TREND IN LANDSCAPE ECOLOGY TOPIC RESEARCH BASED ON WEB OF SCIENCE: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

This studies highlighting the state of research and the dominant issues in Landscape Ecology. Based on Web of Science database and using the bibliometric analysis method, the 4,496 papers were analyzed in the field of Landscape Ecology topic research from 1976 to March 15, 2025. Most papers were written in in English (4,408, 98.043 %), were from 130 countries or regions, 3,651 organizations, and published in 824 journals and 12 book series. The top five journals are *Landscape Ecology* (434, 9.653 %), *Landscape and Urban Planning* (120, 2.669 %), *Ecological Applications* (90, 2.002 %), *Ecology* (86, 1.913 %), *Ecological Indicators* (84, 1.868 %), each journal published more than 84 papers. Top five countries are USA, Peoples R China, Canada, Australia, England, each published more than 304 papers. The top five organizations are United States Department of Agriculture USDA, United States Forest Service, University of California System, Chinese Academy of Sciences, Centre National De La Recherche Scientifique CNRS, each with more than 138 papers. With co-occurrence network visualization by VOSviewer, all keywords were separated into eight clusters topic research. By the all keywords occurrence during the different period, we can found the earlier and front research keywords and cluster. Based on ESI database, there are twenty-one top papers of all highly cited papers. The most papers are focused on the five Sustainable Development Goals of 15 Life On Land (3,486, 77.536 %), 13 Climate Action (2,897, 64.435 %), 14 Life Below Water (2,739, 60.921 %), 02 Zero Hunger (1,121, 24.933 %), 11 Sustainable Cities and Communities (982, 21.842 %). The results will help researchers clarify the research current situation, but also provide guidance for future research. This work is also useful for student identifying graduate schools and researchers selecting journals for publishing the most papers or top papers.

Keywords: Bibliometric analysis; Landscape Ecology; VOSviewer; Web of Science (WoS).

INTRODUCTION

Landscape ecology is sensitive to economic and social alterations caused by land use changes (Saedpanah & Souri, 2025). Landscape ecology is widely accepted as the study of the reciprocal interactions between spatial pattern and ecological processes across multiple scales. Landscape ecology is an interdisciplinary and inclusive field that shares many concepts with geography, plant and wildlife ecology, biogeography, geomorphology, and

hydrology. Remote sensing data are a fundamental information source for landscape ecology research (Villarreal *et al*., 2025). Landscape ecology exemplifies this pattern: initially proposed as a distinct field 85 years ago, it developed steadily in Europe for about 40 years before experiencing swift global expansion in the 1980 s. Today, landscape ecology is a well-established field of study worldwide (Wu *et al*., 2024). Landscape sustainabiliy (LS) has received widespread attention from both scientists and practitioners in recent decades. The Iberian Peninsula is a regional context where interconnections between the ecological and socio-cultural values of landscapes are especially tight and complex. In the Iberian Peninsula, the natural, cultural, and socio-political heterogeneities encountered across a long human and culturally valuable history have resulted in a rich and diverse set of landscapes (Gómez-Sal *et al*., 2024).

Bibliometrics is a common research methodology in the library and information sciences and focuses on quantitative analysis and statistics. Scholars use bibliometric analysis for revealing new trends and developments in the existing literature, analysing cooperation patterns and research composition, and exploring the knowledge structure of particular fields. Bibliometrics analysis technique has been adopted in Landscape Ecology topic research, such as, ecological footprint and urban development (Valderrama *et al*., 2024), landsenses ecology (Fan *et al*., 2024), landscape sustainability (Fang & Kong, 2024), Geographic Information System (GIS) for ecology (Alcaras *et al*., 2024), ecology and sustainable development of Guilin Lijiang River Basin (Dong *et al*., 2024), bibliometric analysis of *Journal of Plant Ecology* during 2017-2021 (Wang *et al*., 2022), landscape ecological concepts in planning (LEP) (Huang et al. 2022), plant ecology in Indian Siwalik range (Kumar *et al*., 2022), impacts of the European Landscape Convention on interdisciplinary and transdisciplinary research (Patru-Stupariu & Nita, 2022), evolution and emerging research trends in the ecological impacts of landscape change (Hernández *et al*., 2021), land consolidation and rehabilitation engineering in China (Wang *et al*., 2021), sustainable land use and management research (Xie *et al*., 2020b), evolutionary overview of urban expansion (Xie *et al*., 2020a), two concepts of sustainable landscapes and landscape sustainability (Zhou *et al*., 2019), Sun and Yuan have analyzed rice and climate change publications based on Web of Science (Yuan & Sun, 2022), top papers in Ecology category and Environmental Studies category based on Essential Science Indicators(Yuan & Sun, 2023a, 2023b).

The purpose of this paper was to use bibliometric methods to analyze the publications of “Landscape Ecology” topic research from 1976 to March 15, 2025, based on the Clarivate Analytics’s Web of Science (WoS) core database and utilized CiteSpace and VOSviewer software for its bibliometric analysis. Citation topics and sustainable development goals (SDGs) were also analyzed based on WoS results. Therefore, this paper will be mapping the research topics on “Landscape Ecology” and will contribute to the field by outlining the recent research trends, identifying general topics and subtopics, and thus guiding future researchers in choosing an attractive research direction.

MATERIALS AND METHODS

Web of Science

The publication counts were derived from the Clarivate Analytics's WoS core collection of databases: SCIE--1900-present, SSCI --2005-present.

Data collection

Data collection was completed on March 15, 2025. The keywords of "Landscape Ecology" were used in the topic, also keywords of "Urban Landscape Ecology", document types were Article or Review Article, with the following query: Topic ("Landscape Ecology") and Document Types (Article or Review).

Here, the 4,496 records were downloaded and saved as plain text and selecting the export format of "full records and cited references", and then imported into VOSviewer (version 1.6.20, 2024, Leiden University, Leiden, the Netherlands) for further citation analysis. The impact factors (IF 2023 and IF 5 year) were taken from the Journal Citation Report (JCR 2023) that was updated in June, 2024.

VOSviewer and CiteSpace

The VOSviewer (www.vosviewer.com) were used to show the international collaboration between the authors, organizations, countries and the research trends through all keywords. In this paper, default parameters values of the VOSviewer (version 1.6.20) are usually used in the analysis. CiteSpace (Basic version 6.3.R1) is a tool designed for conducting a visual analytic study of burst of keywords.

RESULTS AND DISCUSSION

Document types and languages of publications

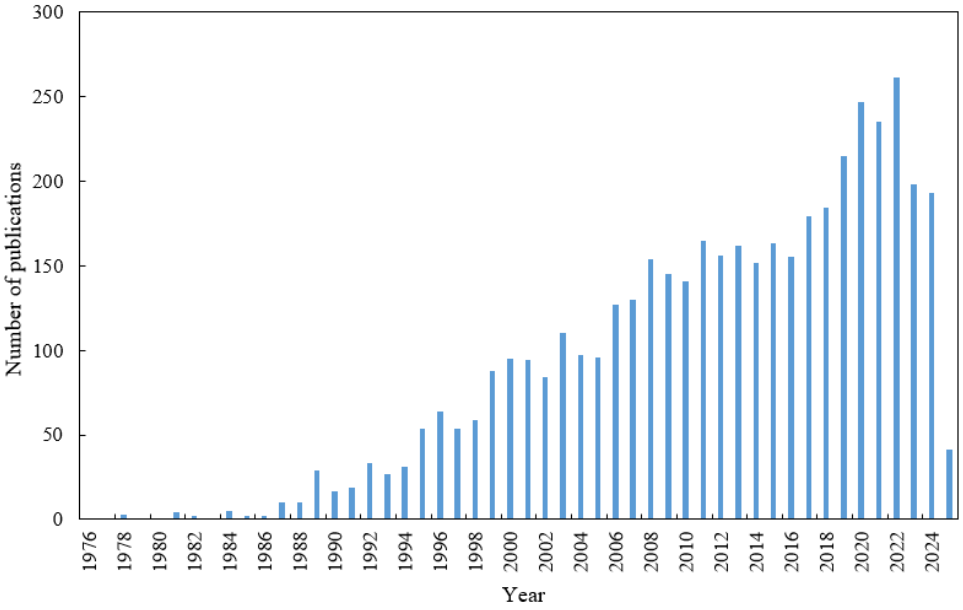
All of 4,496 papers were identified database in Web of Science Index of SCIE (4,284 papers, 95.285 % ratio of total papers), SSCI (857, 19.061 %). The document types were both articles (4,131, 91.882 %) and review articles (365, 8.118 %). The papers were almost published in English (4,408, 98.043 %), and other languages were Portuguese (28, 0.623 %), Spanish (22, 0.489 %), German (16, 0.356 %), French (13, 0.289 %).

Publication output

Figure 1 shows the publications trend of "Landscape Ecology" topic from 1976 to 2025. The highest publication value was 261 in 2022. There are 5, 66, 446, 1,132, 1,672, 1,175 papers during the period of 1976-1979, 1980-1989, 1990-1999, 2000-2009, 2010-2019, 2020-2025, respectively. These trends reflected the increasing attention devoted to this area during the past decade.

