



Bibliometric analysis on desertification restoration based on CiteSpace

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Abstract

Land desertification develops in a gradual manner and can bring about great natural and social disasters. As an important measure that can benefit the nation, desertification restoration can greatly benefit the whole nation and is the key to the restoration of the ecological environment and sustainable development. Based on citation overview theory and literature visualization tool, this research adopts CiteSpace software for the visualized analysis on environmental restoration studies published in SCIE and SSCI from 2000 to 2020 and statistical analysis based on years, nations (areas), work units, authors, journals and key words. The research results show that the number of published papers issued annually tends to rise in the world, especially China. About half of the published papers come from China, in which Chinese Acad Sci units have the largest number of periodicals but limited international influence. Core journals such as BIOGEOCHEMISTRY, P LANT SOIL and ECOLOGY have made greater contributions to this field and multiple themes have been selected, including Gurbantunggut desert, mycorrhizae, soil restoration, Karst, and vegetation pattern formation. The research can be divided into three stages: The inception stage is from 2000 to 2006 with the protection and control of desertification as the major targets; the development stage is from 2007 to 2016, during which ecological system, policy, and reforestation become the focus of the study; the third stage is from 2017 to 2020 during which period there is no catchphrase and relevant studies are represented as diversified development.

Keywords Desertification restoration · Bibliometrics · CiteSpace · Visualized analysis

Introduction

Land desertification is a natural phenomenon. If not solved timely, it will cause serious social problems. Because of objective factors, such as drought and erosion of runoff, and subjective factors, such as over-exploitation and destruction of human

beings and human growth, the desertification in the world is becoming increasingly severe. Deserts in the world are mainly distributed between the subtropical and temperate regions on both sides of the equator, such as Sahara Desert, Arabian Desert, and Libyan Desert, while 18 provinces in China involve desertification problem, including Beijing and Tianjin.

According to the statistics from the United Nations Environment Programs (UNEP), the regions affected by desertification account for 35% in the globe. Desertification has caused land sandification, reduced the number of creatures and outputs of economic crops, intensified ecological environmental pollution, undermined social stability, and harmed human survival and development. Desertification restoration is a complex project and involves multiple disciplines, including environment, computer, management, and economy (You et al. 2018). All countries and areas have formulated and implemented various measures to deal with desertification. Moreover, according to the United Nations, June 17 of each year is the World Day to Combat Desertification and Drought. The World Day to Combat Desertification and Drought aims to arouse people's attention for the desertification by all the

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governments. In 2003, the project of returning grazing land to grass was initiated comprehensively in China, and by 2020, tens of billions of funds have been invested to improve the eco-environment of the grassland and further promote ecological sustainability (Zhang et al. 2015). In the context of global warming, desertification would be deteriorated if it was not well managed.

In recent years, scholars at home and abroad have carried out various studies on the management of desertification (Silva et al. 2018; You et al. 2019). Furthermore, they have summarized some precious experiences on prevention, restoration and control of desertification and have provided knowledge and practices that can be used for studying desertification of China. Zhang et al. (2018) discussed the application of landscape pattern theory in combating desertification using Zhechuan County as an example; Zhu (2016) analyzed the changes of desertification control project based on emergy theory; Zhang and Rao (2020) and Zhang and Chen (2019) analyzed the desertification control in Huanghuamo based on technology; Qiu (2017) investigated the grassland desertification control both at home and abroad from legal perspective.

China started late in studying desertification restoration, so there are not enough relevant academic researches in China. Therefore, the highlights for study should be to clarify the current studies on desertification restoration and grasp the development tendency.

Bibliometric analysis is a common research method. Li and Qiu (2020) used CiteSpace to analyze the documents on heritage protection in ethnic archives in the past 10 years in China based on publishing year, publishing organization, keyword co-occurrence, scholar cooperation network, and topic clustering of the research results. Zhang et al. (2020) studied the literatures on interdisciplinary education research from 1988 to 2019 in Web of Science (WOS) and conducted complete and accurate analysis on the overall situation, evolution characteristics, and frontier hotspots in the interdisciplinary education research over the past 30 years. With 579 papers published in EI, core journals, CSSCI, and CSCS that are included in CNKI in the recent 10 years as the data basis, Xu and Liu (2020) used CiteSpace analysis tools to conduct quantitative analysis on the development track and the research characteristics on land ownership confirmation in ChinaCiteSpace. Yang (2020) analyzed the core journals, core authors, foundational literatures, core literatures, and research hotspots on terrorist intelligence based on CiteSpace V visualized clustering method.

