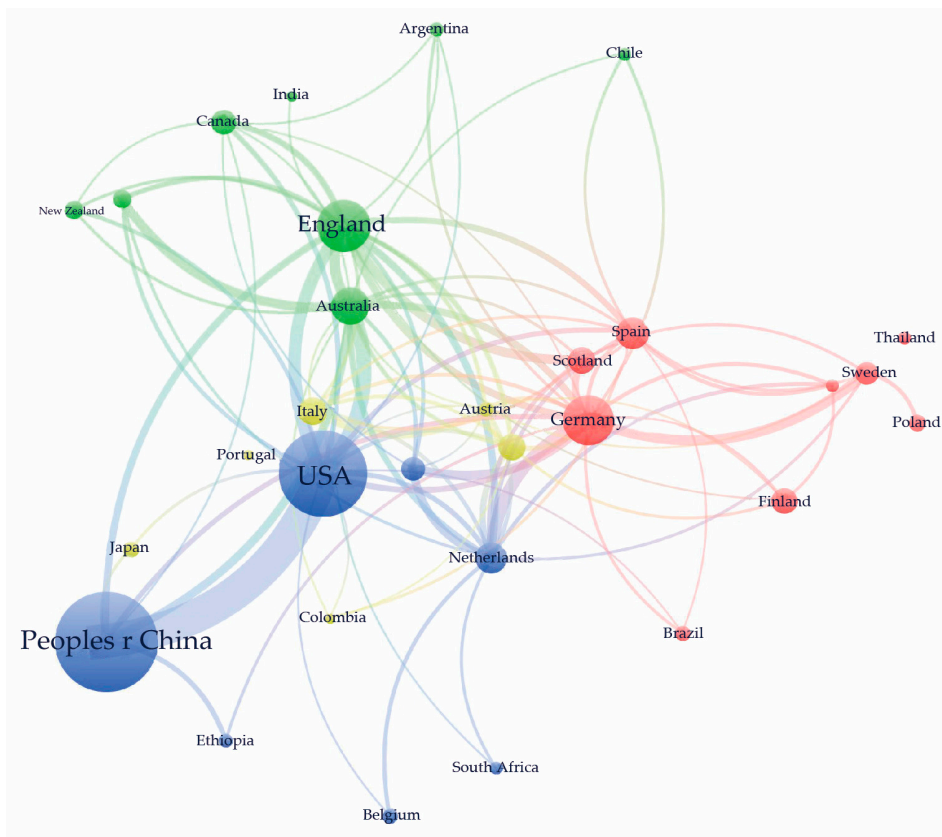
Figure 6. Country collaboration map of the 20 highest producing countries in the field of land ecosystem services.

3.4. Keyword Analysis

3.4.1. High-Frequency Keyword Analysis

The key words are a high-level summary of the article, and the high-frequency keywords that extract many articles can represent the research hotspots in this field to a certain extent. In order to better explore the research hotspots of land ecosystem services, 32 words with a frequency greater than 10 were selected for analysis. As can be seen from Table 5: (1) the hottest areas of research appear in land use change, land use, ecosystem service value, biodiversity, remote sensing, agriculture, land use planning, tradeoffs. Among them, the keyword frequency exceeded 611, far higher than the average. It can be seen that the impact of land use change on the value of ecosystem services is a research hotspot in this field. Among them, the evaluation methods of ecosystem service value mainly include the analytic method, the material quality assessment method and the value quantity assessment method. At the same time, 3S technology provides technical support for the impact of land use change on ecosystem service value, from data acquisition to spatial analysis, enabling related analysis functions from qualitative to quantitative, from static to dynamic, from process to model transformation and development [34]. (2) There are many studies on climate change and urbanization, and the frequency of occurrence is 19 and 18 times, respectively. This can explain that climate change and rapid urbanization are the main factors affecting the level of ecosystem services. For example, Blanco [35] used an agent-based land use model to study the socio-economic changes in Sweden between 2010 and 2100 and the impact of climate change on ecosystem services. The results of the study show that the social behavior of landowners has a more significant impact on land use change than climate change. It is