For the total papers, the h-index is 214, the total number of citations was 245,324 over the period and the average citation per item is 54.56. Based on WoS core database, the first paper on the "Landscape Ecology" topic titled of "Ecological boundaries between plant associations as an expression of an hierarchical order of landscape-factors for an optimal documentation of landscape-ecology, shown at Central-European room" written by Radke (1976) in Berichte Der Deutschen Botanischen Gesellschaft (89 (2-3), 401-413).

Fig. 1: Trends in the quantity of landscape-ecology topic papers from 1976 to March 15, 2025



Web of Science categories and research areas

For the total papers of landscape-ecology topic research from 1976 to 2025, they are belong to 118 WoS subject categories and 84 research areas. Based on the WoS categories, Table 1 shows the top 20 WoS categories and research areas for landscape-ecology topics research from 1976 to March 15, 2025. The top five categories included Ecology (2,239, 49.8 %), Environmental Sciences (1,139, 25.334 %), Geography Physical (729, 16.214 %), Geosciences Multidisciplinary (628, 13.968 %), Biodiversity Conservation (539, 11.988 %). The top five research areas included Environmental Sciences Ecology (3,100, 68.95 %), Physical Geography (729, 16.214 %), Geology (630, 14.012 %), Biodiversity Conservation (539, 11.988 %), Forestry (273, 6.072 %). In WoS publications are mapped to WoS categories which are more detailed than research areas.

Table 1: The top 20 WoS categories and research areas for landscape-ecology topics research from 1976 to March 15, 2025

Rank	WoS categories			Research areas		
	Categories	No. papers	% Total papers	Areas	No. papers	% Total papers
1	Ecology	2,239	49.8	Environmental Sciences Ecology	3,100	68.95
2	Environmental Sciences	1,139	25.334	Physical Geography	729	16.214
3	Geography Physical	729	16.214	Geology	630	14.012
4	Geosciences Multidisciplinary	628	13.968	Biodiversity Conservation	539	11.988
5	Biodiversity Conservation	539	11.988	Forestry	273	6.072

6	Environmental Studies	402	8.941	Science Technology Other Topics	235	5.227
7	Forestry	273	6.072	Geography	224	4.982
8	Geography	224	4.982	Plant Sciences	210	4.671
9	Plant Sciences	210	4.671	Marine Freshwater Biology	202	4.493
10	Marine Freshwater Biology	187	4.159	Zoology	182	4.048
11	Urban Studies	175	3.892	Agriculture	181	4.026
12	Entomology	152	3.381	Urban Studies	175	3.892
13	Regional Urban Planning	148	3.292	Entomology	152	3.381
14	Zoology	148	3.292	Public Administration	149	3.314
15	Water Resources	136	3.025	Water Resources	136	3.025
16	Green Sustainable Science Technology	127	2.825	Remote Sensing	124	2.758
17	Remote Sensing	124	2.758	Engineering	109	2.424
18	Multidisciplinary Sciences	108	2.402	Evolutionary Biology	107	2.38
19	Evolutionary Biology	107	2.38	Imaging Science Photographic Technology	89	1.98
20	Agriculture Multidisciplinary	94	2.091	Life Sciences Biomedicine Other Topics	82	1.824

Core journals

All the 4,496 publications were published in 824 journals and 12 book series. The top 25 core journals were displayed in the Table 2 with total articles each more than 30 papers, and also showed the Journal impact factor as IF 2023 and IF 5 year, Quartile in Category (QC) and Quartile rank (QR) among the total 197 journals in Ecology category from Journal Citation Reports ™ 2023. As to one journal belongs to different WoS category, and the Quartile in category was selected the highest one.

The top 5 journals, top 10 journals, top 15 journals, 20 journals and top 25 journals published about 18.1 %, 25.73 %, 31.41 %, 35.05 % and 38.46 % of the total 4,496 papers, respectively. The top five journals are Landscape Ecology (434, 9.653 %), Landscape and Urban Planning (120, 2.669 %), Ecological Applications (90, 2.002 %), Ecology (86, 1.913 %), Ecological Indicators (84, 1.868 %), each journal published more than 84 papers. Among the top 25 journals in Table 2, fifteen journals were in Quartile 1, seven journals were in Quartile 2, two journals were in Quartile 3, and one journal have no IF in 2023 for Ekologia Bratislava.

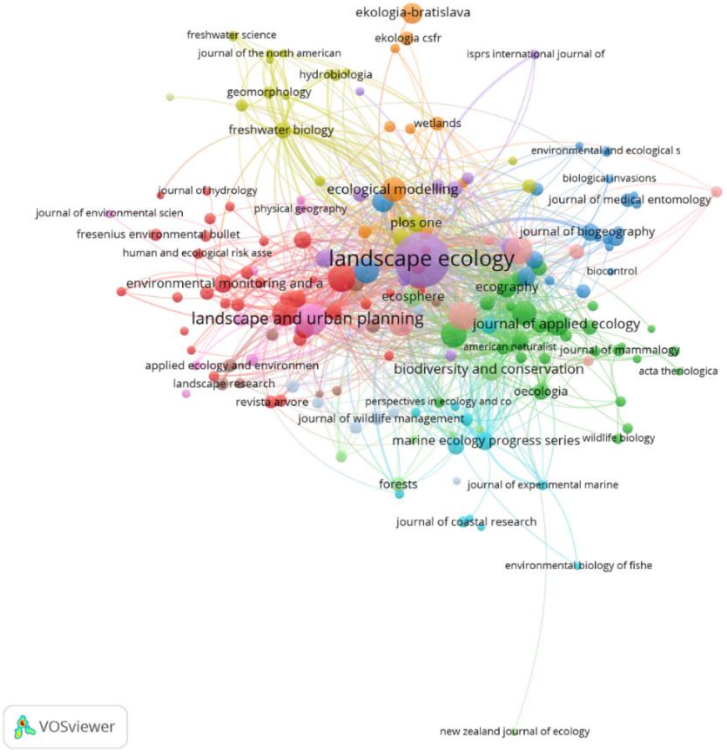
Table 2: The top 25 core Journals on landscape-ecology topic research indexed in the WoS

Rank	Journal	TP	Ratio (%)	IF 2023	IF 5 year	QC	QR
1	*Landscape Ecology*	434	9.653	4	4.9	Q1	38
2	*Landscape and Urban Planning*	120	2.669	7.9	8.7	Q1	7
3	*Ecological Applications*	90	2.002	4.3	5.1	Q1	33
4	*Ecology*	86	1.913	4.4	5.5	Q1	32
5	*Ecological Indicators*	84	1.868	7	6.6	Q1	
6	*Sustainability*	75	1.668	3.3	3.6	Q2	
7	*Biological Conservation*	73	1.624	4.9	6	Q1	25
8	*Land*	68	1.512	3.2	3.4	Q2	
9	*Forest Ecology and Management*	65	1.446	3.7	3.9	Q1	
10	*Ecological Modelling*	62	1.379	2.6	2.9	Q2	73
11	*Agriculture Ecosystems Environment*	60	1.335	6	6.4	Q1	15
12	*Journal of Applied Ecology*	55	1.223	5	6.2	Q1	24
13	*Biodiversity and Conservation*	51	1.134	3	3.5	Q2	60
14	*Environmental Management*	47	1.045	2.7	3.5	Q3	
15	*Ekologia Bratislava*	42	0.934				
16	*Ecosphere*	35	0.778	2.7	3.2	Q2	69
17	*Ecography*	34	0.756	5.4	6.4	Q1	19
18	*Science of the Total Environment*	33	0.734	8.2	8.6	Q1	
19	*Ecology and Evolution*	31	0.69	2.3	2.9	Q2	88
20	*Environmental Monitoring and Assessment*	31	0.69	2.9	3.1	Q3	
21	*Journal of Ecology*	31	0.69	5.4	6.1	Q1	19
22	*Marine Ecology Progress Series*	31	0.69	2.2	2.5	Q2	92
23	*Remote Sensing*	31	0.69	4.2	4.9	Q1	
24	*Journal of Environmental Management*	30	0.667	8	7.9	Q1	
25	*Plos One*	30	0.667	2.9	3.3	Q1	

Note: TP: Total publications; Ratio: Ratio of 4,496 (%); IF 2023: journal impact factor in 2023; IF5 year: journal impact factor of 5 years; QC: Quartile in Category; QR: Quartile rank of 197 journals in Ecology category from Journal Citation Reports ™ 2023.

For the publication data in the citation of 824 journals analysed by VOSviewer, there were 181 journals met the thresholds of 5, and 180 journals were connected to each other. The network map of citation for 180 journals were shown thirteen clusters with different colours in Figure 2, which they were centred as *Ecological Indicators, Biological Conservation, Land, Plos One, Landscape Ecology, Marine Ecology Progress Series, Ecological Modelling, International Journal of Remote Sensing, Landscape and Urban Planning, Ecological Applications, Biodiversity and Conservation, Journal of Wildlife Management, European Journal of Remote Sensing.*

Fig. 2: Network visualization maps of journals for landscape-ecology topic research based on WoS with 180 circles and 13 clusters



Countries/regions co-authorship analysis

There were 130 countries or regions that contributed 4,496 papers from 1976 to 2025, and 66 countries or regions met the requirement threshold as five. Table 3 list the top 20 countries or regions that published more than 59 papers. The top five countries or regions were USA, Peoples R China, Canada, Australia, England. From the average citations, the top five countries were Netherlands, Finland, Switzerland, Japan, USA, which their citations are more than 79.9 times per paper.

