REVISTA CAMINHOS DE GEOGRAFIA **ISSN 1678-6343**
http://www.seer.ufu.br/index.php/caminhosdegeografia/ DOI: http://doi.org/10.14393/RCG238859517

A SCIENCE MAPPING APPROACH TO PASTURE DEGRADATION

Jaíza Santos Motta
Universidade Federal de Mato Grosso do Sul – UFMS
Faculdade de Engenharias, Arquitetura e Urbanismo e Geografia, Pós-Graduação em Recursos Naturais
Campo Grande, MS, Brasil
ea.jsmotta@gmail.com

Alesson Pires Maciel Guirra
Universidade Federal dos Vales do Jequitinhonha e Mucuri – UFVJM
Instituto de Ciência e Tecnologia
Diamantina, MG, Brasil
engeoguirra@gmail.com

Ariane Nogueira de Oliveira
Universidade de Brasília – UnB
Faculdade de Ciências da Saúde
Brasília, DF.
nog.ariane@gmail.com

Eliane Guaraldo
Universidade Federal de Mato Grosso do Sul – UFMS
Faculdade de Engenharias, Arquitetura e Urbanismo e Geografia
Campo Grande, MS, Brasil
eliane.guaraldo@gmail.com

Roberto Macedo Gamarra
Universidade Federal de Mato Grosso do Sul – UFMS
Faculdade de Engenharias, Arquitetura e Urbanismo e Geografia
Campo Grande, MS, Brasil
rm.gamarra@gmail.com

Antonio Conceição Paranhos Filho
Universidade Federal de Mato Grosso do Sul – UFMS
Faculdade de Engenharias, Arquitetura e Urbanismo e Geografia
Campo Grande, MS, Brasil
antonio.paranhos@ufms.br

ABSTRACT

Pastures play a critical role in the global ecological system, covering approximately 20% of the global terrestrial surface. This paper aims to review the progress of research on pasture degradation in different countries. The main research methods for this study include bibliometric analysis, social network analysis and viewing analysis - covering the performance of publications, characteristics of related journals, countries, institutions and authors. The Impact Factor, the H-index and the number of citations are used to investigate the strength of active institutions, authors and scientific periodicals in the field of pasture degradation. Therefore, we intend to outline the research trends already made and point out to future studies. We found 1027 articles published between 1956 and 2018, but none of them has reviewed science in a systematically way. The majority of authors are from China, United States and Germany. These lines of research aim to show the dynamics of pasture in response to the climate, the changes in human activity, the estimates of degraded or healthy areas and the evaluation of public policy interventions. In terms of publication productivity analysis, we highlight the Journal of Arid Environments, the author Richard J. Dean and the institution Chinese Academy of Sciences.

Keywords: Ecosystem Services. Social Networking Analysis. Scientometric. Climate Change. Managing Degraded Areas.

MAPEAMENTO DA CIÊNCIA SOBRE DEGRADAÇÃO DE PASTAGEM

RESUMO

As pastagens desempenham um papel fundamental no sistema ecológico global, cobrindo aproximadamente 20% da superfície emersa. Este trabalho teve como objetivo revisar o progresso de pesquisas sobre degradação de pastagens em diferentes países. Os principais

métodos de pesquisa para este estudo incluem análise bibliométrica, análise de redes sociais e análise de visualização, abrangendo desempenhos de publicações, características de periódicos relacionados, de países, de instituições e de autores. O índice-h e o número de citações são usados para investigar a força de instituições ativas, de autores e de periódicos no campo da degradação de pastagens. Busca-se, assim, delinear as tendências das pesquisas já feitas e apontar para estudos futuros. Encontramos 1.026 artigos publicados entre 1956 e 2018, porém nenhum desses revisou a ciência de forma sistemática. A maioria dos autores é da China, Estados Unidos e da Alemanha. As linhas de pesquisa visam mostrar a dinâmica das pastagens em resposta ao clima e às mudanças causadas por atividade humana, as estimativas de coberturas degradadas ou saudáveis e avaliar intervenções de políticas públicas. Em relação a análise de produtividade, temos como destaque a revista Journal of Arid Environments, o autor Richard J. Dean e a instituição Chinese Academy of Sciences.

Keywords: Serviços Ecossistêmicos. Análise de Redes Sociais. Cienciometria. Mudanças Climáticas. Gerenciamento de Áreas Degradadas.

INTRODUCTION

Pastures are one of the largest terrestrial ecosystems, representing approximately 20% of the emerged surface global (MU et al., 2013). The main land use of pastures is for livestock grazing for human consumption. The overcrowding of pastures and climate change have a deep influence on pasture degradation in dry and semi-arid regions in the world (MEYER et al., 2017; ZHOU et al., 2017). That degradation can cause initial reduction of pasture productivity, fragmentation of grass cover, fertility reduction, soil compaction or the increase of non-palatable herbs species.

The negative aspects between pastures and economic activities are studied since the last century (KAIN, 1975; YEZHKOV et al., 1985; MILTON and DEAN, 1992). Although there are efforts to mitigate this negative impact through the application of advanced technologies and implementation of appropriate resource management policies, the sustainable use of pastures is yet to be achieved The degradation of pastures can cause not only socioeconomic problems to farmers, such as commodity shortages, but also environmental problems, such as hydrological hazards, dust storms and biodiversity changes directly and indirectly throughout a region.

Although many articles have been published in such an important field, few of them aimed to summarize the progress of the research related to this subject, in a way that the main topics, methods, authors and research institutions would be acknowledged. Under this circumstance, it is necessary to review all the literature related to pasture degradation using the method of bibliometric analysis in order to fill this research gap.

METHODS

This study uses a holistic approach to evaluate existing results in the field of pasture degradation localized in the Scopus® database. The science mapping in pasture degradation includes bibliometric data, analysis of the main collaborators in research on the subject and the discussion about the main research topics disseminated.

Bibliographic searching

The bibliometric search of the publications on pasture degradation was done using the SciVerse Scopus database, which is one of the main search engines for academic results. This system has an extended range of data, more than other digital sources, such as the Science® and the Science Direct®. The bibliographic research began by inserting the following keywords in Scopus®:

TITLE-ABS-KEY ("pastur degrad*" OR "grass* degrad*" OR "rangeland* degrad*" OR "grass* deteriorat*" OR "rangeland* deteriorat*" OR "pastur* damag*" OR "grass* damag*" OR "rangeland* damag*" OR "graz* damag*" OR "pastur* degenerat*" OR "grass* degenerat*").*

The strategy of retrieval of publications considered only scientific paper and reviewer paper, published in English, until December of 2018. The other formats of works, such as conference articles, were not considered in the analysis because they did not provide as much information as articles from peer-reviewed journals (BUTLER; VISSER, 2006).