also found that the amount of wood felling will increase significantly in the coming decades, thus increasing the contradiction between the supply and demand of ecosystem services. (3) Carbon and water quality are also keywords with high frequency. It can be seen that many scholars have evaluated and simulated regional ecosystem water production, soil conservation and carbon storage services from the perspective of land use change. Therefore, the contribution of various land use types to ecosystem services is compared, and the scientific basis for improving the ecological environment of the land is provided [36,37]. (4) At the same time, with the gradual development of ecological restoration technology, the research on sustainability, conservation and restoration is gradually increasing, which is in line with human requirements for implementing sustainable development.

Table 5. High-frequency keywords and their occurrence in the field of land ecosystem services.

Terms	Frequency	Terms	Frequency
Ecosystem services	298	Conservation	16
Land use change	79	Land cover	15
Land use	57	Valuation	14
Ecosystem service value	47	Wetlands	14
Biodiversity	38	Payments for ecosystem services	13
China	27	Scenario analysis	13
Remote sensing	24	Scenarios	13
Agriculture	21	Invest	12
Land use planning	20	Mapping	12
Trade offs	20	Green infrastructure	11
Climate change	19	Water quality	11
Ecosystem services function	19	Wetland	11
Urbanization	18	Carbon	10
Land management	17	Restoration	10
Conservation	16	Sustainability	10
Land cover	16	Urban planning	10