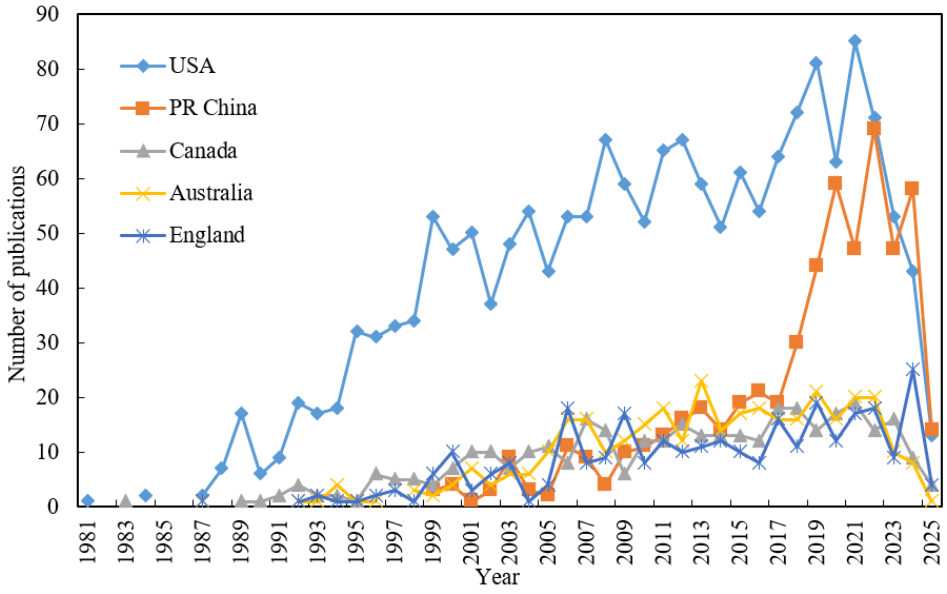
Table 3: Top 20 countries/regions publishing papers on landscape-ecology topic research during period from 1976 to 2025

Rank	Countries/Regions	Records count	% of 4,496	Average citations
1	USA	1746	38.835	79.9
2	Peoples R China	558	12.411	27.7
3	Canada	352	7.829	50.3
4	Australia	350	7.785	46.0
5	England	304	6.762	65.2
6	Brazil	284	6.317	35.2
7	France	276	6.139	58.3
8	Germany	219	4.871	57.3
9	Italy	179	3.981	44.6
10	Spain	161	3.581	46.2
11	Netherlands	127	2.825	90.1

12	Sweden	118	2.625	55.0
13	Switzerland	91	2.024	83.3
14	Belgium	90	2.002	65.7
15	South Africa	87	1.935	27.3
16	New Zealand	73	1.624	63.8
17	Finland	62	1.379	85.7
18	Mexico	62	1.379	27.5
19	Scotland	62	1.379	50.1
20	Japan	59	1.312	81.3

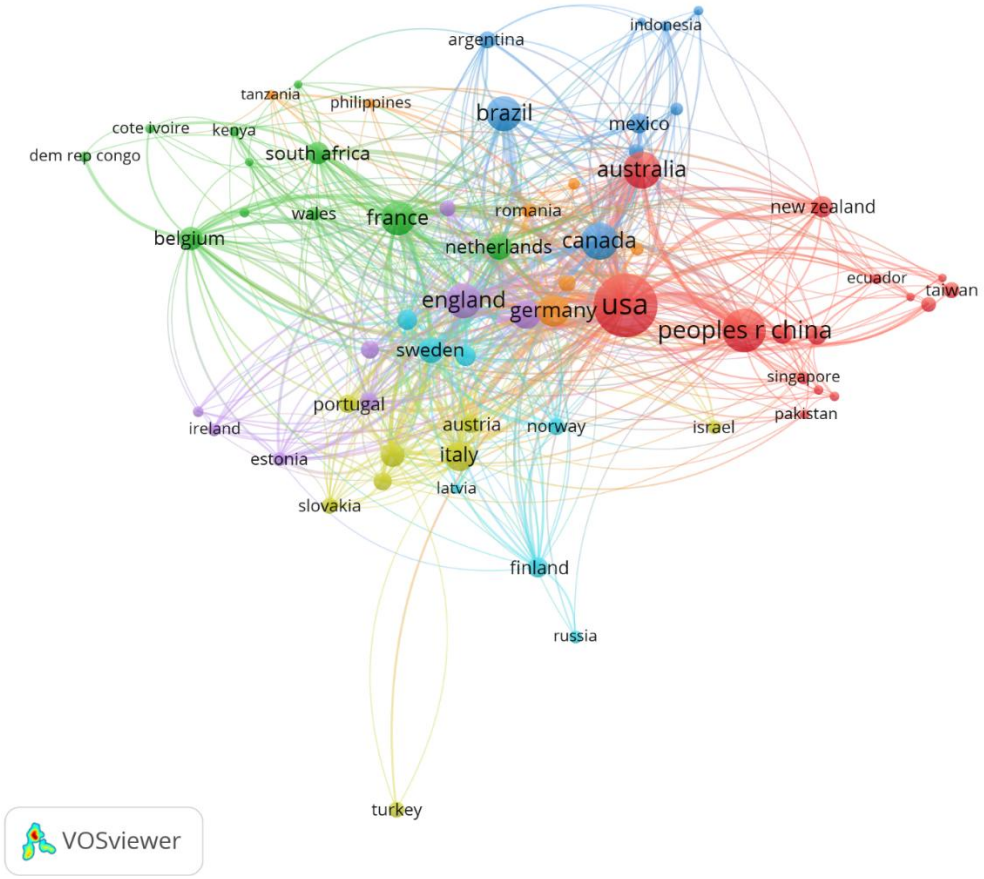
Figure 3 shows the publications trends for five countries studied on landscape-ecology topic research based on WoS from 1976 to 2025. Based on the publications, USA is the first country on this topic, PR China is the second country and published paper increased quickly from 2017.

Fig. 3: Trends of publications for top five countries studied on landscape-ecology topic research based on WoS



The VOSviewer divided these 66 circles into seven clusters in Figure 4. The first cluster consisted of fifteen countries or regions (red) centred as USA, PR China, et al. The second cluster including eleven countries or regions (green) centred as France, Netherlands, et al. The third cluster consisted of nine countries (blue) and centred as Canada, Brazil, et al. The fourth cluster (yellow) including nine countries or regions centred as Italy, Switzerland, et al. The fifth cluster (violet) consisted of eight countries or regions and centred as England, Spain, et al. The sixth cluster (light blue) including seven countries or regions centred as Sweden, Finland, et al. The seventh cluster (orange) consisted of seven countries or regions including Germany, Iran, et al.

Fig. 4: The country co-authorship network of landscape-ecology topic research from 1976 to 2025 with 66 nodes and 7 clusters



Organizations (author affiliation) co-authorship analysis

A total of 3,651 organizations had 4,496 papers based on WoS. Table 4 represented the top 20 organizations and institutions ranked by the number of total publications (more than 62 papers). These top 20 organizations were mainly in USA (15 organizations), France (3 organizations), China (1 organization), Brazil (1 organization). Furthermore, the top five organizations were United States Department of Agriculture USDA, United States Forest Service, University of California System, Chinese Academy of Sciences, Centre National De La Recherche Scientifique CNRS, each with more than 138 papers.

Table 4: Top twenty organizations published papers on landscape-ecology topic research based on WoS

Rank	Organizations	Records	% 4,496	Country
1	United States Department of Agriculture USDA	241	5.36	USA
2	United States Forest Service	186	4.137	USA
3	University of California System	158	3.514	USA
4	Chinese Academy of Sciences	157	3.492	China
5	Centre National De La Recherche Scientifique CNRS	138	3.069	France
6	United States Department of the Interior	135	3.003	USA
7	INRAE	115	2.558	France
8	United States Geological Survey	111	2.469	USA
9	University of Wisconsin System	106	2.358	USA
10	University of Wisconsin Madison	95	2.113	USA
11	State University System of Florida	90	2.002	USA
12	University System of Ohio	72	1.601	USA
13	Institut De Recherche Pour Le Developpement IRD	69	1.535	France
14	Colorado State University Fort Collins	66	1.468	USA
15	Colorado State University System	66	1.468	USA
16	University of Washington	66	1.468	USA
17	University of Washington Seattle	66	1.468	USA
18	Arizona State University	65	1.446	USA
19	Universidade De Sao Paulo	65	1.446	Brazil
20	Arizona State University Tempe	62	1.379	USA