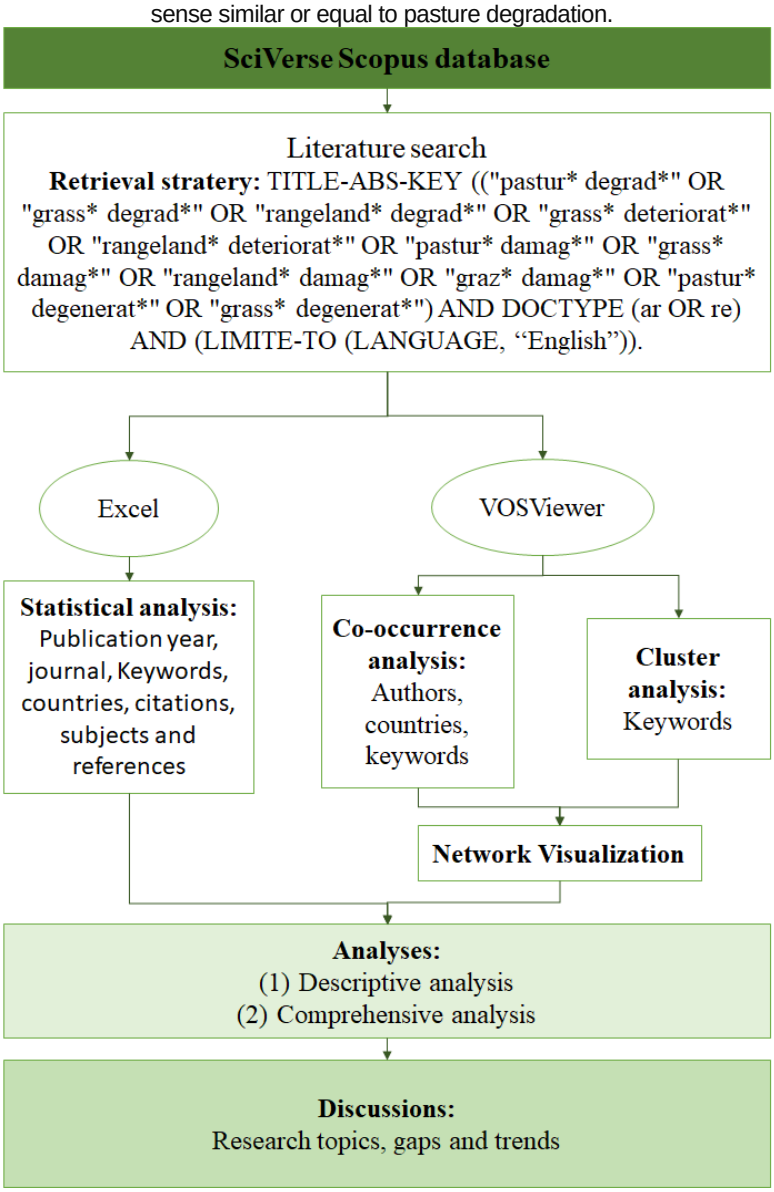
Science Mapping

Science maps work as visual interfaces for analyzing a great amount of data, portraying them in countless ways, such as connections between people or groups. Thus, it allows us to discern effectively atypical data, clusters, and apparent trends. Some of the tools often used to produce visual interfaces are: Pajek, Gephi, UCINET, Citespace II, VOSviewer and SciMAT.

In this study, VOSviewer, a text mining tool that provides distance-based visualizations of bibliometric networks developed by Van Eck and Waltman (2010), was adopted for the analysis and visualization of the collected data. The distance between two nodes reflects the affinity between them, so a shorter distance usually indicates a stronger relationship. This tool is used to achieve the following objectives: 1) To load the literature sample obtained from the Scopus database; and 2) To visualize, compute and analyze the periodicals performances in this study area.

Our guidelines are shown in Figure 1: first we collected the data in a systematic way, then we analyzed them in a descriptive and comprehensive method, and, finally, we discussed the research topics, gaps and trends.

Figure 1 - The workflow for systematic bibliometric analysis of pasture degradation (PD). The gathering of data from publications related to PD was extracted from the SciVerse Scopus database, through a set of keywords with a sense similar or equal to pasture degradation.



SOURCE - The authors.

RESULTS AND DISCUSSIONS

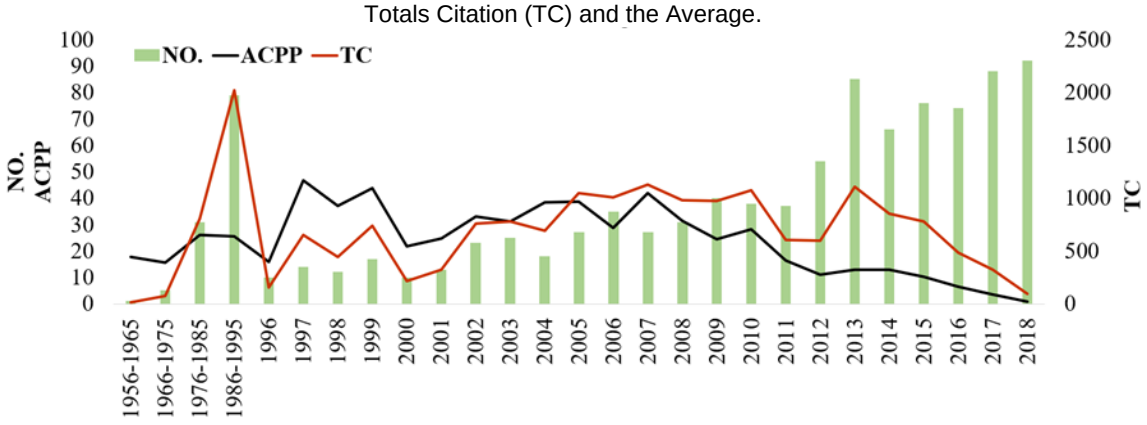
In total, there are 1394 documents available on the subject in question by December 31 of 2018. The general analysis of the documents shows that only 15.06% of the publications found in the SciVerse Scopus database are open access. The most frequently type of publication is in research articles (1186), accounting for 85.08% of total publications, followed by conference articles (7.68%), review articles (3.52%), book chapters (0,7%), books (0,14%), short reviews (0,14%), annals of reviews (0,07%) and other types of documents and news (0.07%). These other types are in a percentage of 1.22%.

Among the publications, it is noted that English is the dominant language (1192), representing 85.08% of the documents, followed by Chinese (11.92%) and Portuguese (1.28%). Other languages represent 1.71% of the publications that were found. Although there are publications in other languages, it was decided in this study that the selection of documents would be limited to research articles and review articles written in English, synthesized in 1026 documents, which are 73.65% of the total publications.

Selected publications performance

As shown in Figure 2, the first document on pasture degradation was published in 1956 and the number of annual publications (NO) had a gradual growth trend until 2018. The annual total of citations (TC) fluctuated over the years, considering that the largest amounts of citations occurred between 2005 and 2010 and also in 2013, following a decline after that. The average number of citations per publication (ACPP) fluctuated until 2007, and then declined gradually. The declines in TC and ACPP are due to the large volume of research published in recent years that has not yet been recognized.

Figure 2 - The performance of publications related to pasture degradation obtained from the SciVerse Scopus database (1956-2018). The initial forty years (1956-1995) were grouped in four equal parts. We can see that the number of publications (NO) has been increasing over time, especially in the last 10 years. The declines in Totals Citation (TC) and the Average.



NO.: Number of annual publications between 1956-2018.
ACPP: Average number of cited publications.
TC: Total of citations from the amount of articles annually published during the period of this study.
SOURCE - The authors.

Performance of different journals

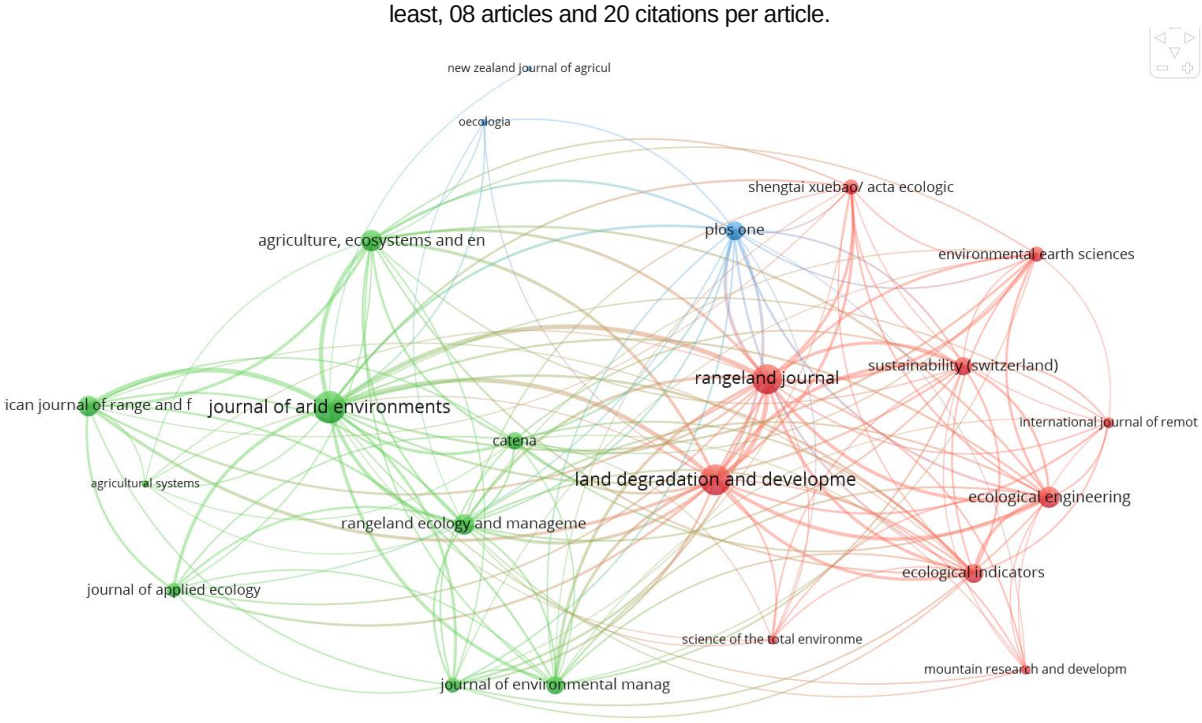
As shown in Figure 2, the first document on pasture degradation was published in 1956 and the number of annual publications (NO) had a gradual growth trend until 2018. The annual total of citations (TC) fluctuated over the years, considering that the largest amounts of citations occurred between 2005 and 2010 and also in 2013, following a decline after that. The average number of citations per publication (ACPP) fluctuated