3.4.2. High-Frequency Keyword Clustering Analysis

According to the relative position of each keyword in the multi-dimensional scale analysis and the classification of the tree dendrogram, the keywords are divided into four clusters (see Figures 7 and 8).
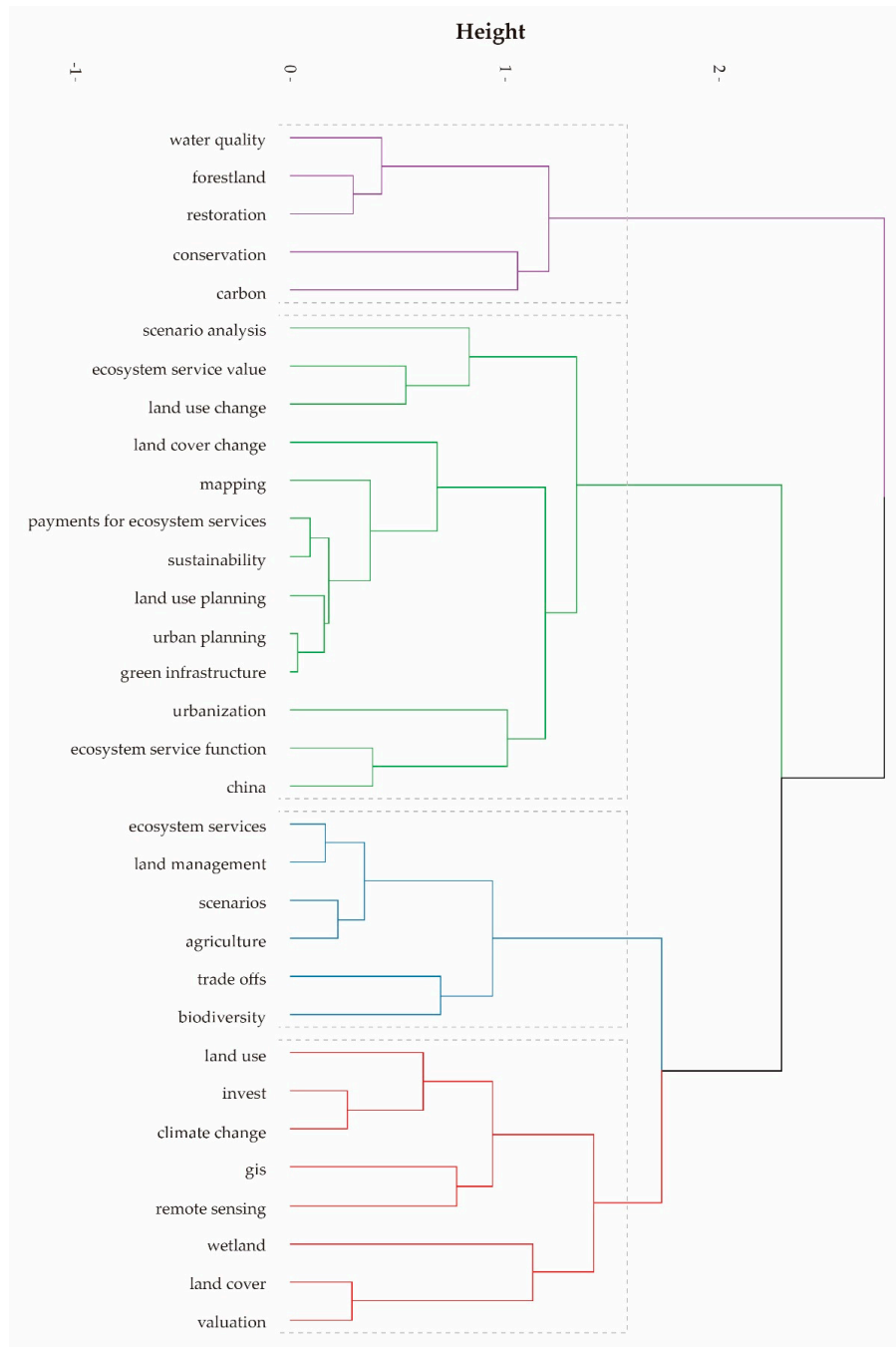
Figure 7. Tree dendrogram of hierarchical cluster analysis of keywords in the field of land ecosystem services.
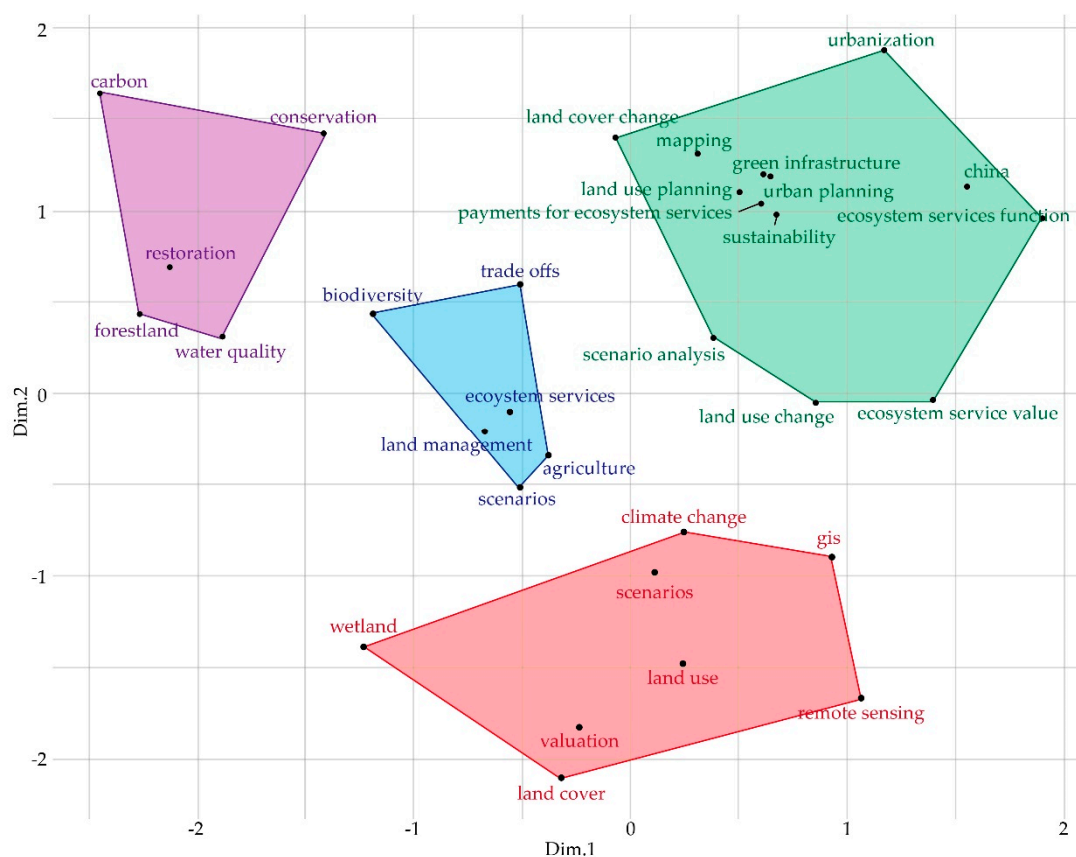
Figure 8. Multidimensional scaling analysis of high-frequency keywords in the field of land ecosystem services.