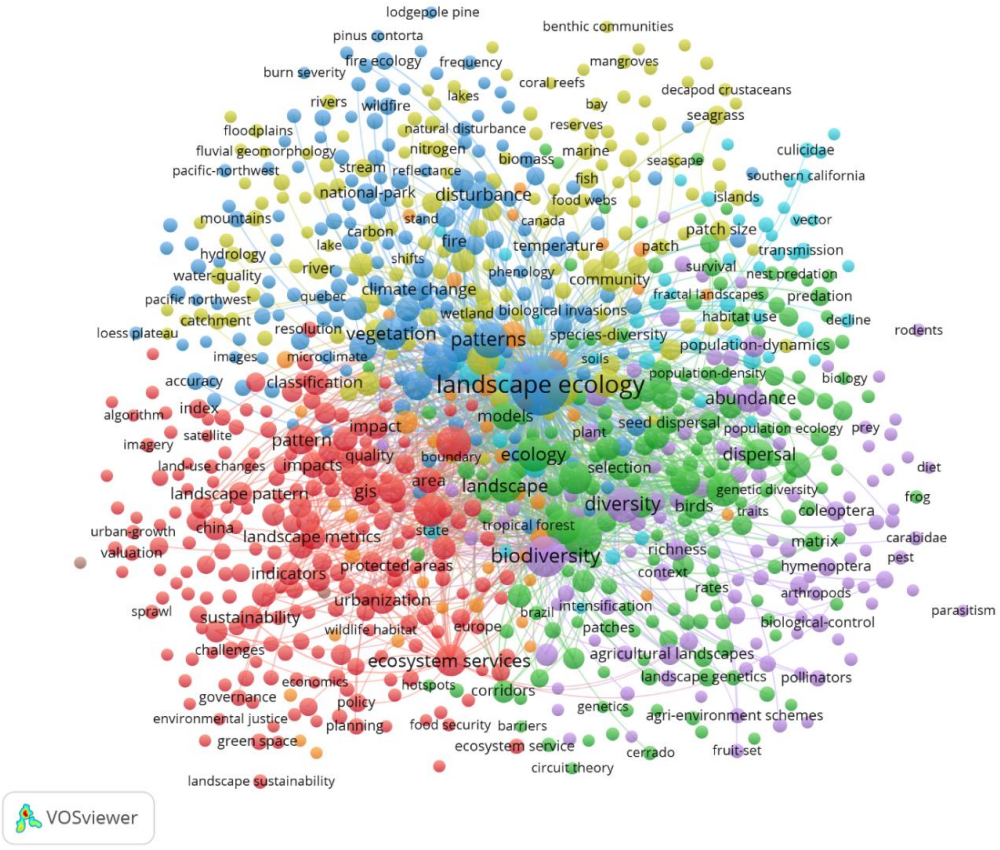
All keywords co-occurrence analysis

By the co-occurrence, author keywords, keywords plus and all keywords as unit were chosen and analysed. For the author keywords by full counting method for co-occurrence analysis, there were total 11,516 author keywords, and 644 author keywords met the five threshold level and were separated into thirteen clusters. The top twenty-one co-occurrence author keywords were landscape ecology, biodiversity, remote sensing, fragmentation, conservation, GIS, habitat fragmentation, connectivity, landscape metrics, ecosystem services, land use, scale, landscape, climate change, dispersal, landscape pattern, disturbance, landscape planning, spatial heterogeneity, urbanization, forest fragmentation, each author keywords occurred more than 50 times.

For the keywords plus, there were total 8,329 keywords, and 936 keywords plus met the five threshold level and were separated into twelve clusters. The top twenty co-occurrence keywords plus were landscape ecology, conservation, biodiversity, patterns, dynamics, diversity, ecology, management, land-use, vegetation, landscape, fragmentation, habitat fragmentation, habitat, scale, forest, climate-change, connectivity, ecosystem services, pattern, each keywords plus occurred more than 196 times.

For the all keywords, there were total 17,792 all keywords, and 902 all keywords met the threshold level of eight and were separated into eight main clusters (Figure 5). The top twenty-two co-occurrence all keywords were landscape ecology, biodiversity, conservation, patterns, diversity, dynamics, ecology, fragmentation, management, habitat fragmentation, landscape, scale, connectivity, land-use, vegetation, ecosystem services, habitat, forest, dispersal, species richness, climate-change, pattern, each all keywords occurred more than 201 times. And the eight research topic were land-use management and ecosystem services, habitat fragmentation and ecology conservation, landscape ecology patterns and dynamics, habitat scale and communities restoration, biodiversity diversity and agricultural landscapes, epidemiology evolution and spatial analysis in United-States, ecosystem heterogeneity, lessons in Norway.

Fig. 5: VOSviewer co-occurrence network visualization mapping of all keywords (minimum of eight occurrences) for landscape ecology topic research till to March 15, 2025

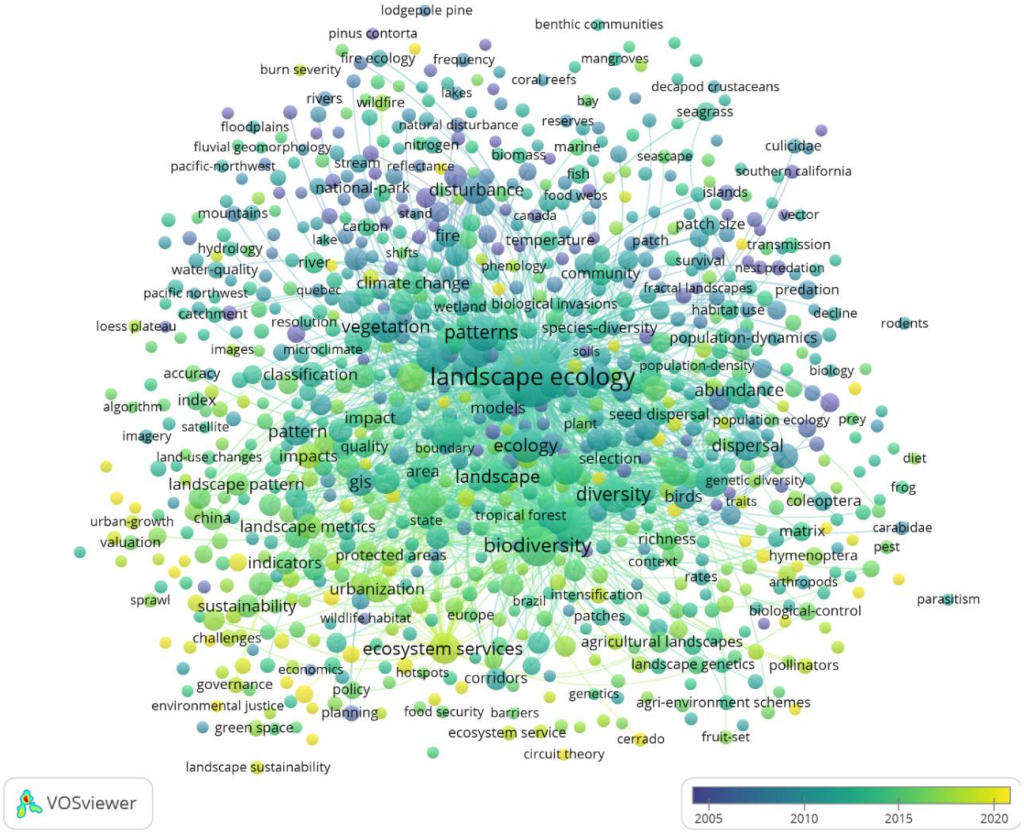


The same data in Figure 5 were then arranged as overlay map for most frequent all keywords in Figure 6. By the all keywords occurrence during the different period, we can found the earlier and front research keywords and cluster. Blue colors indicated earlier research topics, whereas, yellow and green colors indicated more recent topics of interest. Yellow and green circles present those research fronts.

Visualizations conducted on large datasets (big data) offer exploratory information on the current state in a scientific field or discipline as well as indicate possible developments in the future. Here, for total 902 all keywords, about twenty keywords were list and ranked in each cluster based on Figure 5.

The first cluster (red in Figure 5) has 204 all keywords and focused on land-use management and ecosystem services, and top 21 most frequently used keywords as management, land-use, ecosystem services, pattern, GIS, urbanization, model, landscape metrics, area, classification, impacts, framework, impact, land use, landscape pattern, indicators, deforestation, systems, sustainability, cover, science, each all keywords occurred more than 85 times.

Fig. 6: VOSviewer co-occurrence overlay visualization mapping of all keywords for landscape ecology topic research till to March, 2025



The second cluster (green in Figure 5) has 172 all keywords and represents the habitat fragmentation and ecology conservation, and top 21 most frequently used keywords as conservation, ecology, fragmentation, habitat fragmentation, landscape, connectivity, dispersal, species richness, models, forest fragmentation, responses, populations, birds, population, biodiversity conservation, size, landscape connectivity, corridors, extinction, selection, landscape structure, each all keywords occurred more than 70 times. This cluster was the recent research topics.

The third cluster (blue in Figure 5) has 162 all keywords and is focused on the landscape ecology patterns and dynamics, and 21 most frequently used keywords as landscape ecology, patterns, dynamics, vegetation, forest, climate-change, disturbance, remote sensing, climate, climate change, fire, succession, forests, history, national-park, temperature, variability, rain-forest, spatial-patterns, plants, ecosystem management, each keywords occurred more than 41 times.

The fourth cluster (yellow in Figure 5) has 154 all keywords and represents the habitat scale and communities restoration, and 23 most frequently used keywords as scale, habitat, communities, restoration, growth, ecosystems, spatial heterogeneity, community, assemblages, river, spatial scale, water, patch size, species-diversity, community structure,

spatial pattern, wetlands, habitats, patch dynamics, fish, seagrass, carbon, thresholds, each keywords occurred more than 40 times.