until 2007, and then declined gradually. The declines in TC and ACPP are due to the large volume of research published in recent years that has not yet been recognized.

The measure of similarity of bibliographic coupling was used to analyze citations. On this purpose, the minimum number of articles and citations in 8 and 20, respectively, was defined in VOSViewer. 22 journals, out of a total of 432 identified by the software, reached the established limits (Figure 3).

According to the link and source, Figure 3 shows that the Journal of Arid Environments has been the most productive journal in terms of the total number of publications and citations. The colors and connection lines indicate the interrelationship between journals, known as clusters. The following journals, for instance, were actively cited by each other: Rangeland Journal, Environmental Earth Science; Agriculture, Ecosystems and Environment and African Journal of Range and Forage Science.

Figure 3 - Bibliographic coupling web among 22 journals out of 432 which publish on pasture degradation with, at least, 08 articles and 20 citations per article.



SOURCE - The authors.

A more quantitative measure of the relevance of journals is shown in Table 1 and Figure 4, in which the ten most productive journals and their trends over time are presented, being classified according to the number of articles they published. The publications about pasture degradation are clearly concentrated in the 10 most productive journals, as they published 19.77% of the total number of articles (Table 1). The Journal of Arid Environments was the most productive journal, as well as one of the first to give attention to the issue, because it has published 33 articles related to DP until 2018, and that represent 3.21% of the total publications. In addition, this journal received the highest number of citations (1617 citations) and the highest H-index (21) in the follow-up. The second most productive was the Rangeland Journal with 29 articles, representing 2.82%, due to the sum of its publications only in 2015 (10 articles). In third place is Land Degradation and Development with 28 articles, 15 of which received at least 15 citations (H-Index).

Half of the 10 most productive journals are from Elsevier: Journal of Arid Environments; Rangeland Journal; Shengtai Xuebao / Acta Ecologica Sinica, Agriculture; Ecosystems and Environment; Rangeland Ecology and Management.

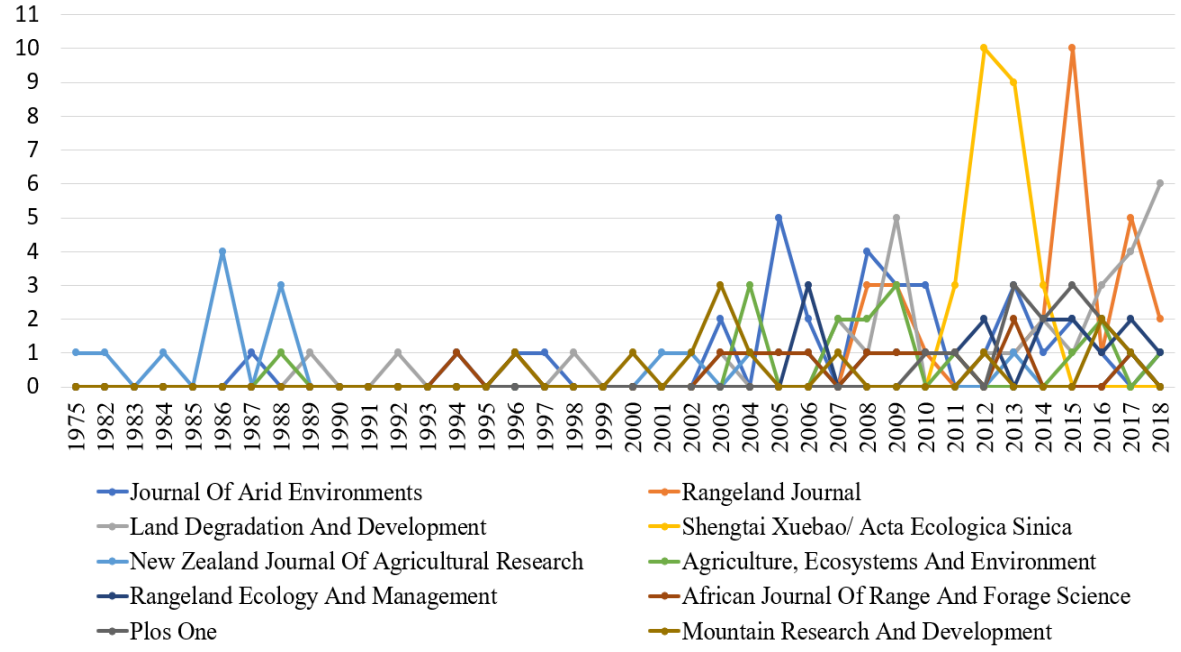
Table 1 - Active journals in research on pasture degradation.

Journal	TP	% (R)	TC	AC	H Index (R)	IF
Journal of Arid Environments	33	3,21% (1)	1617	49,00	21 (1)	1,99
Rangeland Journal	29	2,82% (2)	508	17,52	11 (4)	1,08
Land Degradation and Development	28	2,73% (3)	736	26,29	15 (2)	7,27
Shengtai Xuebao/ Acta Ecologica Sinica	25	2,43% (4)	61	2,44	4 (14)	7,27
New Zealand Journal of Agricultural Research	18	1,75% (5)	160	8,89	7 (8)	1,63
Agriculture, Ecosystems and Environment	16	1,56% (6)	496	31,00	13 (3)	3,54
Rangeland Ecology and Management	15	1,46% (7)	356	23,73	8 (5)	1,97
African Journal of Range and Forage Science	13	1,27% (8)	178	13,69	8 (5)	0,88
Plos One	13	1,27% (9)	253	19,46	7 (8)	2,77
Mountain Research and Development	13	1,27% (10)	208	16,00	7 (8)	1,22

SOURCE - The authors.

The publication tendencies in many journals change over time, but as it can be seen in Figure 4, they have improved since 2002. Shengtai Xuebao / Acta Ecologica Sinica presents two peaks of publications in 2012 and 2013, with 10 and 09 articles, respectively, corresponding to 76% of the total of its publications.

Figure 4 - Timeline of publications in the top 10 most productive journals on pasture degradation (PD) between 1975 and 2018.



SOURCE - The authors.

Publications characteristics

Countries performances

There are authors from 10 nationalities that published more than 40 articles between 1956 and 2018, as shown in Table 2. China, the USA, Germany and the UK had the four greatest H-indexes among countries /

territories active in this field. This finding indicates that those countries have promoted the development and application of research on pasture degradation, especially in the last 10 years.