Based on citation analysis theory, this essay uses CiteSpace software to deal with the keywords of scientific literatures, and annual distribution of papers exhibits vividly the research results of desertification restoration and clarifies the research development on desertification restoration. In this way, it can provide powerful guidance for scholars to have better understanding of and further study desertification restoration.

Method selection and research data

CiteSpace is a Java application program for visualized analysis (Chen et al. 2009). This program is able to display the evolution route, tendency, and critical nodes of the research in diversified knowledge graph and helps demonstrate the research focus and frontline in the discipline (Chen et al. 2016). It can analyze nodes of the authors, keywords, work units, and themes of the literatures; debug different parameters; and obtain the optimal results. At present, CiteSpace is used extensively in computer, medics, and various other fields. In this essay, CiteSpace 5.6 R3 is adopted to mine the data related to the themes of design control, combat design, and design restoration in the foreign essays, so as to grasp the evolution route and the future tendency of relevant studies abroad. Compared with sci2, the CiteSpace network node can not only express the number of occurrences, but also give the node centrality, and the time domain diagram in CiteSpace can more accurately reflect the characteristics of the study over time, which are more useful for this study.

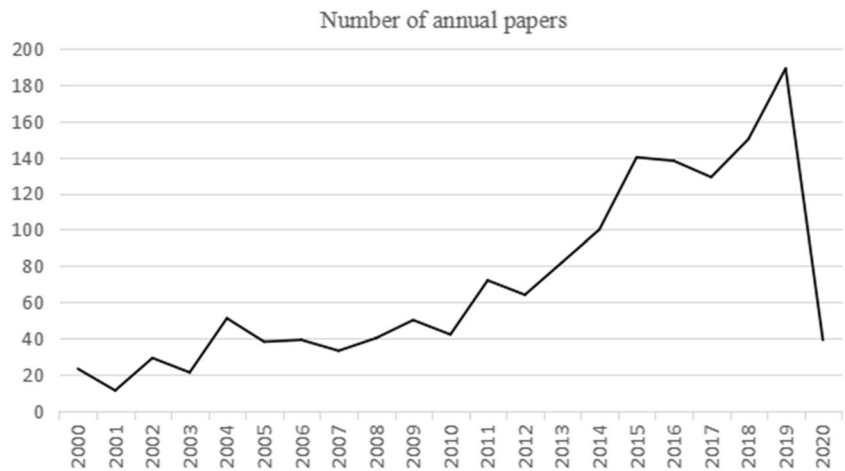
To ensure the quality of literature analysis, this essay makes sure that the foreign literatures collected in this study are all from SCIE and SSCI journals, two core databases on the Web of Science (Wos) platform. More than most authoritative and influential 9000 academic journals in the field of natural science have been included in SCIE database, and SSCI includes more than 3300 authoritative journals in the field of social science with the themes of economics, business, law, and many others. Using SCIE and SSCI data can fully guarantee the quality and quantity of foreign language literature. Subject terms are set for retrieval: (Desertification Control) OR (Combating desertification) OR (desertification restoration). Then, after advanced search, the literature types are selected: (ARTICLE), and the years are set from 2000 to 2020. The retrieval time is April 1, 2020. Although most of the studies are based on years, upon the composition of this thesis, relevant papers have been retrieved on March 2020 on the web of science website. There are a large number of papers published in the 3 months, so it is necessary to analyze the papers in the field of desertification control and restoration in these 3 months. As a result, 1478 valid literatures are obtained after the repeated ones are excluded.

Results and discussion

Analysis on the number of published papers

The number of papers published each year reflects the concern of the research field to some extent. According to the exported literature data, graph of year distribution of the research documents on desertification restoration is prepared with Excel, as shown in Fig. 1. “Wetlands: Lifeline for People at the

Fig. 1 Distribution of research literature on desertification restoration abroad



Edge” published by Silvius et al. (2000) was the first paper for studying desertification restoration and was published in 2000. According to that article that many of the amenities, functions, and values of wetlands are crucial, not only for the food security of these people, but also for the survival of their cultures, so it can be said that this study is of great significance to solve the problem of desertification.

Based on Fig. 1, the number of papers on desertification restoration in 2000 is 23 and reaches 189 in 2019 and 39 in the first quarter of 2020, respectively. From 2000 to 2012, the number of papers shows the tendency of down bearing within up bearing. Eco-environmental control and sustainable development are inseparable from desertification restoration, so desertification attracts more concerns from many fields. Therefore, more scholars have been more committed to the research of desertification restoration.

Analysis on different nations

The papers on desertification restoration published by all the countries are shown in Fig. 2.

