JISTaP http://www.jistap.org
Journal of Information Science Theory and Practice

Research Paper
J. of infosci. theory and practice 2(3): 40-54, 2014
http://dx.doi.org/10.1633/JISTaP.2014.2.3.4

A Ten-year Bibliometric Analysis of Research Trends in Three Leading Ecology Journals during 2003-2012

G. Saravanan *

French Institute of Pondicherry
Department of Library and Information Science
Karpagam University, India
Email: saravanan.g@ifpindia.org

J. Dominic

Karunya University, India
Email: jdom16@gmail.com

ABSTRACT

This paper attempts to highlight quantitatively the growth and development of literature in the field of ecology in terms of publication output using the resource Web of Science®. The focus of this analysis was to study the literature on ecology published in three journals, viz., *Ecology Letters, Trends in Ecology & Evolution,* and *Annual Review of Ecology Evolution and Systematics.* 2946 records were retrieved for 10 years (2003–2012). The study revealed that multiple authorship in the field with collaborations of two (30.31%) and three authors (19.89%) was dominant. The Degree of collaboration, Collaborative coefficient, and Collaborative index were calculated and the applicability of Lotka's law was tested. The study identified five-year patterns in research trends, using the three studied journals, to see if the subjects of focus changed within a decade. The most productive institution was University Calif. Davis, USA, followed by University Calif. Santa Barbara, USA, and University Queensland, Australia, and the most productive countries were the USA followed by UK and Canada.

Keywords: Ecology, Bibliometrics, Ecology literature, Author productivity, Collaboration pattern, Lotka's Law

1. INTRODUCTION

With the population explosion, associated with increasing industrialization and urbanization in the last few decades, the study of ecology has gained importance, evolving as a separate discipline. During the last three decades, the research in this field has gained momentum due to the occurrences of natural

Open Access

Accepted date: July 5, 2014
Received date: February 21, 2014

***Corresponding Author:** G. Saravanan
Ph. D. Scholar
Department of Library and Information Science
Karpagam University, India
E-mail: saravanan.g@ifpindia.org

calamities in addition to the focus on climate change. Researchers are trying to find the causal relationships among different environmental factors and are addressing different issues to tackle them in future.

Ecology is the study of interactions between organisms and their environments (Stiling, 1999). Ecology is an interdisciplinary field that includes Biology and Earth Sciences. To expand the scope of the field, ecology deals with the relationships between air, land, water, animals, and plants, usually of a particular area, or their scientific study. The rationale for taking up this field is that ecology is a rapidly advancing field that evolves almost every day with new concepts, new areas of scientific focus, and innovative technologies. One more reason is that, unlike disciplines in the humanities, in ecology the issues are similar across the world (with every country facing issues that can be compared), enabling a true comparison of participation of international communities of researchers. The literature of ecology is neither precisely located nor rigidly defined. A possible bibliographic means of capturing the literature of ecology is through journal articles which are the most vital mode of communication among scientists (Thanuskodi & Venkatalakshmi, 2010). Realizing the importance of this area of research, the present study attempts a bibliometric depiction of three leading journals in ecology, namely, *Ecology Letters, Trends in Ecology & Evolution,* and *Annual Review of Ecology Evolution and Systematics*.

Pritchard (1969) explained the term bibliometrics as "the application of mathematical and statistical methods to books and other media of communication." Sengupta (1985) stated that bibliometrics studies lies between the broader areas of the social sciences and the physical sciences. Borgman (1989) indicated the scope of bibliometrics by mentioning that scholarly communication can be studied by bibliometric methods using one or more of three theoretical variables: producers of communication, artifacts of communication, and communication concepts. Feather and Sturges (1997) reported that 'bibliometric' refers to the study of the use of documents and patterns of publication, by means of mathematical and statistical methods. Bibliometrics can be divided into 'descriptive' and 'evaluative' approaches, both of which can, in turn, be further divided by 'productive count' (geography, time, and discipline) and 'literature count' (references and citation).

2. REVIEW OF LITERATURE

There are several studies analyzing the contribution of different journals in the field of ecology. A study conducted by Liao and Huang (2014) laid stress to the fact that aquatic ecosystems were ecologically important but continuously threatened by a growing number of human induced changes, and evaluated the research trends of 'aquatic ecosystems' between 1992 and 2011 in journals of all subject categories of the science citation index and social sciences citation index.

The study of Parker et al. (2013) examined the publication and citation patterns of the world's most highly cited environmental scientists and ecologists, inquiring into their levels of scientific productivity and visibility, examining relationships between scientific productivity and quality within their research programs, and considering how different publication strategies contribute to these distinctive successes. The paper concluded that highly cited researchers were also highly productive, publishing on average well over 100 articles each. Additionally, articles published by this group were more highly cited on average than articles published in premier generalist journals like *Nature* and *Science*, and their citation to publication ratios were more equitably distributed than was typical.