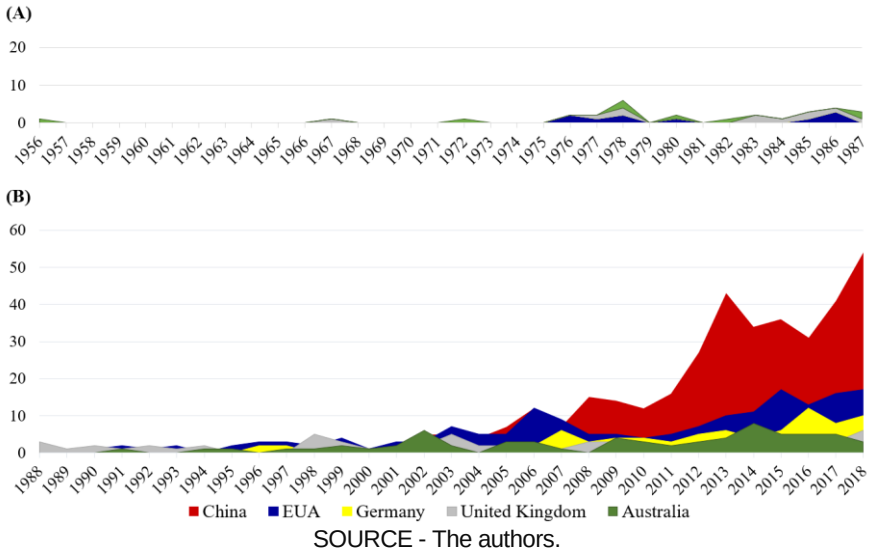
Table 2 - Active countries in research on pasture degradation. TP: Total of publications of countries between 1956 and 2018. TC: Total of citations of countries between 1956 and 2018; AC: Average of citations of countries per article; % (R): The percentage of the country's publications and their classifications; SP% (R): The percentage of publications and their classifications without international contribution; CP% (R): The percentage of publications and their classifications with international contribution; C% (R): The percentage of international collaborative publications of a county; H-Index: The classification of the H-index of the country in the data established by that article.

Países	TP	TC	AC	% (R)	SP% (R)	CP% (R)	C%	Índice-H
China	368 (1)	5938	16,14	35,83 (1)	21,83 (1)	14,04 (1)	39,13	38 (1)
USA	186 (2)	4642	24,96	18,13 (2)	7,60 (2)	10,53 (2)	58,06	37 (2)
Germany	84 (3)	2053	24,44	8,19 (3)	0,97 (10)	7,21 (3)	88,10	25 (4)
United Kingdom	79 (4)	1884	23,85	7,70 (4)	3,80 (4)	3,90 (4)	50,63	27 (3)
Australia	76 (5)	1607	21,14	7,41 (5)	3,90 (3)	3,51 (5)	47,37	23 (6)
South Africa	59 (6)	1846	31,29	5,75 (6)	3,80 (4)	1,95 (6)	33,90	24 (5)
Brazil	54 (7)	978	18,11	5,26 (7)	3,31 (6)	1,95 (6)	37,04	14 (7)
New Zealand	47 (8)	722	15,36	4,58 (8)	2,63 (7)	1,95 (6)	42,55	14 (7)
Canada	43 (9)	670	15,58	4,19 (9)	2,44 (8)	1,75 (10)	41,86	14 (7)
Japan	41 (10)	527	12,85	4,00 (10)	1,56 (9)	2,44 (9)	60,98	11 (10)

SOURCE - The authors.

Figure 4 shows the annual amount of publications by the 5 most productive countries. Among them, only Germany, USA and UK had published on pasture degradation until 1993. The records of German and Chinese authors' publications appeared from 1994 and 1995, respectively, according to the data set selected. China has become the most productive country since 2008, evidencing its growing concern about the pasture degradation, due to the demand of this resource for the production of food for human consumption, besides the environmental and socioeconomic impacts in some regions, which are degraded or in the process of desertification in its territory. For these specific areas, the Chinese government is funding projects to study and recover degraded pastures from desertification, climate change mitigation, ecological restoration, and rehabilitation of degraded pastures, because the investments in these issues provide higher productivity in agropastoral systems, generating greater natural resources sustainability.

Figure 4 - Growth trends of the five most productive countries in the pasture degradation field divided in two parts: (A) the representation of the active countries between 1956 and 1987 and (B) the production from 1988 to 2018.



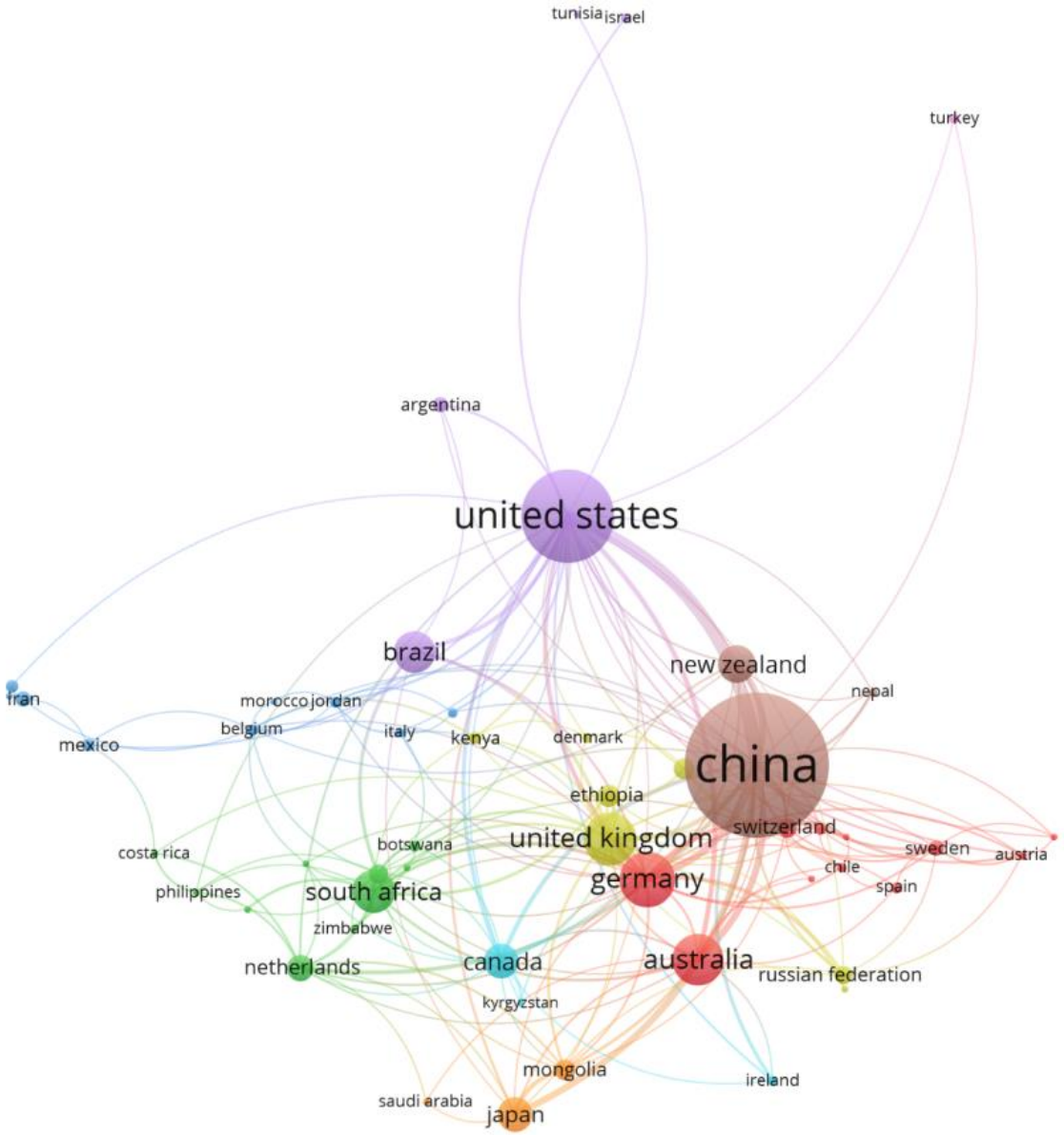
SOURCE - The authors.

Academic cooperations

Figure 5 represents the co-authorship network of 52 countries, with at least 3 articles related to pasture degradation. The network visualization shows 7 clusters and the diversification in the research directions.