Among the distributed countries/areas, China (developing country) ranks the first in the total number of papers published, followed by USA, Spanish, Italy, and other developed countries. The number of papers is 791 in China, accounting for 49.7% of the total; the number of papers published by the USA is 277, taking 17.4% of the total.

The total number of published papers is just a measurement for the importance attached by one country. To further analyze the influence of papers published by different countries, this study obtains the centrality and ranking of papers published by the countries, as shown in Table 1. In terms of the intensity of the centrality, it could be seen that America has the highest centrality, the largest number of papers published, and the highest influences. As one of the earliest countries for controlling desertification, America has a strong sense of environmental protection, complete laws and regulations, and rich experience and emphasizes harmonious development between human being and the nature, so America has the highest centrality in the field of desertification restoration. On the contrary, though China has published the most papers, its centrality only ranks the ninth place, which suggests that China

Fig. 2 Main source countries/ regions of papers in the field of desertification restoration

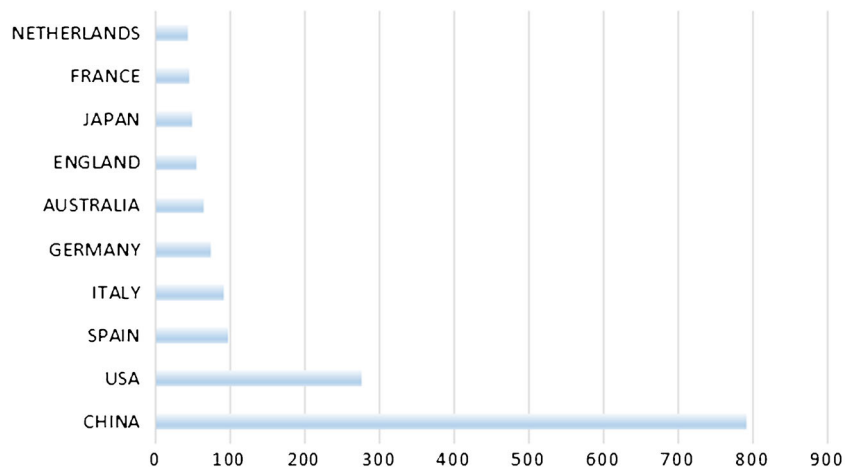


Table 1 Central ranking of national publications

Country	Centrality	Rank	Country	Centrality	Rank
USA	0.27	1	Australia	0.11	6
Germany	0.22	2	Canada	0.11	7
Italy	0.15	3	Belgium	0.09	8
England	0.14	4	China	0.08	9
Netherlands	0.13	5	Uzbekistan	0.08	10

should continue to improve its international influence in terms of the research results on desertification restoration.

Analysis of the units publishing papers

Node types are set as the institution and the visibility graph of organization distribution of documents on desertification restoration are obtained, as shown in Fig. 3. Table 2 presents the top ten organizations for publishing papers.

As shown in Fig. 3, there are less nodes among the institutions for publishing papers. Most of them conduct the study independently and are short of cooperation. From Table 2, it can be seen that the top ten institutions are all from China. In terms of the number of published papers, Chinese Acad Sci ranks the first, and the number of published papers is 407, but there are less links between the institutions, indicating that the institutions seldom seek cooperation.

Author analysis

For observing and determining the contribution of scholars in the field of desertification restoration, this study calculates the author co-occurrence map (as shown in Fig. 4). In Fig. 4, it can be seen that the network in the whole graph is more scattered, the scale of cooperation is smaller, and there are more independent studies. Then, the number of authors and the top 10 cores during the research period (as shown in Table 3) are calculated. The author who published the most papers during the period of the study was Xueyong Zhao, and the number of published papers reached 21 articles, followed by 11 articles.

Table 2 Top 10 institutions of document quantity

Serial number	Organization name	Number of papers	Serial number	Organization name	Number of papers
1	Chinese Acad Sci	407	6	Chinese Acad Forestry	30
2	Univ Chinese Acad Sci	78	7	Nanjing Univ	23
3	Beijing Normal Univ	53	8	Northwest A&F Univ	23
4	Beijing Forestry Univ	47	9	China Agr Univ	23
5	Lanzhou Univ	37	10	Guizhou Univ	20

The number of papers published is generally small, and the studies are not concentrated.

Analysis of author co-citation

As can be seen from Fig. 5, the author who was cited the most often in the field of desertification restoration is Reynolds JF (37 times), and the paper that is cited the most comes from Global desertification: Building a science for dryland development (Reynolds et al. 2007). In this paper, Reynolds JF introduced a new synthetic framework of the Drylands Development Paradigm (DDP). The DDP has obtained much support from a growing and well-documented set of tools for policy and management action and can help navigate the inherent complexity of desertification and dryland development and identify and synthesize those factors important to research, management, and policy communities.