(1) The first major category of cluster analysis is mainly concerned with the restoration of degraded land and its impact on ecosystem services. Ecological restoration is considered to be an effective means to deal with ecological degradation and improve environmental quality, and has been widely used. Land remediation projects can provide comprehensive management of unused, inefficient use and degraded land. Therefore, while land remediation promotes regional economic and social benefits, it also has a positive impact on the rational distribution of natural ecosystems and the improvement of ecosystem services [38]. Qi [39] pointed out that China began its large-scale ecosystem restoration project, represented by returning farmland to forests, in 2000. Qi used the Invest model to simulate changes in land use and changes in water-related ecosystem services (water production, water purification capacity and soil protection). The results of the study show that the forest restoration project has greatly promoted the conversion of bushes and cultivated land to forests, thereby improving the level of water purification and soil and water conservation services.

(2) The second major category of cluster analysis mainly deals with the environmental impact assessment of land use planning based on the ecosystem services value. The environmental impact assessment of land use planning can analyze, predict and evaluate the environmental impacts caused by the implementation of land use planning, propose countermeasures to prevent adverse environmental impacts, and conduct tracking and monitoring methods and systems. However, the transformation of land use patterns and structures will have an impact on the attributes of the ecosystem services it provides. Therefore, it is of practical significance to measure the impact of land use planning on the ecological environment based on the theory of ecosystem service function value. Based on the connotation of the ecosystem service function value theory, this method calculates the change in the total value of the ecosystem service function before and after the implementation of the land use planning scheme, so as to measure its impact on the ecological environment. At the same time, the

gray infrastructure will be transformed into a green infrastructure through greening projects, which will improve the level of ecosystem services in the region. Green engineering facility systems include sustainable stormwater management techniques, river ecological restoration and ecological flood control projects, and road ecological engineering [40]. Therefore, green infrastructure construction and ecosystem services should be integrated into land use planning [41,42].

(3) The third major category of cluster analysis mainly deals with the trade-off analysis of ecosystem services in sustainable land management. Ecosystem services mainly have four widely used types of service, including supply services, regulatory services, support services, and cultural services [43]. However, at a specific time and space scale, the ecosystem services are not completely independent, but exhibit complex interactions. This interaction creates a trade-off and synergy between services of all types [44]. In ecosystem services, trade-offs refer to the increase or decrease in certain types of ecosystem services, resulting in a decrease or increase in other types of ecosystem service. Synergy refers to situations in which two or more ecosystem services are simultaneously enhanced or simultaneously reduced. The government or society must make natural resource management decisions based on the relative demand preferences of different services, maximizing the overall benefits of ecosystem services. Therefore, trade-off analysis tools and methods in ecology, economics, geography, and other fields should be used to provide measurement methods of the trade-off relationship between ecosystem services from the perspective of different land-use scenarios [45]. Asadolahi [46] argued that trade-off analysis of multiple ecosystem services can help planners and decision makers make informed decisions.