China is the most active country in international collaborations, especially with the USA (65 links), with the Germany (20 links). The USA is the second most active, working mainly with researchers in Australia (10) and Germany (8). As shown in Figure 6, geographical advantage is not the main factor influencing the cooperative relationship, since groups in developing countries / territories also actively participate in collaborations. The continued expansion of collaborations in research on pasture degradation not only improves the country's research skills, but also facilitates the development of these studies.

Figure 5 - Collaboration networks among 52 countries with at least 3 articles related to pasture degradation.



SOURCE - The authors.

Institutions performance

The Chinese institutions have hegemony in this study, because 14 out of 20 most productive institutions belong to this country. The Chinese Academy of Sciences is the leading research organization, contributing

with 179 publications, 17.41% of the 1,028 articles selected. Beijing Normal University comes next with 50 articles, also a Chinese institution. The performance of the 20 best productive institutions is shown in Table 3.

The first institution outside China occupies the fifth place and it is Brazilian, the Brazilian Agricultural Research Corporation - Embrapa with 24 publications. The scientific production of these institutions together accounts for approximately half of the scientific output of the Chinese Academy of Sciences. This shows that the productivity of Chinese authors is exceptional in this area of research.

Table 3 - Active institutions in research on pasture degradation. TP: Total publications of each institution between 1956 and 2017; %: The percentage of publications per country.

Organization	Country	TP	%
Chinese Academy of Sciences	China	179	17,43
Beijing Normal University	China	50	4,87
University of Chinese Academy of Sciences	China	47	4,58
Lanzhou University	China	35	3,41
Institute of Geographical Sciences and Natural Resources Research Chinese Academy of Sciences	China	34	3,31
Empresa Brasileira de Pesquisa Agropecuária - Embrapa	Brazil	24	2,34
Institute of Botany Chinese Academy of Sciences	China	23	2,24
Cold and Arid Regions Environmental and Engineering Research Institute Chinese Academy of Sciences	China	20	1,95
Ministry of Education China	China	19	1,85
Peking University	China	19	1,85
Chinese Academy of Agricultural Sciences	China	19	1,85
Northwest Institute of Plateau Biology, Chinese Academy of Sciences	China	19	1,85
China Agricultural University	China	18	1,75
Neimenggu Agricultural University	China	17	1,66
University of the Free State	South Africa	14	1,36
Northwest A&F University	China	14	1,36
Universität Göttingen	Germany	14	1,36
Universitetet for miljø- og biovitenskap	Noruega	13	1,27
Cornell University	EUA	13	1,27
AgResearch Ruakura Research Centre	New Zealand	12	1,17

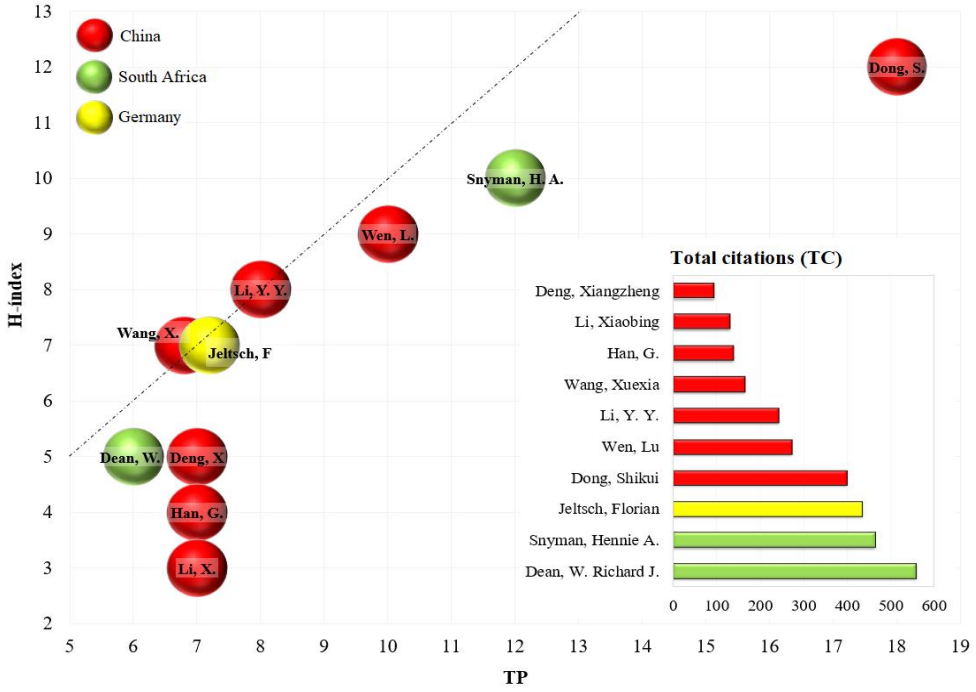
SOURCE - The authors.

Performance evaluation

The performance of authors according to their H-Index are shown in Figure 6. The authors Yuanyuan Li, Florian Jeltsch, Xu and Wang, are the scientists with the greatest impacts, according to the H-Index, because their citation numbers are equal to or greater than the numbers of published articles.

Figure 1 also shows the total of citations per article. The South African publications Dean, W. Richard J. (1992-1997) and Syman, Hennie A. (2000-2013) and German Jeltsch, Florian (1997 - 2012) are the most cited authors, probably because of the relevance of the content of the research, as they are pioneers in the field. Regarding the authors' nationality, 7 authors are from China, 2 are from South Africa and 1 from Germany.

Figure 6 - The performances of the 10 most productive authors, with at least 7 publications and at most 18 publications.



SOURCE - The authors.

Citations of articles

Table 4 presents the twenty most cited articles among the articles that were selected in this study. The articles generally had some common research directions as applied geotechnologies (GAO et al., 2010; LIU et al., 2013; WU et al., 2013), agropastoral system optimization models (CHEN et al., 2009 ; CAMPANA et al., 2015), literature review (CUI and GRAF, 2009; MCKEON et al., 2009; HARRIS, 2010; BRISKE et al., 2011; LKHAGVADORJ et al., 2013; WANG et al., 2013; ADKINS and SHABBIR, 2014), landscape ecology (YAYNESHET et al., 2009; CEBALLOS et al., 2010), sustainability (MIEHE et al., 2010; SCHÖNBACH et al., 2011), among others highlighted in Table 4.

Table 4 - Most cited articles in the field of pasture degradation.

Article	Author	Year	TC
Rangeland degradation on the Qinghai-Tibetan plateau: A review of the evidence of its magnitude and causes	Harris	2010	393
Recent land cover changes on the Tibetan Plateau: A review	Cui & Graf	2009	167
Grassland responses to grazing: Effects of grazing intensity and management system in an Inner Mongolian steppe ecosystem	Schönbach et al.	2011	137
Rangeland Degradation On The Qinghai-Tibet Plateau: Implications For Rehabilitation	Li, Ma, Xu, Wang, & Zhang	2013	98
Rapid loss of lakes on the Mongolian Plateau	Tao et al.	2015	96
Climate change impacts on northern Australian rangeland livestock carrying capacity: A review of issues	McKeon et al.	2009	86
Origin, persistence, and resolution of the rotational grazing debate: Integrating human dimensions into rangeland research	Briske et al	2011	85
Energy balance and partition in Inner Mongolia steppe ecosystems with different land use types	Chen et al.	2009	75
Changing Climate and Overgrazing Are Decimating Mongolian Steppes	Liu et al.	2013	71
Impact of land use and land cover change on environmental degradation in lake Qinghai watershed, Northeast Qinghai-Tibet Plateau	(Li, Ma, Xu, Wang, & Zhang	2009	65

SOURCE - The authors.

Qualitative discussion

After bibliometric analysis, this study conducted an in-depth discussion, mainly on the 20 most cited articles, to summarize contemporary research topics, identify limitations and propose research directions for future research. Results are reported below.

Estimation and quantification of pasture degradation by geotechnologies

Assessing pasture degradationis the basis for ecological restoration. The monitoring of pasture degradation is traditionally conducted through in-field data collection. This method is inefficient, time-consumingand costly as thepastures generally cover extentensive areas. On the other hand, remote sensing has the potential for monitoring pasture areas in a much more efficient way.