After calculation, the centrality of the authors in the field of desertification restoration is 0, indicating that no effective academic union has been formed between different authors, and authors conduct their researches independently.

Analysis of core journals

From Fig. 6, it can be seen that the co-cited documents in terms of desertification restoration are mainly from CW, J ARID ENVIRON, SCIENCE, LAND DEGRAD DEV, CATENA and NATURE journals. Based on the analysis of journal centrality (as shown in Table 4), the centrality of the BIOGEOCHEMISTRY, PLANT SOIL, ECOLOGY journal is high, and is 0.49, 0.47, and 0.43, respectively. High centrality shows that journals play a significant role in the study of desertification.

Keywords analysis

The frequency of keywords provides the research highlights in this field within a certain period. To study the research topics of the literature, this study analyzes the frequency of keywords in papers. CiteSpace software is operated, and it is set: time slicing is 2000–2020, with 1 year as a time slice. Keywords are selected for the analysis. The keywords that are sorted out

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 Selection Criteria: Top 50 per slice, LRF=3.0, LBY=8, e=2.0
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 Nodes Labeled: 1.0%
 Pruning: Pathfinder

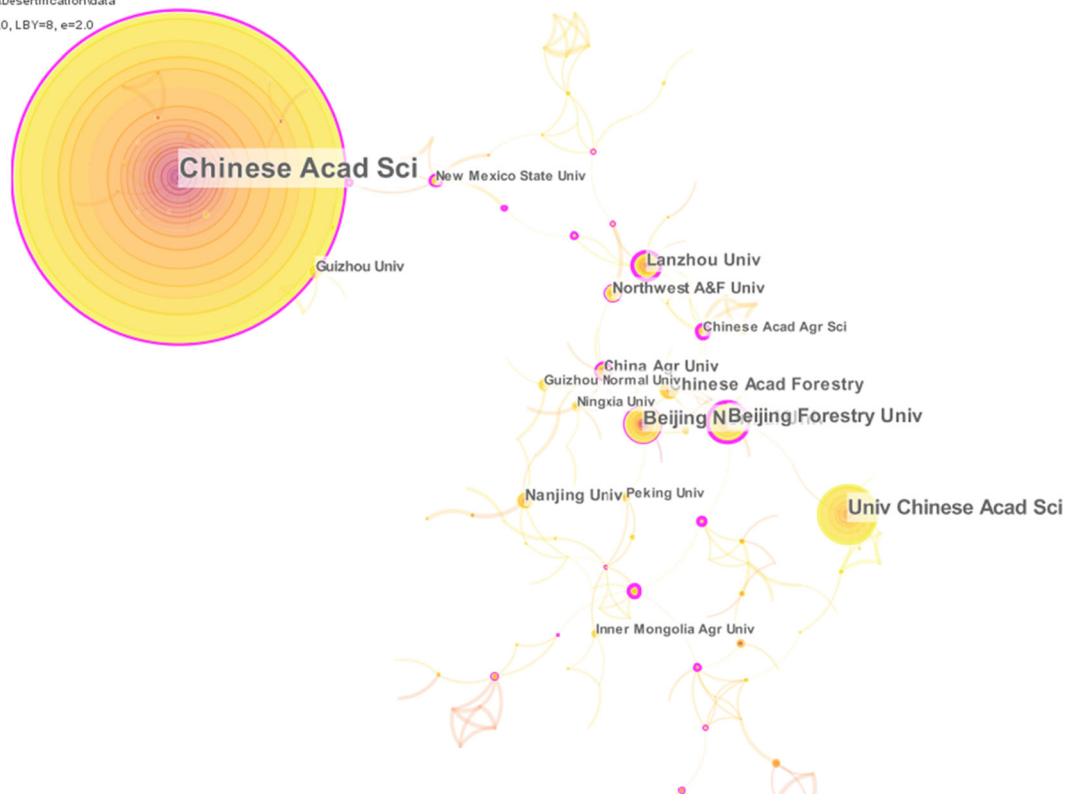


Fig. 3 Distribution of document sending mechanism

are shown in Table 5. Keyword matrix is formed in project file. The analysis on word frequency of the keywords can show that related studies on desertification restoration include multiple keywords as the research focus in the field. Desertification, restoration, and climate change rank the top in all the keywords, indicating that scholars have taken land degradation, desertification, and vegetation as the focus of study.