(4) The fourth major category of cluster analysis is mainly concerned with the impact of land cover change on ecosystem services. Land cover change not only brings about great changes in the surface structure, but also affects ecological processes such as material circulation and energy flow, thereby affecting the entire ecosystem and structure, which in turn affects ecosystem services and human well-being [47]. Clerici [48] used two different watersheds in Colombia as research areas to explore the impact of land cover change and climate change on ecosystem services (carbon storage and water production). The results of the study indicate that land use development policies in near urban basins should greatly reduce the use of agricultural land and pasture. The reason is that rapid urbanization will lead to a reduction in water production. On the other hand, land-use development policies should protect forests and shrubs to maximize their carbon sequestration capacity. Shrestha [49] believes that land cover change is one of the main factors affecting ecosystem services. Shrestha used 3S technology to monitor land cover changes in the central Himalayas from 2000 to 2017. The results of the study showed that the area of shrubs/grass, agriculture, wasteland and plantation increased by 82.21, 1.44, 991.97 and 3.11 km^2, respectively, over 18 years. This has led to an increase in the value of ecosystem services in the region.

3.5. Historical Analysis of Citied Papers of Land Ecosystem Services Research

This paper uses two important indicators, local citation score (LCS) and global citation score (GCS). GCS stands for the number of citations in the Web of Science database. LCS represents the number of times a document has been cited in the current sample literature. We used the hisNetwork and histPlot functions in the Bibliometrix package to generate a historical direct citation network and visually analyze the network (see Figure 9 and Table 6).
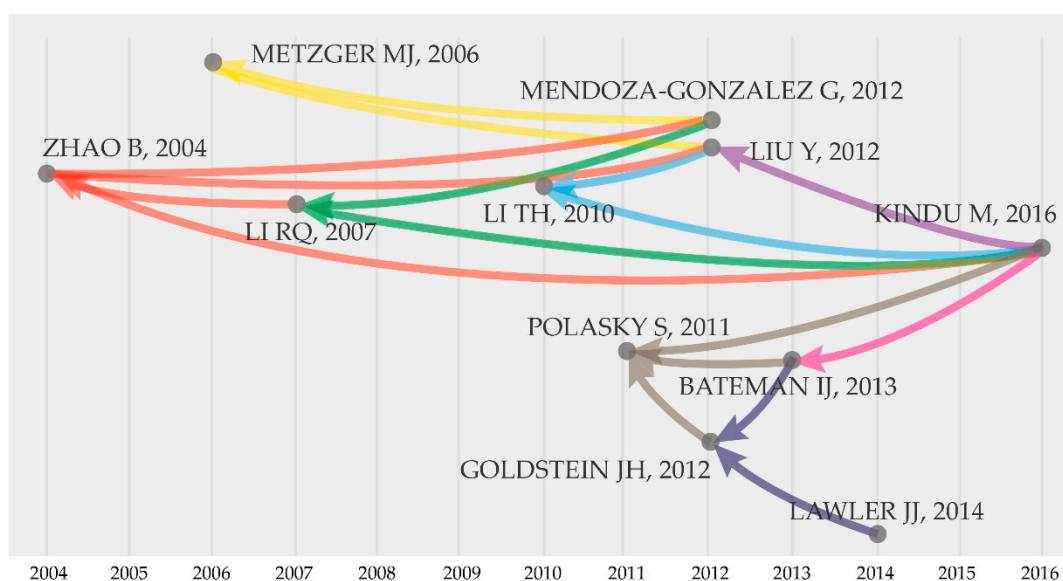
Figure 9. Historical direct citation network of 20 top-cited papers in the field of land ecosystem services from 2000 to 2019.

Table 6. Top 11 local citation score (LCS) in Land degradation research.