Many alternatives that indicate the driving forces of pasture degradation have been developed, such as the calculation of the difference between the real and potential net primary productivity (NPP), (MEYER et al., 2017; ZHOU et al., 2017). Assessing pastures and measuring the intensity of changes of the heat waves and temperature, to obtain information from vegetation indexes, through remote sensing data, in the evaluation of the pasture degradation. The authors Wen et al. (2010) statistically evaluate 10 indices and they concluded that NDVI is the best index to distinguish a forage cover crops in semi-arid environment, with a performance that is statistically similar to IPVI and MSR (Wen et al., 2010).

The results of most of the studies on pasture degradation focus mainly on productive capacity, without analyzing social or managerial interactions (FAN et al., 2010; XU et al., 2016). Hopping et al. (2018) gathered information from social science, remote sensing and biophysical data to bridge this scientific gap. The authors demonstrated that NDVI is useful for understanding the health of extensive pasture systems, although it is unable to distinguish between palatable and unpalatable vegetation, as satellite images do not allow such distinction. In contrast, in-depth sampling provides much more useful data on health indicators, but is limited in time and space. In order to quantify the degree of pasture degradation using visible indicators, the first GDI index based on the classification criteria for alpine pastures was developed and tested by Gao et al. (2010).

Approach of different pasture practices and management

While analyzing the degradation process and management practices, Schönbach et al. (2011) identified that the mixed system is more efficient and sustainable to perform livestock and agriculture activities than the traditional system, since the former is more resistant to moderate to high stocking rates , considering the primary net production of grasses. Although stocking rates previously recommended by pasture scientists, such as Harris (2010), did not consider the invasion of shrubs in an interval of 20 years. It is noteworthy that the bibliographic review of Harris (2010) does not highlight the excessive number of cattle, responsible for overgrazing, as one of the main driving forces for the degradation of pastures.

Degradation caused by different mechanisms should be treated with specific measures for each geographically distinct region, but the reduction of grazing pressure and the number of stocks can be considered as practices that can rehabilitate degraded areas, besides other actions such as sowing, pest control and erosion control methods (GAO et al., 2013).

Therefore, it is necessary to consider people and their actions on their productive lands, as well as information on land values in relation to the ecosystem services they provide (BEDUNAH and ANGERER, 2012). These authors also emphasize that the success of pasture management projects depended on community involvement, policy developmentand reforms that should address health, education, research, land use and governance issues.

Performance in restoration of degraded pastures

The vegetation of semi-arid regions is able to regenerate in a relatively short time; measures such as fencing of the area to avoid cattle herding allow the natural restoration of the degraded area (YAYNESHET et al., 2009). However, Gao et al. (2013) argue that it is very difficult to rehabilitate a new assembly of plant species due to climate change or deep changes in abiotic conditions and that inedible (toxic) plants can serve to help restore degraded ecosystems, although they are not economically valuable.

The delimitation of areas to be protected for restoration was studied by Fuller et al. (1998), which combined field surveys of plants and animals with remote sensing in order to delimit these protection areas against grazing, but also defined areas of multiple use to facilitate studies of biogeographic factors in the choice of agricultural practices that are more adequate for maintaining biodiversity in the long term.

The main gaps in pasture degradation

Studies at a global scale in determining the causes of pasture degradation still have limitations to conducting quantitative analysis, according to Gang et al. (2015). One of the limitations discussed by Miehe et al. (2010) is the importance of analyzing pasture dynamics based on multitemporal data and information with at least 15 years of observations, but most of the studies have been developed with data from observations of 5 years or less.

The authors state that long multitemporal monitoring with information on the climatic gradient and the variation of the vegetation cover are preconditions for a better understanding of the pasture dynamics and the ecological factors involved. These authors further demonstrate that remote sensing techniques are valid tools for studies on pasture degradation if these studies are also based on data obtained from in loco observations.

Monitoring via long-term remote sensing is more efficient when information is extrapolated to areas of similar conditions while using vegetation parameters as indicators. However, most of studies are not marked out by field information, becoming that a scientific gap to be filled.

Information collected in the field requires ecological data, but also the experience of the farmer in planning and implementation of management strategies for interventions and restoration actions in degraded pastures to be successful, in addition to meeting specific demands of the local producers (SOLOMON et al., 2007).

However, integrated approaches in solving problems of agropastoral systems are still deficient due to the extensive lands covered by pastures, especially in developing countries, which have growing population associated with the intensification of extractive economic activities, in which the capacity to maintain biodiversity and other critical ecosystem services are challenging (BEDUNAH AND ANGERER, 2012).

We observed the absence of studies assessing how multiscale variation can occur in the identification / quantification of healthy or degraded pastures in this collection of articles, as well as the inexpressive number of surveys that group GIS tools, field data and social, ecological and economic information for more precise responses to the monitoring of degraded areas.

Gang et al. (2014) point out that the degradation of pastures analyzed on a global scale remains a major challenge, given the limited capacity to conduct a precise quantitative assessment capable of distinguishing the influence of climate over human factors, as well as determining that in some areas of the globe, degradation has become an irreversible process.

FINAL CONSIDERATIONS

Research on degradation is fundamental in promoting the sustainable management of this natural resource. However, due to the large tracts of grassland and inadequate use / management, their quality is being degraded, leading to rapid depletion and corresponding emissions. In addition, no peer-reviewed publications have completed a holistic review to summarize recent progress and point to future directions for research. Under this circumstance, this article adopts bibliometric analysis to analyze the academic characteristics of publications (scientific papers and review articles) in English on the degradation of pastures indexed by Scopus during 1956 and 2018.

The results show that scientific attention in this area has gradually increased due to growing concerns over pasture. The Journal of Environmental Management has been the most productive journal in terms of total number of publications and citations, with the highest amount of interactions with other journals and better H-index. Land Degradation and Development and Shegtai Xuebao / Acta Ecologia Sinica are the most influential periodicals in terms of Impact Factor (IF).

On the global scale, China is the leading country with the most publications, with greater academic influence and the most active in international cooperation. China has 14 institutions among the 20 most productive,

besides that, 12 articles among the 20 most cited are case studies in Chinese pastures and 7 authors among the 10 most productive are Chinese. This is mainly due to the fact that Chinese pastures have been suffering severe degradation and desertification in recent years, playing a critical role for the population and the government. Before China began to publish indexed articles at Scopus, the US was the most productive country (until 2007), currently occupying the second place. The USA has one institution listed among the 20 most productive institutions but no article among the 20 most cited was developed specifically about American pastures.

The most cited papers address public policy issues and their efficiency, analysis of changes in soil cover and pasture production methods, using varied methodological strategies. The diffusion of the theme in areas such as Biology, Landscape Ecology, Remote Sensing, Sustainability and Agriculture show that the subject has been developed under a multidisciplinary domain. However, no single method can handle such a complex issue, therefore, the integration of different methods is necessary to obtain more holistic and accurate information on pasture degradation providing scientific knowledge for decision-making processes.

In general, the purpose of this study is to provide a thorough review of current progress and important issues related to pasture degradation. These results can provide valuable information for the scientific community involved in this field so that more research results can be generated to guide the sustainable use of pastures.