The fifth cluster (violet in Figure 5) has 112 all keywords and is focused on the biodiversity diversity and agricultural landscapes, and 22 most frequently used keywords as biodiversity, diversity, abundance, agriculture, population-dynamics, richness, landscapes, agricultural landscapes, biogeography, coleopteran, competition, plant, biological-control, hymenoptera, spatial ecology, agricultural intensification, pollination, intensification, natural enemies, landscape heterogeneity, agroecology, context, each keywords occurred more than 28 times.

The sixth cluster (light blue in Figure 5) has 53 all keywords and is focused on the epidemiology evolution and spatial analysis in United-States, and 21 most frequently used keywords as evolution, United-States, spatial analysis, epidemiology, state, geographic information systems, spatial-distribution, transmission, risk, disease, white-tailed deer, satellite imagery, bird communities, habitat suitability, logistic regression, culicidae, diptera, invasion, wildlife, geographic information system, lyme-disease, each keywords occurred more than 18 times.

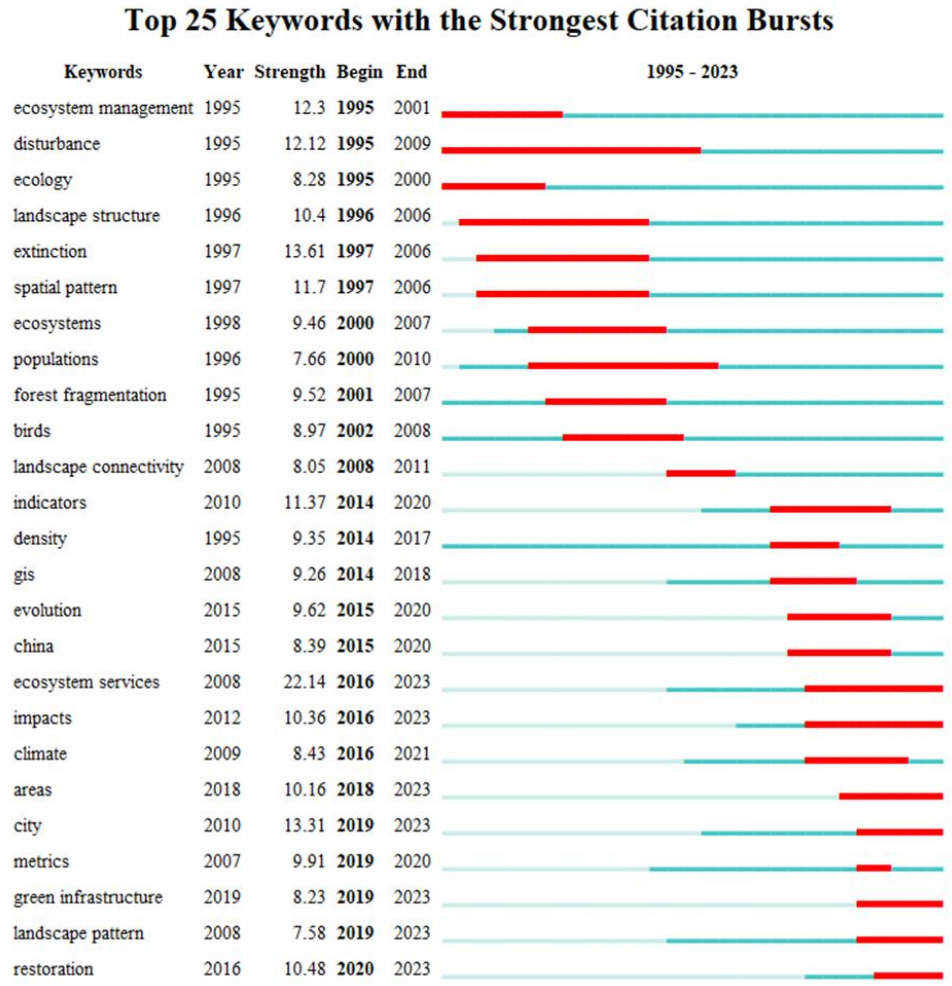
The seventh cluster (orange in Figure 5) has 43 all keywords and is focused on the ecosystem heterogeneity, and 22 most frequently used keywords are heterogeneity, ecosystem, consequences, complexity, distributions, landscape patterns, information, landscape configuration, plant-species richness, edge effect, scaling, macroecology, organization, multiple scales, time, emergence, abandonment, boundaries, entropy, global patterns, methodology, shape, each keywords occurred more than 12 times.

The eighth cluster (pink in Figure 5) has two keywords both lessons and Norway.

Burst of keywords

A keyword with strong emergence can reflect a new perspective with a high impact in a certain period of time, thus showing a phase of academic frontier. The word frequency exploration was performed in CiteSpace (Basic version 6.3.R1), and the top 25 keywords related to landscape ecology topic research based on WoS from 1995 to 2023 were used (Figure 7). The keywords are sorted by the beginning years of bursts. The period during which these keywords are more popular among scholars is depicted in red. The emerging trends in landscape ecology topic research based on WoS can be identified by analyzing the burst duration of different keywords. Top 25 keywords with the strongest citation bursts were ecosystem management, disturbance, ecology, landscape structure, extinction, spatial pattern, ecosystems, populations, forest fragmentation, birds, landscape connectivity, indicators, density, GIS, evolution, China, ecosystem services, impacts, climate, areas, city, metrics, green infrastructure, landscape pattern, restoration.

Fig. 7: Information about top 25 keywords of landscape ecology topic research based on WoS with the strongest citation bursts from 1995 to 2023 by CiteSpace (6.3.R1).
Begin, year when the burst begins; End, year when the burst ends. Red grids indicate the years when a particular term started to be frequently used. A longer the red bar, the keywords has been cited for a longer duration



Top papers based on Essential Science Indicators (ESI)

Top papers are the sum of hot papers and highly cited papers, based on Clarivate Analytics' Essential Science Indicators (ESI). Here, the ESI database has been updated as March 13, 2025, data covers over a 11-year period: January, 2014 – December, 2024. Based on ESI database, there are twenty-one top papers of all highly cited papers. Table 5 show the all top papers ranked by total citations. The total citations for each paper were 667, 654, 520, 450, 447, 300, 270, 235, 225, 199, 178, 169, 167, 152, 122, 118, 86, 74, 49, 27, 19, and the average citations per year were 95.3, 54.5, 43.3, 50.0, 49.7, 27.3, 54.0, 21.4, 45.0, 22.1, 16.2, 18.8, 23.9, 16.9, 20.3, 29.5, 21.5, 18.5, 12.3, 9.0, 9.5, respectively. These top papers were published in year of 2014 (2 papers), 2015(3), 2017 (5), 2019 (2), 2020 (1), 2021(2), 2022

(4), 2023 (1), 2024(1), respectively. The published source titles were *Landscape and Urban Planning* (2014, 2017, 2022, 2023), *Journal of Cleaner Production* (2019, 2021), *Land Use Policy* (2015, 2022), and each other paper published in *Agriculture Ecosystems & Environment* (2014), *Agronomy for Sustainable Development* (2015), *Annual Review of Entomology* (2022), *Biological Reviews* (2017), *Bioscience* (2017), *Cities* (2020), *Earth Surface Processes and Landforms* (2015), *Ecography* (2019), *Ecological Indicators* (2022), *Ecology Letters* (2024), *European Journal of Remote Sensing* (2017), *New Phytologist* (2017), *Science of the Total Environment* (2021), respectively.

Table 5: **Twenty-one top papers of landscape ecology topic research based on ESI till to March 15, 2025**

Rank	Top Papers	Total citations	Average per year
1	Hesselbarth, M.H.K., Sciaini, M., With, K.A., Wiegand, K., Nowosad, J. (2019). *Landscapemetrics*: an open-source *R* tool to calculate landscape metrics. *Ecography,* 42(10), 1648-1657.	667	95.3
2	Wu, J.G. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning,* 125, 209-221.	654	54.5
3	Lemaire, G., Franzluebbers, A., Carvalho, P.C.D., Dedieu, B. (2014). Integrated crop-livestock systems: Strategies to achieve synergy between agricultural production and environmental quality. *Agriculture Ecosystems & Environment,* 190, 4-8.	520	43.3
4	Lepczyk, C.A., Aronson, M.F.J., Evans, K.L., Goddard, M.A., Lerman, S.B., Macivor, J.S. (2017). Biodiversity in the City: fundamental questions for understanding the ecology of urban green spaces for biodiversity conservation. *Bioscience,* 67(9), 799-807.	450	50.0
5	Arroyo-Rodriguez, V., Melo, F.P.L., Martinez-Ramos, M., Bongers, F., Chazdon, R.L., Meave, J.A., Norden, N., Santos, B.A., Leal, I.R., Tabarelli, M. (2017). Multiple successional pathways in human-modified tropical landscapes: new insights from forest succession, forest fragmentation and landscape ecology research. *Biological Reviews,* 92(1), 326-340	447	49.7
6	Woodget, A.S., Carbonneau, P.E., Visser, F., Maddock, I.P. (2015). Quantifying submerged fluvial topography using hyperspatial resolution UAS imagery and structure from motion photogrammetry. *Earth Surface Processes and Landforms,* 40(1), 47-64.	300	27.3
7	Dai, L., Liu, Y.B., Luo, X.Y. (2021). Integrating the MCR and DOI models to construct an ecological security network for the urban agglomeration around Poyang Lake, China. *Science of the Total Environment,* 754, 141868.	270	54.0
8	Duru, M., Therond, O., Martin, G., Martin-Clouaire, R., Magne, M.A., Justes, E., Journet, E.P., Aubertot, J.N., Savary, S., Bergez, J.E., Sarthou, J. (2015). How to implement biodiversity-based agriculture to enhance ecosystem services: a review. *Agronomy for Sustainable Development,* 35(4), 1259-1281.	235	21.4
9	Xu, W.X., Wang, J.M., Zhang, M., Li, S.J. (2021). Construction of landscape ecological network based on landscape ecological risk assessment in a large-scale opencast coal mine area. *Journal of Cleaner Production,* 286, 125523.	225	45.0
10	Vogt, P., Riitters, K. (2017). GuidosToolbox: universal digital image object analysis. *European Journal of Remote Sensing,* 50(1), 352-361.	199	22.1