Paper	DOI	Year	LCS	GCS
METZGER MJ, 2006, AGR ECOSYST ENVIRON	10.1016/J.AGEE.2005.11.025	2006	53	350
POLASKY S, 2011, ENVIRON RESOUR ECON	10.1007/S10640-010-9407-0	2011	53	230
ZHAO B, 2004, LAND USE POLICY	10.1016/J.LANDUSEPOL.2003.10.003	2004	45	182
LI TH, 2010, ECOL ECON	10.1016/J.ECOLECON.2008.05.018	2010	43	143
BATEMAN IJ, 2013, SCIENCE	10.1126/SCIENCE.1234379	2013	42	400
GOLDSTEIN JH, 2012, P NATL ACAD SCI USA	10.1073/PNAS.1201040109	2012	40	250
KINDU M, 2016, SCI TOTAL ENVIRON	10.1016/J.SCITOTENV.2015.12.127	2016	32	64
MENDOZA-GONZALEZ G, 2012, ECOL ECON	10.1016/J.ECOLECON.2012.07.018	2012	30	91
LAWLER JJ, 2014, P NATL ACAD SCI USA	10.1073/PNAS.1405557111	2014	30	215
LI RQ, 2007, ENVIRON MONIT ASSESS	10.1007/S10661-006-9344-0	2007	27	69
LIU Y, 2012, ECOL MODEL	10.1016/J.ECOLMODEL.2011.11.017	2012	27	61

This figure is the chronicle of the document with the threshold set to the top 11 of the LCS ranking. The number of nodes in the figure is 11, and the number of connections is 16. The minimum LCS is 27 and the maximum is 53. The minimum GCS is 61 and the maximum is 400. The earliest node in the picture is the paper published by Zhao on the Land use policy, with an LCS of 45. This paper focuses on the land use change in eastern Chongming Island (Dongtan City) between 1990 and 2000 and its impact on ecosystem services. The results of the study show that the value of ecosystem services in Dongtan City has dropped by 62%. This huge decline is due to the decline in the area of land use such as wetlands and tidal flats. It is also proposed that future land use development policies should protect ecosystem services rather than unrestrained reclamation [50]. Another influential document that forms a citation relationship with above article is Liu's paper published on ecological modelling. This document belongs to the four citation relationship chains and is an important research node in the stage of volatility growth. Liu believes that in China's Loess Plateau, urban expansion and returning farmland to forests will lead to complex land use changes that will greatly affect ecosystem services. Liu used remote sensing technology to assess the value of ecosystem services in 1990 and 2005. The results of the study show that the value of ecosystem services has declined significantly. The reason is that the area of farmland and grassland has been greatly reduced. It was also suggested that local governments should formulate policies to maintain high quality arable land, grassland and woodland, and continue to implement policies that convert barren arable land into forest land and grassland [51].

Polasky's paper on environmental and resource economics led to a new research direction for land ecosystem services, incorporating ecosystem services into decision-making research for land managers and land use planners. The correct assessment of ecosystem service provision and stakeholder demand for ecosystem services at the landscape and regional scales will help to develop optimal decisions for adaptation to regional ecosystems and sustainable human development, thereby maintaining and improving the relationship between landscape ecosystem services and human well-being. Polasky [52] studied the effects of land use change on ecosystem services, habitat vulnerability and landowner returns in Minnesota between 1992 and 2001. The results of the study show that landowners have high returns in the context of large-scale agricultural expansion. However, this leads to a significant reduction in carbon stocks, poor water quality, loss of biodiversity and habitat degradation of the forest warbler. Therefore, land use entities and land managers need to integrate ecosystem services into the decision-making system in order to achieve maximum net social benefits and economic benefits. As can be seen from Figure 9, since 2011, important literature in the field of land ecosystem services has begun to increase significantly. The literature of Bateman [27] is a crucial node in the historical citation network map. The GCS value of this paper is 400, indicating that the literature has received extensive attention from scholars in different fields.

4. Discussion and Conclusions

4.1. Discussion

Based on the previous literature, the current research on land ecosystem services is in the ascendancy. Although NCP is still a relatively new and untested framework, the NCP framework can provide a broader analytical perspective for the land systems science community [53]. Future research work can be further deepened in the following aspects based on constructive cooperation with the NCP:

(1) Accurate accounting of land ecosystem services value. Land use change is considered to be one of the most important drivers of changes in ecosystems services [54], but the factors that influence the value of ecosystem services are many-sided. Most of the existing literature studies the impact of land use change on land ecosystem services, and the factors that change the level of ecological conditions with time are not taken into account in the framework of ecological service value assessment, and less consideration is given to spatial heterogeneity. The calculation of the total value of ecosystem service functions generally only considers the value of ecological services, but does not consider the value of economic services, social services and culture services functions. The NCP framework uses a valuation system that interacts with people and the environment to better understand and recognize the value systems associated with NCP that are critical to sustainability science [55]. How to more accurately assess the value of ecosystem services requires further exploration and research in future research.