Keyword clustering can exhibit the hotspots in different research directions in this field. This study conducts clustering with LSI algorithm and has achieved better clustering effects using the clustering of foreign research topics on desertification restoration (see Fig. 7; Table 6). Cluster ID is the number displayed after clustering. The smaller the number, the larger the scale. Size refers to the number of the clustering members,

and mean year is the average years of the literatures in the cluster. Both can help determine the time of the cluster.

Figure 7 sorts the keywords according to the size of the outline. The size of the outline represents the closeness of the nodes within the outline. The larger the value, the closer the connection of the nodes is. The clustering results are shown in the figure.

1. The headline of cluster no. 0 is Gurbantunggut desert. It includes drylands, desertification, soil loss, climate, microbial fixation, and water bodies. Gurbantunggut desert is the second largest desert in china. Due to its special geographical location, China has invested a lot of capital and human resources in the process of controlling the desert, planting vegetation, grass, and other organisms

Table 3 Top ten authors and number of papers

Serial number	Author	Freq	Serial Number	Author	Freq
1	Xueyong Zhao	21	6	Jianlong Li	8
2	Kelin Wang	11	7	Xian Xue	8
3	Tao Wang	11	8	Luca salvati	8
4	Shixiong Cao	10	9	Fernando T Maestre	7
5	Quanhou Dai	9	10	Yuqiang Li	7

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 Largest CC: 15 (2%)
 Nodes Labeled: 1.0%
 Pruning: Pathfinder

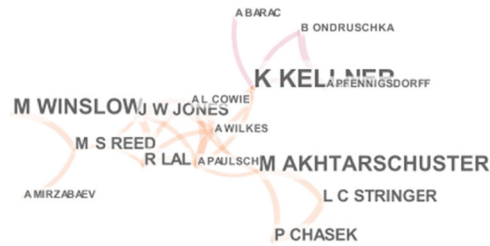


Fig. 4 The author's Atlas

suitable for desert restoration in Western China so as to realize the grand goal of western development in China. Microorganisms have unique effects on curbing financial pollution and salinization

2. The headline of cluster no. 1 is mycorrhizae. It includes potential reversal, semiarid ecosystems, directional climate change, vegetation communities, and using symbiotic wild legume shrubs. Mycorrhizae can promote absorption of soil nutrients, improve the rate of photosynthesis and enhance the soil's resistance to coldness and saltification, help

mycorrhized afforestation, and accelerate restoration of saline-alkali soil.

3. The headline of cluster no. 2 is soil restoration, and it includes controlling desertification, west Africa, fallow band, and land management practice. Soil restoration poses requirements to improve the soil, increase soil fertility, improve organic materials in the soil, and ensure fallow land in turns.

Burst terms with the most powerful intensity are desertification. Desertification emerged in 2000 and began to descend