REFERENCES

ADKINS, S; SHABBIR, A. Biology, ecology and management of the invasive parthenium weed (Parthenium hysterophorus L.). **Pest Management Science**, v. 70, n. 7, p. 1023-1029, 2014. https://doi.org/10.1002/ps.3708

BEDUNAH, D. J.; ANGERER, J. P. Rangeland degradation, poverty, and conflict: How can rangeland scientists contribute to effective responses and solutions? **Rangeland Ecology and Management**, v. 65, n. 6, p. 606-612, 2012. https://doi.org/10.2111/REM-D-11-00155.1

BLAUM, N; SEYMOUR, C; ROSSMANITH, E; SCHWAGER, M; JELTSCH, F. Changes in arthropod diversity along a land use driven gradient of shrub cover in savanna rangelands: Identification of suitable indicators. **Biodiversity and Conservation**, v. 18, n. 5, p. 1187-1199, 2009. https://doi.org/10.1007/s10531-008-9498-x

BRISKE, D. D.; NATHAN, F. S.; HUNTSINGER, L.; FERNANDEZ-GIMENEZ, M.; BUDD, B.; DERNER, J. D. Origin, Persistence, and resolution of the rotational grazing debate: Integrating human dimensions into rangeland research. **Rangeland Ecology and Management,** v. 64, n. 4, p. 325-334, 2011. ISSN 15507424. https://doi.org/10.2111/REM-D-10-00084.1

CAMPANA, P. E; LI, H.; ZHANG, J.; ZHANG, R.; LIU, J.; YAN, J. Economic optimization of photovoltaic water pumping systems for irrigation. **Energy Conversion and Management**, v. 95, p. 32-41, 2015. https://doi.org/10.1016/j.enconman.2015.01.066

CEBALLOS, G.; DAVIDSON, A.; LIST, R.; PACHECO, J.; MANZANO-FISCHER, P.; SANTOS-BARRERA, G.; CRUZADO, J. Rapid decline of a grassland system and its ecological and conservation implications. **PLoS ONE**, v. 5, n. 1, 2010. https://doi.org/10.1371/journal.pone.0008562

CHEN, S.; CHEN, J.; LIN, G.; ZHANG, W.; MIAO, H.; WEI, L.; HUANG, J. HAN, X. Energy balance and partition in Inner Mongolia steppe ecosystems with different land use types. **Agricultural and Forest Meteorology,** v. 149, n. 11, p. 1800-1809, 2009. https://doi.org/10.1016/j.agrformet.2009.06.009

COBO, M. J.; López-Herrera, A. G.; Herrera-Viedma, E.; Herrera, F. An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. **Journal of Informetrics**, v. 5, n. 1, p. 146-166, 2011. https://doi.org/10.1016/j.joi.2010.10.002

CUI, X.; GRAF, H. F. Recent land cover changes on the Tibetan Plateau: A review. **Climatic Change,** v. 94, n. 1-2, p. 47-61, 2009. https://doi.org/10.1007/s10584-009-9556-8

FAN, JW.; SHAO, QQ.; LIU, JY.; WANG JB.; HARRIS, W.; CHEN ZQ. ZHONG, HP.; XU, XL.; LIU, RG. Assessment of effects of climate change and grazing activity on grassland yield in the Three Rivers Headwaters Region of Qinghai-Tibet Plateau, China. **Environmental Monitoring and Assessment**, v. 170, n. 1-4, p. 571-584, 2010. https://doi.org/10.1007/s10661-009-1258-1

FENG, Y; LU, Q. TOKOLA, T.; LIU, H.; WANG, X. Assessment of grassland degradation in Guinan county, Qinghai province, China, in the past 30 years. **Land Degradation and Development,** v. 20, n. 1, p. 55-68, 2009. https://doi.org/10.1002/ldr.877

FU, X.; TANG, C.; ZHANG, X.; FU, J.; JIANG, D. An improved indicator of simulated grassland production based on MODIS NDVI and GPP data: A case study in the Sichuan province, China. **Ecological Indicators**, v. 40, p. 102-108, 2014/05/01/ 2014. https://doi.org/10.1016/j.ecolind.2014.01.015

FULLER, R. M.; NOVIO, G. B.; MUGISHA, S.; IPULET, P.; POMEROThe integration of field survey and remote sensing for biodiversity assessment: A case study in the tropical forests and wetlands of Sango Bay, Uganda. **Biological Conservation,** v. 86, n. 3, p. 379-391, 1998. https://doi.org/10.1016/S0006-3207(98)00005-6

FUNK, F. A.; PETER, G.; LOYDI, A. KRÖPFL., A. I.; DISTEL, R. A. Structural and functional recovery of intershrub spaces after 10-years of grazing exclusion in a semiarid steppe of northeastern Patagonia. **Ecologia Austral,** v. 22, n. 3, p. 195-202, 2012. https://doi.org/10.25260/EA.12.22.3.0.1226

GANG, C.; ZHOU, W.; CHEN, Y.; WANG, Z.; SUN, ZG.; LI, J.; QI, J.; ODEH, I. Quantitative assessment of the contributions of climate change and human activities on global grassland degradation. **Environmental Earth Sciences**, v. 72, n. 11, p. 4273-4282, 2014. https://doi.org/10.1007/s12665-014-3322-6

GAO, Q. Z.; WAN, Y. F.; XU, H. M.; LI, Y.; JIANGCUN, W. Z.; BORJIGIDAI, A. Alpine grassland degradation index and its response to recent climate variability in Northern Tibet, China. **Quaternary International**, v. 226, n. 1-2, p. 143-150, 2010. https://doi.org/10.1016/j.quaint.2009.10.035

GAO, Y.; GIESE, M.; BRUECK, H.; YANG, H.; LI, Z. The relation of biomass production with leaf traits varied under different land-use and precipitation conditions in an Inner Mongolia steppe. **Ecological Research**, v. 28, n. 6, p. 1029-1043, 2013. https://doi.org/10.1007/s11284-013-1086-1

HARRIS, R. B. Rangeland degradation on the Qinghai-Tibetan plateau: A review of the evidence of its magnitude and causes. **Journal of Arid Environments**, v. 74, n. 1, p. 1-12, 2010. https://doi.org/10.1016/j.jaridenv.2009.06.014

HOPPING, K. A.; YEH, E. T.; HARRIS, R. B. Linking people, pixels, and pastures: A multi-method, interdisciplinary investigation of how rangeland management affects vegetation on the Tibetan Plateau. **Applied Geography**, v. 94, p. 147-162, 2018/05/01/ 2018. https://doi.org/10.1016/j.apgeog.2018.03.013

JELTSCH, F.; MILTON, S. J., DEAN, W. R. J.; ROOYEN, N. V. Analysing shrub encroachment in the southern Kalahari: A grid-based modelling approach. **Journal of Applied Ecology,** v. 34, n. 6, p. 1497-1508, 1997. https://doi.org/10.2307/2405265

LI, J.; YANG, X.; JIN, Y.; YANG, Z.; HUANG, W.; ZHAO, L.; GAO, T.; YU, H.; MA, H. QIN, Z. XU, B. Monitoring and analysis of grassland desertification dynamics using Landsat images in Ningxia, China. **Remote Sensing of Environment,** v. 138, p. 19-26, 2013. https://doi.org/10.1016/j.rse.2013.07.010

LI, X. L.; GAO, J.; BRIERLEY, G.; QIAO, Y.M.; ZHANG, J.; YANG, Y.W. Rangeland degradation on the Qinghai-Tibet Plateau: Implications for rehabilitation. **Land Degradation and Development**, v. 24, n. 1, p. 72-80, 2013. https://doi.org/10.1002/ldr.1108

LI, X. Y.; Mãe, Y. J.; XU, J. H. WANG, J.H.; ZHANG, D. S. Impact of land use and land cover change on environmental degradation in lake Qinghai watershed, Northeast Qinghai-Tibet Plateau. **Land Degradation and Development**, v. 20, n. 1, p. 69-83, 2009. https://doi.org/10.1002/ldr.885

LIU, Y. Y.; EVANS, J. P.; MCCABE, M. F.; de Jeu, RAM; VAN DIJK, A. I. J. M.; DOLMAN, A. J.; SAIZEN, I. Changing Climate and Overgrazing Are Decimating Mongolian Steppes. **PLoS ONE,** v. 8, n. 2, 2013. https://doi.org/10.1371/journal.pone.0057599

LKHAGVADORJ, D.; HAUCK, M.; DULAMSUREN, C.; TSOGTBAATAR, J. Pastoral nomadism in the forest-steppe of the Mongolian Altai under a changing economy and a warming climate. **Journal of Arid Environments**, v. 88, p. 82-89, 2013. https://doi.org/10.1016/j.jaridenv.2012.07.019

MARTYN, J. Bibliographic coupling. **Journal of Documentation,** v. 20, n. 4, p. 236, 1964. https://doi.org/10.1108/eb026352