(2) Research on multi-assessment methods of land ecosystem services. Studies have shown that ecosystems have an impact on quality of life, and ecosystem services can successfully measure the contribution of nature to human well-being [56]. The existing evaluation methods of ecosystem service value have well-known defects. For example, ecological modeling (such as InVEST model, SWAT model) is complex and costly, the Economic Value Assessment Method (such as Expense Payment Method) is subjective [57], the reliability of the Benefit Transfer Method (such as Equivalent Factor Method) needs to be considered [58]. Due to the limitations of the prior art, it is difficult to completely overcome the limitations of current ecosystem service assessment methods. Therefore, the methodology and case studies of diversification assessment need to be further studied.

(3) Interdisciplinary and systematic study on land ecosystem services. Ecosystem services research combines the natural science and humanities and social sciences [59–61], and the required technical method are complex and diverse. According to the present research situation, the method and technology of natural science in the framework of ecosystem service are more mature, while in the part of humanities and social sciences, the method and technology are weak, and the methodological

research paradigm of integrating multi-disciplinary is even less. Although the demand for ecosystem services has been considered in existing studies, they have analyzed ecosystem services with physical products (such as food and energy) without including non-physical services (such as climate regulation). Further research on ecosystem services value of various land use types has not been carried out, and the correlation between the types of land ecosystem services has not been considered [62]. The NCP framework proposed by IPBES is more inclusive in scientific disciplines, including various knowledge systems, especially providing more space science for the humanities and society [53]. In the future, research on land ecosystem services can be conducted in the NCP framework.

(4) Comprehensive study on the trade-off and synergy analysis of land ecosystem services. At present, most of the research on ecosystem services trade-off and synergy analysis has focused on connotation, characterization methods, the degree of trade-off and synergy and empirical analysis, but less on the spatial dynamic expression and quantitative cause analysis of the trade-off and synergy. In addition, the trade-off between supply and demand of land ecosystem services, the relationship between supply, regulation, support and cultural services, how to transform the land ecosystem services trade-off and synergy, and what are the conditions and ways of transformation all need to be supplemented and deepened in future research.

(5) The practical application of land ecosystem services research results. According to existing research, the application of ecosystem services research results is not enough. The depth and breadth of research results applied to land remediation and reclamation, ecological compensation or payment for ecosystem services, land use planning and management, accountability audit and green infrastructure construction are not enough. For example, how the multiple perspectives on the value of ecosystem services are linked to the multiple perspectives of people's quality of life. However, there are still many obstacles in the application of ecological compensation. The accuracy of the assessment, the accounting errors of supply and usage of service suppliers and consumers limit the possibility of serving as the main basis of ecological compensation policy.

(6) Research on the relationship between land ecosystem services and human well-being. The relationship between land ecosystem services and human well-being is complex and is influenced by a variety of natural, policy, economic, and human factors. Natural factors include the nonlinear characteristics of ecosystems, dynamic evolution; policy factors include protected area management policies and land use policies; cultural factors include background culture and customs of well-being; and economic factors include regional socio-economic differences, differences in beneficiaries, technological advances, and market mechanisms. Moreover, land ecosystem services are ostensibly accessible to everyone. The services provided by land ecosystems are not automatically and evenly distributed to all in the region, and the resulting benefits are often not brought to the most vulnerable. The distribution and consumption of the benefits of ecosystem services are affected by the complex mechanism formed by the accessibility of ecosystem services, family size, education level, poverty, vulnerability, social relations, regulation, capacity, gender, rights and various capitals. It can be seen that the survival and development rights of vulnerable groups have become a focus of concern for all sectors, and their sensitivity to changes in ecosystem services is high. Therefore, the distribution of consumption of ecosystem services to vulnerable groups and their impact on well-being is a core issue that needs to be explored in depth. In addition, scale is an important analytical perspective (time and space) in assessing and measuring the impact of ecosystem services on human well-being. Therefore, time, space and socioeconomic status scale variables should be included in the human well-being measure. A comprehensive survey of human well-being at multiple scales can help decision makers develop ecological protection and ecological compensation policies that contribute to sustainable livelihoods.