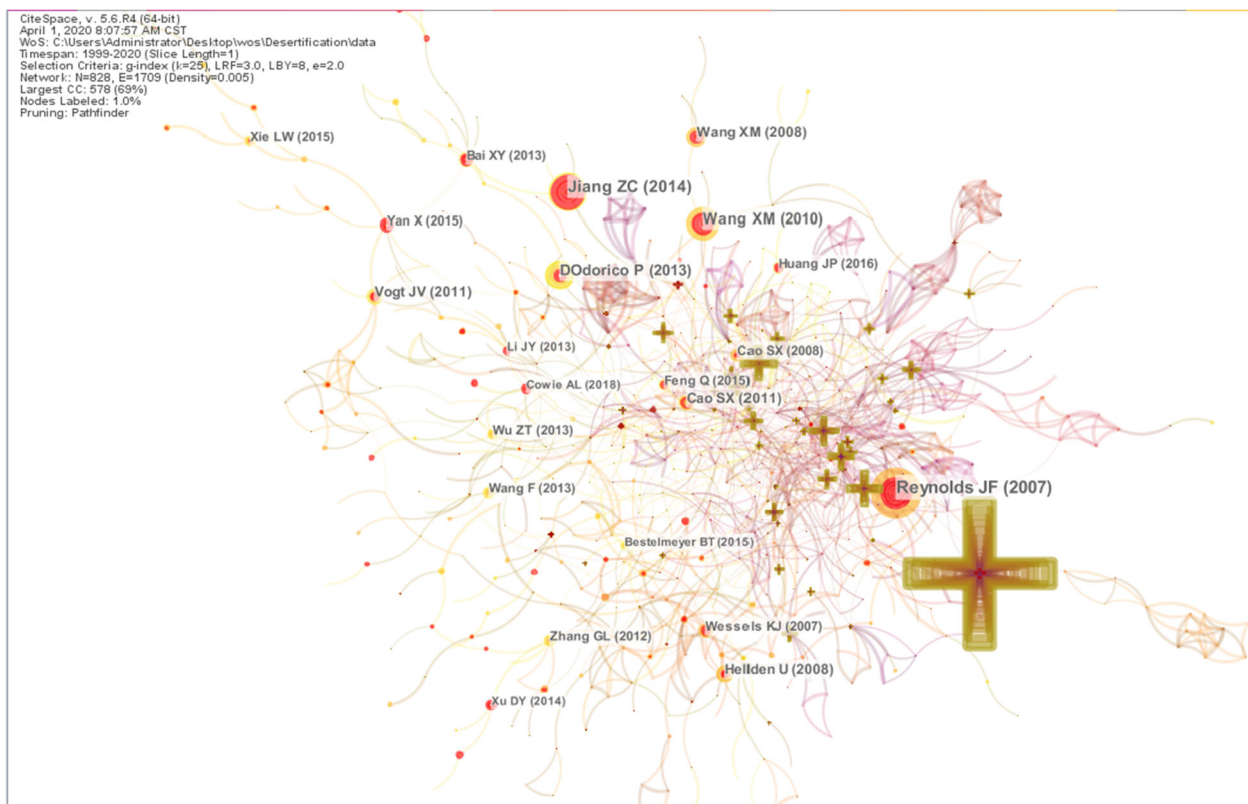


Fig. 5 Cited views of authors in the field of desertification restoration

Table 4 The core journals are cited centrally

Source	Centrality	Rank	Source	Centrality	Rank
AMBIO	0.49	1	LAND DEGRAD DEV	0.28	6
BIOGEOCHEMISTRY	0.47	2	NATURE	0.25	7
PLANT SOIL	0.43	3	J DESERT RES	0.22	8
ECOLOGY	0.33	4	GLOB CHANGE BIOL	0.22	9
SOIL SCI	0.31	5	SOIL SCI SOC AM J	0.21	10

in 2004; Spain emerged in 2000 and began to decline in 2011. It has been over a hundred years for Spain to combat desertification. Affected by excessive-exploitation and drought, the problem of desertification is aggravated. In 2001, Spain passed a new law on land utilization to improve desertification. For quite a long time, Spain’s desertification restoration became an issue of international concern. Australia (2005–2011) and Africa also adopted similar measures (2007–2014).

Based on the changes of the burst terms in Fig. 8, the research on desertification restoration has gone through three stages:

Stage One: 2000–2006 is the beginning of the study on desertification restoration. The major burst terms at that time include Spain/deforestation/desertification/grazing/revegetation/aggregate stability/indigenous knowledge/dune/Australia/environmental change/southern New Mexico. The research at that time is to conduct studies on desertification protection and control. Stage Two: From 2007 to 2016, burst terms appeared in a large number and mainly include teppe/classification/Africa/growth/landscape/pattern/ecosystem/

rangeland/facilitation/policy/reforestation. The research fields and directions were expanded, and ecological system, policy, and reforestation were taken for the study.

Stage Three: From 2017 to 2020, no new burst term appears, indicating that the study has developed into the maturity. No new technology or research highlight has been developed.

Conclusion

Desertification restoration is an arduous task. Since the beginning of the twenty-first century, scholars in the world have published 1478 high-quality research papers which involve desertification restoration from all aspects. Based on CiteSpace software, this essay studies relevant literatures in SCIE and SSCI databases in the past 20 years and investigates the number of published papers published annually, the country and unit publishing the paper, the author, core journals, and research focus, so as to clarify the important information and

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 Largest CC: 206 (92%)
 Nodes Labeled: 1.0%
 Pruning: Pathfinder