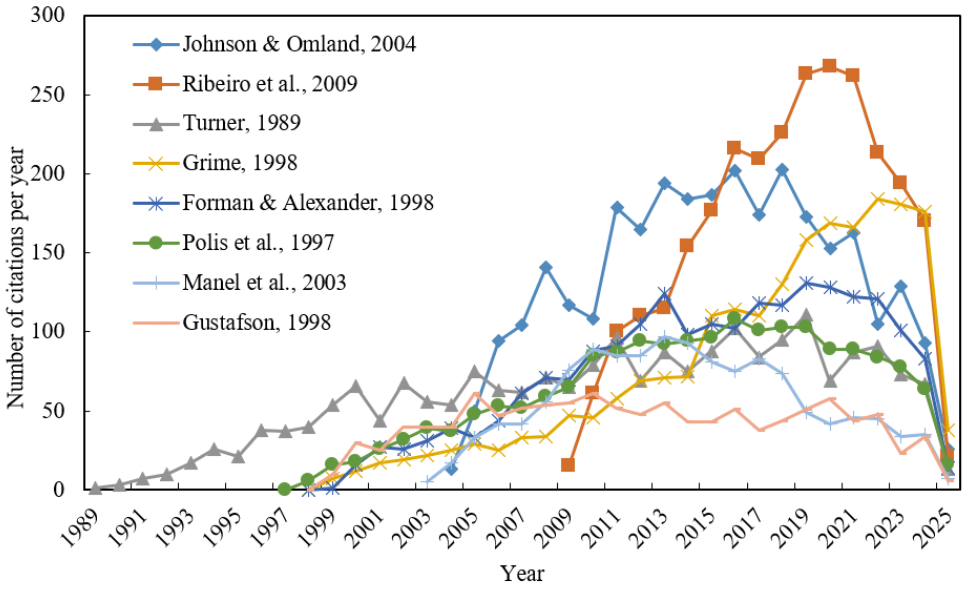
11	Tian, L. (2015). Land use dynamics driven by rural industrialization and land finance in the pen-urban areas of China: The examples of Jiangyin and Shunde. *Land Use Policy,* 45, 117-127.	178	16.2
12	Chiang, Y.C., Li, D.Y., Jane, H.A. (2017). Wild or tended nature? The effects of landscape location and vegetation density on physiological and psychological responses. *Landscape and Urban Planning,* 167, 72-83.	169	18.8
13	Wang, Y., Pan, J.H. (2019). Building ecological security patterns based on ecosystem services value reconstruction in an arid inland basin: A case study in Ganzhou District, NW China. *Journal of Cleaner Production,* 241, 118337.	167	23.9
14	Aartsma, Y., Bianchi, F.J.J.A., van der Werf, W., Poelman, E.H., Dicke, M. (2017). Herbivore-induced plant volatiles and tritrophic interactions across spatial scales. *New Phytologist,* 216(4), 1054-1063.	152	16.9
15	Feng, X.H., Xiu, C.L., Bai, L.M., Zhong, Y.X., Wei, Y. (2020). Comprehensive evaluation of urban resilience based on the perspective of landscape pattern: A case study of Shenyang city. *Cities,* 104, 102722.	122	20.3
16	Hu, J.Y., Zhang, J.X., Li, Y.Q. (2022). Exploring the spatial and temporal driving mechanisms of landscape patterns on habitat quality in a city undergoing rapid urbanization based on GTWR and MGWR: The case of Nanjing, China. *Ecological Indicators,* 143, 109333.	118	29.5
17	Ha, J., Kim, H.J., With, K.A. (2022). Urban green space alone is not enough: A landscape analysis linking the spatial distribution of urban green space to mental health in the city of Chicago. *Landscape and Urban Planning,* 218, 104309.	86	21.5
18	Campbell, J.F., Athanassiou, C.G., Hagstrum, D.W., Zhu, K.Y. (2022). *Tribolium castaneum*: a model insect for fundamental and applied research. *Annual Review of Entomology,* 67, 347-365.	74	18.5
19	Kubacka, M., Zywica, P., Subiros, J.V., Brodka, S., Macias, A. (2022). How do the surrounding areas of national parks work in the context of landscape fragmentation? A case study of 159 protected areas selected in 11 EU countries. *Land Use Policy,* 113, 105910.	49	12.3
20	Guan, J.X., Wang, R.Z., Van Berkel, D., Liang, Z.Y. (2023). How spatial patterns affect urban green space equity at different equity levels: A Bayesian quantile regression approach. *Landscape and Urban Planning,* 233, 104709.	27	9.0
21	Priyadarshana, T.S., Martin, E.A., Sirami, C., Woodcock, B.A., Goodale, E., Martinez-Nunez, C., Lee, M.B., Pagani-Nunez, E., Raderschall, C.A., Brotons, L., Rege, A., Ouin, A., Tscharntke, T., Slade, E.M. (2024). Crop and landscape heterogeneity increase biodiversity in agricultural landscapes: A global review and meta-analysis. *Ecology Letters,* 27(3), e14412.	19	9.5

The most frequently cited articles

The annual citations of the eight most cited papers showed an increasing trend after year of publication (Figure 8). Here, the total citations for the eight most frequently cited articles were more than 1153 times. The eight papers were Johnson & Omland (2004) Model selection in ecology and evolution. Trends in Ecology & Evolution, 19(2), 101-108; Ribeiro *et al*. (2009) The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation, 142(6), 1141-1153; Turner (1989) Landscape ecology-the effect of pattern on process. *Annual*

Review of Ecology and Systematics, 20, 171-197; Grime (1998) Benefits of plant diversity to ecosystems: immediate, filter and founder effects. *Journal of Ecology,* 86(6), 902-910; Forman & Alexander (1998) Roads and their major ecological effects. *Annual Review of Ecology and Systematics,* 29, 207-231; Polis *et al*. (1997) Toward an integration of landscape and food web ecology: The dynamics of spatially subsidized food webs. *Annual Review of Ecology and Systematics,* 28, 289-316; Manel *et al*. (2003) Landscape genetics: combining landscape ecology and population genetics. *Trends in Ecology & Evolution,* 18(4),189-197; Gustafson (1998) Quantifying landscape spatial pattern: What is the state of the art? *Ecosystems,* 1(2), 143-156. Total citations of eight most cited papers were 2957, 2774, 2164, 2124, 2070, 1834, 1292 and 1153 times. From the publication year to March 15, 2025, the average citation per year of the eight most citation papers were 134.41, 163.18, 58.49, 75.86, 73.93, 63.24, 56.17 and 41.18 times. Among eight articles, the highest average citation per year (163.18) was article of Ribeiro *et al*. (2009) published in Biological Conservation (Figure 8).

Fig. 8: Comparison of the eight most cited papers from their initial publications to arch 15, 2025



Citation topics Meso and Micro

This is a three-level hierarchical document-level classification system, which are Macro-topics (10), Meso-topics (326) and Micro-topics (2488). Based on the analysis results, there are 107 levels of Meso-topics and 264 levels of Micro-topics for landscape ecology topic research. Table 6 show the top 10 Meso-topics and Micro-topics for all research papers. In Table 6, the most five Meso-topics are 3.40 Forestry (2,239, 49.8 %), 3.2 Marine Biology (413, 9.186 %), 3.35 Zoology & Animal Ecology (381, 8.474 %), 3.32 Entomology (276, 6.139 %), 4.169 Remote Sensing (132, 2.936 %); and the most five Micro-topics are 3.40.195 Maxent (944, 20.996 %), 3.40.635 Ecosystem Services (718, 15.97 %), 3.2.62 Macroinvertebrates (190, 4.226 %), 3.40.55 Dendrochronology (182, 4.048 %), 3.40.86 Seed Dispersal (179, 3.981 %).