4.2. Conclusions

Based on the Web of Science database, literatures in the field of land ecosystem services from 2000–2019 are retrieved, and Bibliometrix software packages are used for data mining and analysis. Land ecosystem services research presents the following characteristics and laws:

(1) In terms of quantity, the number of global land ecosystem services research literatures showed a rapid growth trend from 2000 to 2019. In particular, the global volume of publications has entered a period of rapid growth since 2015, indicating that research on land ecosystem services is highly valued globally.

(2) Developed countries are the main research force of land ecosystem services, and cooperation between developed countries is close. Although there are also developing countries that continue to pay attention to this research field, their research strength is still far from the leading developed countries. Therefore, developing countries should strengthen their attention and research on land ecosystem services, expand international relations, strengthen international cooperation, and enhance scientific research capabilities. Scholars need to continually explore the value of ecosystem services, promote the harmonious coexistence between man and nature, and seek the sustainable development of human society.

(3) High-frequency keywords for land ecosystem services research include land use change, land use, climate change, urbanization, carbon and water quality. This shows that the research hotspots in this field are mainly focused on the impact of land use change on the value of ecosystem services. It can also be seen that climate change and urbanization are the main factors affecting the level of ecosystem services. Land managers should incorporate ecosystem services into decision-making systems with a view to improving the carbon storage capacity of the land and improving water quality.

(4) From the perspective of cluster analysis, the research on land ecosystem services is divided into four categories, which can be summarized as: (I) restoration of degraded land and its impact on ecosystem services; (II) environmental impact assessment of land use planning based on the ecosystem services value; (III) trade-off analysis of ecosystem services in sustainable land management; and (IV) the impact of land cover change on ecosystem services.

Appendix A

Table A1. Authors' main information per year.

Author	Year	Frequency	Total Citations	Average Article Citations
FURST C	2012	1	182	20.22
	2013	1	39	4.88
	2014	1	35	5.00
	2018	3	5	1.67
	2019	2	1	0.50
LAVOREL S	2007	1	91	6.50
	2011	1	112	11.20
	2013	1	124	15.50
	2014	1	46	6.57
	2017	2	23	5.75
	2018	2	10	3.33
SONG W	2015	2	98	16.33
	2016	1	18	3.60
	2017	4	108	27
	2019	1	0	0
TAPPEINER U	2011	1	112	11.20
	2013	2	195	24.38
	2014	1	21	3
	2017	4	69	17.25
BRYAN BA	2013	1	37	4.63
	2015	3	83	13.83
	2017	1	13	3.25
	2018	2	17	5.67
LI F	2006	1	114	7.60
	2014	1	29	4.14
	2017	2	43	10.75
	2018	2	13	4.33
	2019	1	0	0
LIU Y	2011	1	14	1.40
	2012	2	64	7.11
	2014	1	104	14.86
	2015	2	21	3.50
	2017	2	5	1.25
	2018	8	57	19
	2019	3	0	0
POLASKY S	2010	1	95	8.64
	2011	1	230	23
	2012	2	311	34.56
	2013	1	20	2.50
	2014	1	215	30.71
	2016	1	27	5.40
ZHANG H	2012	1	61	6.78
	2013	2	111	13.88
	2014	1	24	3.43
	2016	1	10	2
	2017	1	3	0.75
	2018	1	3	1
DENG XZ	2015	2	98	16.33
	2016	1	18	3.60
	2017	2	98	24.50
	2018	1	21	7

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