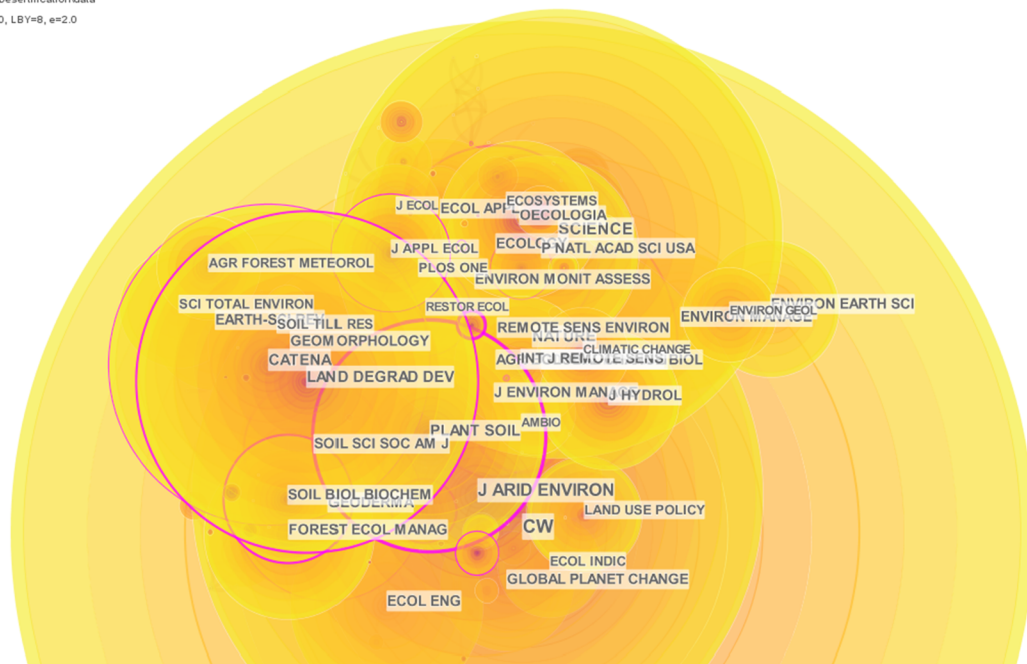


Fig. 6 Cited views of core journals of desertification restoration

Table 5 Keyword distribution

Freq	Keyword	Rank	Freq	Keyword	Rank
638	desertification	1	100	inner mongolia	11
183	restoration	2	96	soil	12
173	climate change	3	88	ecosystem	13
164	vegetation	4	86	desert	14
132	dynamics	5	78	grassland	15
119	land degradation	6	75	pattern	16
116	management	7	75	land use	17
114	impact	8	73	drought	18
114	China	9	71	northern china	19
111	degradation	10	70	region	20

Table 6 Cluster distribution sequence of subject words

Cluster ID	Clustering keywords	Size	Silhouette	Mean (year)
0	Gurbantunggut Desert	51	0.867	2006
1	Mycorrhizae	40	0.928	2008
2	Soil Restoration	36	0.905	2007
3	Karst	35	0.859	2009
4	Vegetation Pattern Formation	35	0.894	2010
5	Combating Desertification	33	0.906	2005
6	Environmental Change	33	0.891	2009
7	Grazing Management	33	0.863	2009
8	Atacama Desert	32	0.944	2006
9	Land Degradation Neutrality	31	0.892	2011