Table 6: Comparison of the top 10 Citation Meso-topics and Citation Micro-topics for landscape ecology topic research based on WoS

Rank	Citation Topics Meso			Citation Topics Micro		
	Meso-topics	No. papers	% of 4,496	Micro-topics	No. papers	% of 4,496
1	3.40 Forestry	2,239	49.8	3.40.195 Maxent	944	20.996
2	3.2 Marine Biology	413	9.186	3.40.635 Ecosystem Services	718	15.97
3	3.35 Zoology & Animal Ecology	381	8.474	3.2.62 Macroinvertebrates	190	4.226
4	3.32 Entomology	276	6.139	3.40.55 Dendrochronology	182	4.048
5	4.169 Remote Sensing	132	2.936	3.40.86 Seed Dispersal	179	3.981
6	3.45 Soil Science	115	2.558	3.35.274 Species Conservation	137	3.047
7	6.223 Hospitality, Leisure, Sport & Tourism	114	2.536	4.169.91 Ndvi	112	2.491
8	3.64 Phylogenetics & Genomics	104	2.313	6.223.972 Place Attachment	101	2.246
9	6.153 Climate Change	57	1.268	3.35.33 Breeding Success	99	2.202
10	1.228 Virology - Tropical Diseases	53	1.179	3.32.750 Apis Mellifera	96	2.135

Sustainable development goals

According to the InCites Benchmarking & Analytics Help File, The Sustainable Development Goals (SDGs) schema allows to explore and analyze according 17 SDGs. Table 7 show the all Sustainable Development Goals for landscape ecology topic research based on WoS. The papers covered fifteen SDGs, and the most papers are focused on five Sustainable Development Goals of 15 Life On Land (3,486, 77.536 %), 13 Climate Action (2,897, 64.435 %), 14 Life Below Water (2,739, 60.921 %), 02 Zero Hunger (1,121, 24.933 %), 11 Sustainable Cities And Communities (982, 21.842 %).

Table 7: All Sustainable Development Goals for landscape ecology topic research based on WoS

Rank	Sustainable Development Goals	Record Count	% of 4,496
1	15 Life On Land	3486	77.536
2	13 Climate Action	2897	64.435
3	14 Life Below Water	2739	60.921
4	02 Zero Hunger	1121	24.933
5	11 Sustainable Cities And Communities	982	21.842
6	06 Clean Water And Sanitation	853	18.972
7	03 Good Health And Well Being	430	9.564
8	01 No Poverty	50	1.112
9	07 Affordable And Clean Energy	40	0.89
10	09 Industry Innovation And Infrastructure	36	0.801
11	12 Responsible Consumption And Production	33	0.734
12	08 Decent Work And Economic Growth	18	0.4
13	04 Quality Education	7	0.156
14	10 Reduced Inequality	7	0.156
15	16 Peace And Justice Strong Institutions	1	0.022

CONCLUSIONS

This study analyzed 4,496 papers of Landscape Ecology topic research during of 1976 to March 15, 2025. Papers mainly written in in English, were from 130 countries or regions and published in 824 journals and 12 book series. The top five journals are *Landscape Ecology, Landscape and Urban Planning, Ecological Applications, Ecology, Ecological Indicators.* Top five countries are USA, Peoples R China, Canada, Australia and England. The top five organizations are United States Department of Agriculture USDA, United States Forest Service, University of California System, Chinese Academy of Sciences, Centre National De La Recherche Scientifique CNRS. All keywords were separated into eight clusters on Landscape Ecology topic research of land-use management and ecosystem services, habitat fragmentation and ecology conservation, landscape ecology patterns and dynamics, habitat scale and communities restoration, biodiversity diversity and agricultural landscapes, epidemiology evolution and spatial analysis in United-States, ecosystem heterogeneity, lessons in Norway. Based on ESI database, there are twenty-one top papers of all highly cited papers. The most papers are focused on the three Sustainable Development Goals of 15 Life On Land, 13 Climate Action, 14 Life Below Water. These aspects could be the highlights of further research topics. For a broader dissemination of their findings, authors are encouraged to pay greater attention to these factors: inter-country collaboration, leading institution, journal choice, and topic choice on Landscape Ecology. The results provide valuable references for researchers and developers in Landscape Ecology topic research.

CONFLICT OF INTEREST

The authors state that they have no conflicts of interest.

REFERENCES

Aartsma, Y., Bianchi, F.J.J.A., van der Werf, W., Poelman, E.H., Dicke, M. (2017). Herbivore-induced plant volatiles and tritrophic interactions across spatial scales. *New Phytologist,* 216(4),1054-1063. https://doi.org/10.1111/nph.14475

Alcaras, E., Amoroso, P.P., Figliomeni, F.G., Parente, C. (2024). Geographic Information System (GIS) for ecology: a bibliometric network analysis. *Ecological Questions,* 35(1), 1. https://doi.org/10.12775/EQ.2024.006

Arroyo-Rodriguez, V., Melo, F.P.L., Martinez-Ramos, M., Bongers, F., Chazdon, R.L., Meave, J.A., Norden, N., Santos, B.A., Leal, I.R., Tabarelli, M. (2017). Multiple successional pathways in human-modified tropical landscapes: new insights from forest succession, forest fragmentation and landscape ecology research. *Biological Reviews,* 92(1), 326-340. https://doi.org/10.1111/brv.12231

Campbell, J.F., Athanassiou, C.G., Hagstrum, D.W., Zhu, K.Y. (2022). *Tribolium castaneum*: a model insect for fundamental and applied research. *Annual Review of Entomology,* 67, 347-365. https://doi.org/10.1146/annurev-ento-080921-075157

Chiang, Y.C., Li, D.Y., Jane, H.A. (2017). Wild or tended nature? The effects of landscape location and vegetation density on physiological and psychological responses. *Landscape and Urban Planning,* 167, 72-83. https://doi.org/10.1016/j.landurbplan.2017.06.001

Dai, L., Liu, Y.B., Luo, X.Y. (2021). Integrating the MCR and DOI models to construct an ecological security network for the urban agglomeration around Poyang Lake, China.

Science of the Total Environment, 754, 141868. https://doi.org/10.1016/j.scitotenv.2020.141868

Dong, S.L., Mo, Y.H., Ma, J.M. (2024). Research progress on ecology and sustainable development of Guilin Lijiang River Basin, China, based on bibliometric analysis. *Environmental Science and Pollution Research,* 31(5), 6694-6722. https://doi.org/10.1007/s11356-023-31614-1

Duru, M., Therond, O., Martin, G., Martin-Clouaire, R., Magne, M.A., Justes, E., Journet, E.P., Aubertot, J.N., Savary, S., Bergez, J.E., Sarthou, J. (2015). How to implement biodiversity-based agriculture to enhance ecosystem services: a review. *Agronomy for Sustainable Development,* 35(4), 1259-1281. https://doi.org/10.1007/s13593-015-0306-1

Fan, J.C., Guo, Q.H., Tang, L.N. (2024). Advancements and prospects of landsenses ecology research based on bibliometric analysis. *Heliyon,* 10(17), e36924. https://doi.org/10.1016/j.heliyon.2024.e36924

Fang, X.N., Kong, L.Q. (2024). Recent trends in landscape sustainability research-a bibliometric assessment. *Land,* 13(6), 811. https://doi.org/10.3390/land13060811

Feng, X.H., Xiu, C.L., Bai, L.M., Zhong, Y.X., Wei, Y. (2020). Comprehensive evaluation of urban resilience based on the perspective of landscape pattern: A case study of Shenyang city. *Cities,* 104, 102722. https://doi.org/10.1016/j.cities.2020.102722

Forman, R.T.T., Alexander, L.E. (1998). Roads and their major ecological effects. *Annual Review of Ecology and Systematics,* 29, 207-231. https://doi.org/10.1146/annurev.ecolsys.29.1.207

Gómez-Sal, A., Bonet, A., Saldaña-López, A., Muñoz-Rojas, J. (2024). Landscape ecology and landscape approaches in the Iberian context: challenges, opportunities, and future prospects. *Landscape Ecology,* 39(8), 153. https://doi.org/10.1007/s10980-024-01938-5

Grime, J.P. (1998). Benefits of plant diversity to ecosystems: immediate, filter and founder effects. *Journal of Ecology,* 86(6), 902-910. https://doi.org/10.1046/j.1365-2745.1998.00306.x

Guan, J.X., Wang, R.Z., Van Berkel, D., Liang, Z.Y. (2023). How spatial patterns affect urban green space equity at different equity levels: A Bayesian quantile regression approach. *Landscape and Urban Planning,* 233, 104709. https://doi.org/10.1016/j.landurbplan.2023.104709

Gustafson, E.J. (1998). Quantifying landscape spatial pattern: What is the state of the art? *Ecosystems,* 1(2), 143-156. https://doi.org/10.1007/s100219900011

Ha, J., Kim, H.J., With, K.A. (2022). Urban green space alone is not enough: A landscape analysis linking the spatial distribution of urban green space to mental health in the city of Chicago. *Landscape and Urban Planning,* 218, 104309. https://doi.org/10.1016/j.landurbplan.2021.104309

Hernández, C., Echeverría, C., Nelson, C. (2021). Evolution and emerging research trends in the ecological impacts of landscape change: perspectives from a Chilean biodiversity hotspot. *Landscape Ecology,* 36(6), 1587-1603. https://doi.org/10.1007/s10980-021-01247-1

Hesselbarth, M.H.K., Sciaini, M., With, K.A., Wiegand, K., Nowosad, J. (2019). *Landscapemetrics*: an open-source *R* tool to calculate landscape metrics. *Ecography,* 42(10), 1648-1657. https://doi.org/10.1111/ecog.04617