MCKEON, G. M.; STONE, G. S.; SYKTUS, J. I.; CARTER, J. O.; FLOOD, N. R.; AHRENS, D. G.; BRUGET, D. N.; CHILCOTT, C. R.; COBON, D. H.; COWLEY, R. A.; CRIMP, S. J.; FRASER, G. W.; HOWDEN, S. M.; JOHNSTON, P. W.; RYAN, J. G.; STOKES, C. J.; DIA, K. A. Climate change impacts on northern Australian rangeland livestock carrying capacity: A review of issues. **Rangeland Journal,** v. 31, n. 1, p. 1-29, 2009. https://doi.org/10.1071/RJ08068

MEYER, H.; LEHNERT, L. W.; WANG, Y.; REUDENBACH, C.; NAUSS, T.; BENDIX, J. From local spectral measurements to maps of vegetation cover and biomass on the Qinghai-Tibet-Plateau: Do we need hyperspectral information? **International Journal of Applied Earth Observation and Geoinformation,** v. 55, p. 21-31, 2017. https://doi.org/10.1016/j.jag.2016.10.001

MIEHE, S.; KLUGE, J.; VON WEHRDEN, H.; RETZER, V. Long-term degradation of Sahelian rangeland detected by 27 years of field study in Senegal. **Journal of Applied Ecology,** v. 47, n. 3, p. 692-700, 2010.

https://doi.org/10.1111/j.1365-2664.2010.01815.x

MU, S.; ZHOU, S.; CHEN, Y.; LI, J.; JU, W.; ODEH, I. O. A. Assessing the impact of restoration-induced land conversion and management alternatives on net primary productivity in Inner Mongolian grassland, China. **Global and Planetary Change,** v. 108, p. 29-41, 2013. https://doi.org/10.1016/j.gloplacha.2013.06.007

REED, M. S.; STRINGER, L. C.; DOUGILL, A. J.; PERKINS, J. S.; ATLHOPHENG, J. R.; MULALE, K.; FAVRETTO, N. Reorienting land degradation towards sustainable land management: Linking sustainable livelihoods with ecosystem services in rangeland systems. **Journal of Environmental Management,** v. 151, p. 472-485, 2015. https://doi.org/10.1016/j.jenvman.2014.11.010

REEVES, M. C.; BAGGETT, L. S. A remote sensing protocol for identifying rangelands with degraded productive capacity. **Ecological Indicators,** v. 43, p. 172-182, 2014. https://doi.org/10.1016/j.ecolind.2014.02.009

ROBERTS, R. J. A NEWLY RECOGNIZED FROM OF PASTURE DAMAGE BY PHAULACRIDIUM VITTATUM (ACRIDIDAE) ON THE NORTHERN TABLELANDS OF N.S.W. **Australian Journal of Entomology,** v. 11, n. 3, p. 257-258, 1972. https://doi.org/10.1111/j.1440-6055.1972.tb01626.x

SCHÖNBACH, P.; WAN, H.; GIERUS, M.; BAI, Y.; MÜLLER, K.; LIN, L.; SUSENBETH, A.; TAUBE, F. Grassland responses to grazing: Effects of grazing intensity and management system in an Inner Mongolian steppe ecosystem. **Plant and Soil,** v. 340, n. 1, p. 103-115, 2011. ISSN 0032079X (ISSN). https://doi.org/10.1007/s11104-010-0366-6

SOLOMON, T. B.; SNYMAN, H. A.; SMIT, G. N. Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia. **Journal of Environmental Management,** v. 82, n. 4, p. 481-494, 2007. https://doi.org/10.1016/j.jenvman.2006.01.008

SUN, F.; CHEN, W.; LIU, L.; LIU, W.; LU, C. SMITH, P. The density of active burrows of plateau pika in relation to biomass allocation in the alpine meadow ecosystems of the Tibetan Plateau. **Biochemical Systematics and Ecology**, v. 58, p. 257-264, 2015. https://doi.org/10.1016/j.bse.2014.12.016

TAO, S.; FANG, J.; ZHAO, X.; ZHAO, S.; SHEN, H.; HU, H.; TANG, Z.; WANG, Z.; GUO, Q.; TURNER, BL L. Rapid loss of lakes on the Mongolian Plateau. **Proceedings of the National Academy of Sciences of the United States of America,** v. 112, n. 7, p. 2281-2286, 2015. https://doi.org/10.1073/pnas.1411748112

VAN ECK, N. J.; WALTMAN, L. Software survey: VOSviewer, a computer program for bibliometric mapping. **Scientometrics**, v. 84, n. 2, p. 523-538, 2010. https://doi.org/10.1007/s11192-009-0146-3

WANG, J.; BROWN, D. G.; AGRAWAL, A. Climate adaptation, local institutions, and rural livelihoods: A comparative study of herder communities in Mongolia and Inner Mongolia, China. **Global Environmental Change**, v. 23, n. 6, p. 1673-1683, 2013. https://doi.org/10.1016/j.gloenvcha.2013.08.014

WASHINGTON-ALLEN, R. A.; WEST, N. E.; RAMSEY, R. D.; EFROYMSON, R. A. A protocol for retrospective remote sensing-based ecological monitoring of rangelands. **Rangeland Ecology and Management**, v. 59, n. 1, p. 19-29, 2006. https://doi.org/10.2111/04-116R2.1

WEN, L.; DONG, S. K. ZHU, L. LI, X. Y. SHI, J. J.; WANG, Y. L.; MA, Y. S. The construction of grassland degradation index for alpine meadow in Qinghai-Tibetan Plateau. International Conference on Ecological

Informatics and Ecosystem Conservation, ISEIS 2010, 2010, Beijing. p.1966-1969. https://doi.org/10.1016/j.proenv.2010.10.210

WU, Z.; WU, Z.; WU, J.; LIU, J.; ELE, B.; LEI, T.; WANG, Q. Increasing terrestrial vegetation activity of ecological restoration program in the Beijing-Tianjin Sand Source Region of China. **Ecological Engineering**, v. 52, p. 37-50, 2013. https://doi.org/10.1016/j.ecoleng.2012.12.040

XU, H. J.; WANG, X. P.; ZHANG, X. X. Alpine grasslands response to climatic factors and anthropogenic activities on the Tibetan Plateau from 2000 to 2012. **Ecological Engineering**, v. 92, p. 251-259, 2016.

https://doi.org/10.1016/j.ecoleng.2016.04.005

YAYNESHET, T.; EIK, L. O.; MOE, S. R. The effects of exclosures in restoring degraded semi-arid vegetation in communal grazing lands in northern Ethiopia. **Journal of Arid Environments**, v. 73, n. 4-5, p. 542-549, 2009. https://doi.org/10.1016/j.jaridenv.2008.12.002

YIN, F.; DENG, X.; JIN, Q.; YUAN, Y.; ZHAO, C. The impacts of climate change and human activities on grassland productivity in Qinghai Province, China. **Frontiers of Earth Science**, v. 8, n. 1, p. 93-103, 2014. https://doi.org/10.1007/s11707-013-0390-y

ZHAO, H. D.; LIU, S.; DONG, S.; SU, X.; WANG, X.; WU, X.; WU, L.; ZHANG, X. Analysis of vegetation change associated with human disturbance using MODIS data on the rangelands of the Qinghai-Tibet Plateau. **Rangeland Journal**, v. 37, n. 1, p. 77-87, 2015. https://doi.org/10.1071/RJ14061

ZHOU, W.; GANG, C. ZHOU, L. CHEN, Y.; LI, J.; JU, W.; ODEH, I. Dynamic of grassland vegetation degradation and its quantitative assessment in the northwest China. **Acta Oecologica-International Journal of Ecology,** v. 55, p. 86-96, Feb 2014. https://doi.org/10.1016/j.actao.2013.12.006

ZHOU, W.; YANG, H.; HUANG, L.; CHEN, C.; LIN, X.; HU, Z.; LI, J. Grassland degradation remote sensing monitoring and driving factors quantitative assessment in China from 1982 to 2010. **Ecological Indicators**, v. 83, p. 303-313, 2017. https://doi.org/10.1016/j.ecolind.2017.08.019

Recebido em: 27/02/2021
Aceito para publicação em: 22/09/2021