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 Pruning: Pathfinder

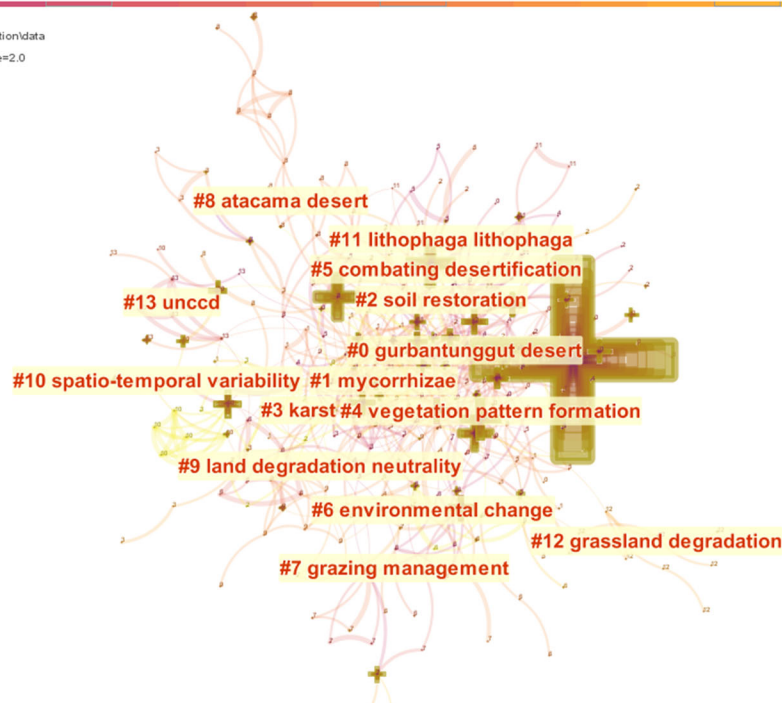
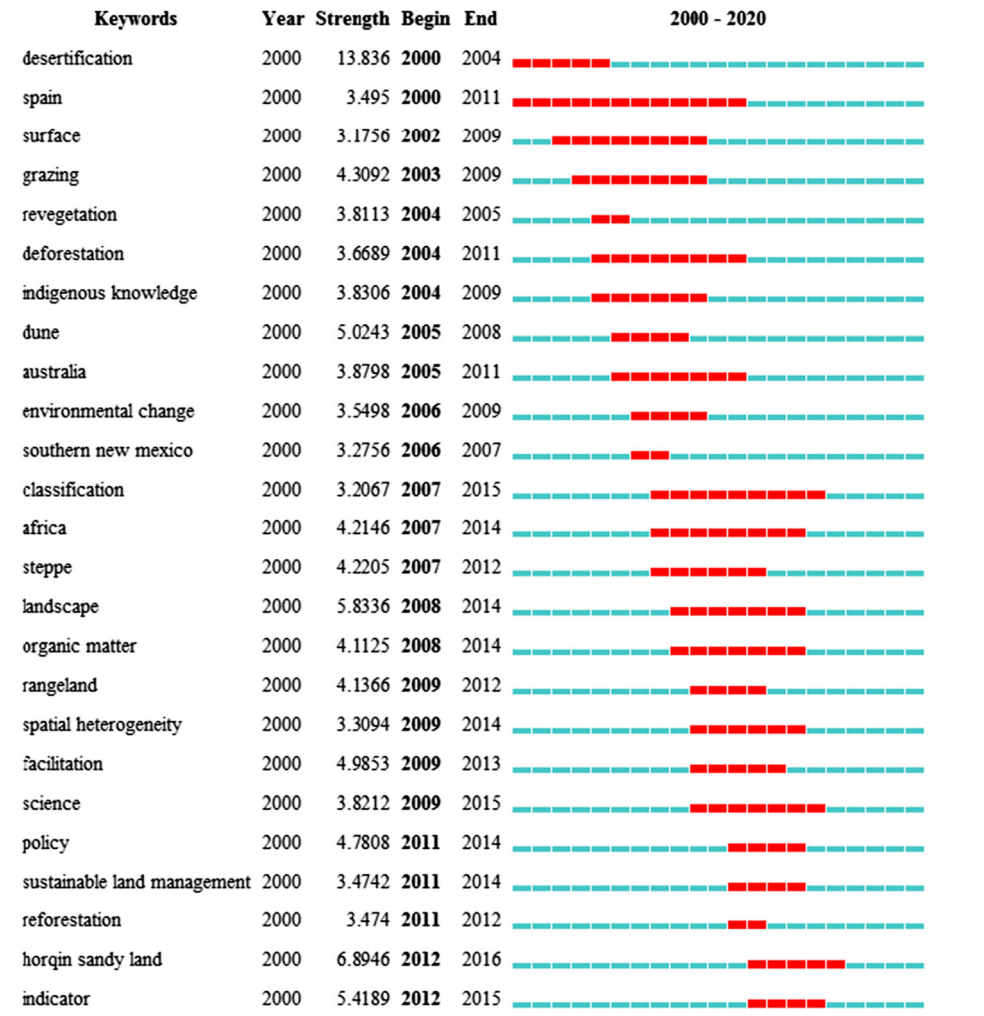


Fig. 7 Keyword cluster analysis

Fig. 8 Ranking of mutation keywords

Top 25 Keywords with the Strongest Citation Bursts



frontier trends in the field of desertification restoration. The conclusions are as follows: According to the statistical analysis on the number of papers published in SCIE and SSCI databases, the annual number of papers published in foreign-language journals related to desertification restoration is on the rise. Based on the number of papers published by the country, China ranks the first, and Chinese papers published occupy half of the total, followed by the USA. China is active in studying desertification restoration. Based on the analysis on the authors and the authors to be cited, the author with the most papers is Xueyong Zhao, but the citation frequency is low, and he is not active in information exchange in the field. Chinese Acad Sci units published the most journals. The centrality of core journals shows that biogeochemistry, plant soil, and ecology have higher centrality and have made greater contributions in this field. Based on the keywords' analysis, the research focuses on desertification, restoration, and climate change. Through clustering analysis, it is found the clustering word labels are Gurbantungut desert, mycorrhizae,

soil restoration, Karst, vegetation pattern formation, etc. The research fields can be divided into three stages: the beginning stage (2000–2006), during which desertification control and prevention were studied; development stage (2007–2016), in which ecological system, policy and reforestation were taken as the highlights of the study; and the third stage (2017–2020) presents no new burst words.

This paper studies the status quo, hot spots, evolution status, and frontier trend in the field of desertification remediation in the academic community and points out the direction for future research on desertification restoration. It should be noted that there is no abrupt map in the recent research. In the future research, it shows that there are no new achievements in the research in recent years. At the same time, we should focus on the application of desertification restoration in interdisciplinary aspects and pay attention to the contribution of computer, biology, and Geological Sciences in the field of desertification restoration.

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