Hu, J.Y., Zhang, J.X., Li, Y.Q. (2022). Exploring the spatial and temporal driving mechanisms of landscape patterns on habitat quality in a city undergoing rapid urbanization

based on GTWR and MGWR: The case of Nanjing, China. *Ecological Indicators,* 143, 109333. https://doi.org/10.1016/j.ecolind.2022.109333

Huang, Y., Peng, L., Li, Y.C. (2022). Landscape ecological concepts in planning (LEP): progress, hotspots, and prospects. *Sustainability,* 14(24), 16642. https://doi.org/10.3390/su142416642

Johnson, J.B., Omland, K.S. (2004). Model selection in ecology and evolution. *Trends in Ecology & Evolution,* 19(2), 101-108. https://doi.org/10.1016/j.tree.2003.10.013

Kubacka, M., Zywica, P., Subiros, J.V., Brodka, S., Macias, A. (2022). How do the surrounding areas of national parks work in the context of landscape fragmentation? A case study of 159 protected areas selected in 11 EU countries. *Land Use Policy,* 113, 105910. https://doi.org/10.1016/j.landusepol.2021.105910

Kumar, A., Patil, M., Kumar, P., Kumar, M., Singh, A.N. (2022). Plant ecology in Indian Siwalik range: a systematic map and its bibliometric analysis. *Tropical Ecology,* 63(3), 338-350. https://doi.org/10.1007/s42965-022-00229-x

Lemaire, G., Franzluebbers, A., Carvalho, P.C.D., Dedieu, B. (2014). Integrated crop-livestock systems: Strategies to achieve synergy between agricultural production and environmental quality. *Agriculture Ecosystems & Environment,* 190, 4-8. https://doi.org/10.1016/j.agee.2013.08.009

Lepczyk, C.A., Aronson, M.F.J., Evans, K.L., Goddard, M.A., Lerman, S.B., Macivor, J.S. (2017). Biodiversity in the City: fundamental questions for understanding the ecology of urban green spaces for biodiversity conservation. *Bioscience,* 67(9), 799-807. https://doi.org/10.1093/biosci/bix079

Manel, S., Schwartz, M.K., Luikart, G., Taberlet, P. (2003). Landscape genetics: combining landscape ecology and population genetics. *Trends in Ecology & Evolution,* 18(4), 189-197. https://doi.org/10.1016/S0169-5347(03)00008-9

Patru-Stupariu, I., Nita, A. (2022). Impacts of the European Landscape Convention on interdisciplinary and transdisciplinary research. *Landscape Ecology,* 37(5), 1211-1225. https://doi.org/10.1007/s10980-021-01390-9

Polis, G.A., Anderson, W.B., Holt, R.D. (1997). Toward an integration of landscape and food web ecology: The dynamics of spatially subsidized food webs. *Annual Review of Ecology and Systematics,* 28, 289-316. https://doi.org/10.1146/annurev.ecolsys.28.1.289

Priyadarshana, T.S., Martin, E.A., Sirami, C., Woodcock, B.A., Goodale, E., Martinez-Nunez, C., Lee, M.B., Pagani-Nunez, E., Raderschall, C.A., Brotons, L., Rege, A., Ouin, A., Tscharntke, T., Slade, E.M. (2024). Crop and landscape heterogeneity increase biodiversity in agricultural landscapes: A global review and meta-analysis. *Ecology Letters,* 27(3), e14412. https://doi.org/10.1111/ele.14412

Radke, G.J. (1976). Ecological boundaries between plant associations as an expression of an hierarchical order of landscape-factors for an optimal documentation of landscape-ecology, shown at Central-European room. *Berichte Der Deutschen Botanischen Gesellschaft,* 89 (2-3), 401-413.

Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J., Hirota, M.M. (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation,* 142(6), 1141-1153. https://doi.org/10.1016/j.biocon.2009.02.021

Saedpanah, M., Souri, B. (2025). Routing land use changes using the landscape ecology approach in Isfahan city, central Iran. *Earth Science Informatics,* 18(1), 47.

https://doi.org/10.1007/s12145-024-01508-y

Tian, L. (2015). Land use dynamics driven by rural industrialization and land finance in the pen-urban areas of China: The examples of Jiangyin and Shunde. *Land Use Policy,* 45, 117-127. https://doi.org/10.1016/j.landusepol.2015.01.006

Turner, M.G. (1989). Landscape ecology-the effect of pattern on process. *Annual Review of Ecology and Systematics,* 20, 171-197. https://doi.org/10.1146/annurev.es.20.110189.001131

Valderrama, C., Diaz, L., Ceron, A. (2024). Trends of the ecological footprint and urban development: A systematic and bibliometric review. *Ecological Frontiers,* 44(5), 865-873. https://doi.org/10.1016/j.ecofro.2024.01.007

Villarreal, M.L., Bishop, T.B.B., Sankey, T.T., Smith, W.K., Burgess, M.A., Caughlin, T.T., Gillan, J.K., Havrilla, C.A., Huang, T., Lebeau, R.L., Norton, C.L., Sankey, J.B., Scholl, V.M., von Nonn, J., Yao, E.H. (2025). Applications of unoccupied aerial systems (UAS) in landscape ecology: a review of recent research, challenges and emerging opportunities. *Landscape Ecology,* 40(2), 43. https://doi.org/10.1007/s10980-024-02040-6

Vogt, P., Riitters, K. (2017). GuidosToolbox: universal digital image object analysis. *European Journal of Remote Sensing,* 50(1), 352-361. https://doi.org/10.1080/22797254.2017.1330650

Wang, J.M., Yun, W.J., Bai, Z.K., (2021). Review and prospect of land consolidation and rehabilitation engineering in China--Based on the bibliometric analysis of the literature published amount in the Land Consolidation and Rehabilitation Engineering column of Transactions of the CSAE from 2002 to 2020. *Transactions of the Chinese Society of Agricultural Engineering,* 37(10), 307-316.

Wang, P., Liu, L.J., Dong, B.C., Zhang, W.H., Schmid, B. (2022). Bibliometric analysis of Journal of Plant Ecology during 2017-2021. *Journal of Plant Ecology (植物生态学报),* 15(6), 1316-1323. https://doi.org/10.1093/jpe/rtac107

Wang, Y., Pan, J.H. (2019). Building ecological security patterns based on ecosystem services value reconstruction in an arid inland basin: A case study in Ganzhou District, NW China. *Journal of Cleaner Production,* 241, 118337. https://doi.org/10.1016/j.jclepro.2019.118337

Woodget, A.S., Carbonneau, P.E., Visser, F., Maddock, I.P. (2015). Quantifying submerged fluvial topography using hyperspatial resolution UAS imagery and structure from motion photogrammetry. *Earth Surface Processes and Landforms,* 40(1), 47-64. https://doi.org/10.1002/esp.3613

Wu, J.G. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning,* 125, 209-221. https://doi.org/10.1016/j.landurbplan.2014.01.018

Wu, J.G., Buyantuev, A., Fernandez, I., Gilman, J., Jenerette, G.D., Wang, X. (2024). Forty milestones in landscape ecology: commemorating the 40th anniversary of the Allerton Park workshop. *Landscape Ecology,* 39 (12), 216. https://doi.org/10.1007/s10980-024-02000-0

Xie, H.L., Zhang, Y.W., Duan, K.F. (2020a). Evolutionary overview of urban expansion based on bibliometric analysis in Web of Science from 1990 to 2019. *Habitat International,* 95, 102100. https://doi.org/10.1016/j.habitatint.2019.102100

Xie, H.L., Zhang, Y.W., Zeng, X.J., He, Y.F. (2020b). Sustainable land use and management research: a scientometric review. *Landscape Ecology,* 35(11), 2381-2411. https://doi.org/10.1007/s10980-020-01002-y

Xu, W.X., Wang, J.M., Zhang, M., Li, S.J. (2021). Construction of landscape ecological network based on landscape ecological risk assessment in a large-scale opencast coal mine area. *Journal of Cleaner Production,* 286, 125523. https://doi.org/10.1016/j.jclepro.2020.125523

Yuan, B.Z., Sun, J. (2022). Bibliometric analysis of rice and climate change publications based on Web of Science. *Theoretical and Applied Climatology,* 150(1-2), 347-362. https://doi.org/10.1007/s00704-022-04169-3

Yuan, B.Z., Sun, J. (2023a). Bibliometric analysis of top papers in Ecology based on Essential Science Indicators during 2011–2021. *Polish Journal of Ecology,* 71(1), 1-14. https://doi.org/ 10.3161/15052249PJE2023.71.1.001

Yuan, B.Z., Sun, J. (2023b). Research trend analysis in Environmental Studies category based on Essential Science Indicators during 2011-2021: a bibliometric analysis. *Polish Journal of Environmental Studies*, 32(4), 3467–3480. https://doi.org/10.15244/pjoes/161664

Zhou, B.B., Wu, J.G., Anderies, J.M. (2019). Sustainable landscapes and landscape sustainability: A tale of two concepts. *Landscape and Urban Planning,* 189, 274-284. https://doi.org/10.1016/j.landurbplan.2019.05.005