Goodland (1975) worked on the tropical origins of ecology. Arunachalam and Manorama (1988) analysed the standards of Indian ecology journals. Budilova et al. (1997) conducted scientometric analysis of publications from the journals *Ecology* and *Ecologia* (Russia) based on ecological and mathematical keywords. Biradar and Mathad (2000) focused on the references appended to the articles that appeared in *Annual Review of Ecology and Systematics* for the years 1995–1996. Major forms of literature, core journals, authorship patterns, obsolescence of literature etc., were identified. Thanuskodi and Venkatalakshmi (2010) studied the growth and development of research on ecology in India. Saravanan et al. (2012) conducted bibliometric analysis of 161 articles published in *Tropical Ecology* during the years 2007-2012.

The review revealed that there were not many studies in the area of ecology literature, especially in more than two journals or cumulative journal studies. Hence this paper attempts to study the research trends in ecology literature in the selected three ecology journals.

3. OBJECTIVES

The purpose of the present study was to examine the quantitative growth of literature in the field of ecology during 2003-2012 from three journals covering the authorship pattern, authors' collaboration, applicability of Lotka's law, authors' dominance, subject-wise distribution, institution-wise distribution of contributors, and geographical representation of publications.

4. HYPOTHESES

The following two hypotheses were cast: that research trends in a dynamic scientific discipline like Ecology change over the course of a decade, reflecting the fluctuations in the field based on the issues prevailing during the period and also based on the priorities of the funding agencies; and multiple authored publications would be more in number than single authored ones.

5. MATERIALS AND METHODS

The analysis included three chosen journals in the field of ecology listed below. The choice of these journals was based primarily on impact factor (impact factor is the average citation rate of a journal's articles). The three journals were identified on the ISI Web of Knowledge℠ in the Journal Citation Report® under the Subject Category Section 'Ecology' with the 2012 impact factor and sorted by 5-year impact factor in decreasing order. (Journal Citation Report® - journal performance metrics offer a systematic, objective means to critically evaluate the world's leading journals.) To strengthen the data fruitfully, personal interaction with domain experts in ecology was also conducted. The following are the journals undertaken for the study:

1. *Ecology Letters* (John Wiley & Sons Ltd./ Centre National de la Recherche Scientifique, France. ISSN: 1461-023X. Start year: July 1998; Frequency: 12 Issues/Year).
2. *Trends in Ecology & Evolution* (Elsevier Science, England. ISSN: 0169-5347. Start year: July 1986; Frequency: 12 Issues/Year).
3. *Annual Review of Ecology Evolution and Systematics* (Annual Reviews, USA. ISSN: 1543-592x. Start year: 1970; Frequency: 1 Issue/Year).

The keywords used were "Ecology Letters or Trends in Ecology & Evolution or Annual Review of Ecology Evolution and Systematics" as search terms in the field of "Publication Name" and the time period was limited to 2003-2012 (10 years). A total of 2,946 records were retrieved. Once a marked list of papers was created, the resulting export file was processed by HistCite™ (Bibliometric Analysis and Visualization Software developed by Garfield et al., 2006) in accordance with the stated objectives.

6. BIBLIOMETRIC INDICATORS AND LOTKA'S LAW

Bibliometric indicators are the principal tools for measuring research output, while providing a very good tool — contrary to popular belief — for research conducted by other types of actors. For this reason, they deserve a place in scientific and technological directories (Bradford, 1934).

6.1. Collaborative Index

Collaborative Index (CI) is the number of authors per paper, as first given by Lawani (1980). Let the collection A be the research papers published in a discipline or in a journal during a certain period of interest. In the following, we write

$$CI = \frac{\sum_{j=1}^{A} jf_j}{N} \qquad (1)$$

Where, f_j = number of papers having j authors in collection A

N = total number of papers in A. $N = \Sigma\, jf_j$

A = total number of authors in collection

As a measure of mean number of authors, although CI is easily computable, it is not easily interpretable as a degree. Moreover, it gives a non-zero weight to single authored papers, which refers to no collaboration (Karpagam et al., 2012).

6.2. Degree of Collaboration

Degree of Collaboration (DC) is a measure of proportion of multiple authored papers derived by Subramanyam (1983) as,

$$DC = \frac{N_m}{N_m + N_s} \quad (2)$$

Where, DC = degree of collaboration
N_m = Number of multi authored publications
N_s = Number of single authored publications

6.3. Collaborative Coefficient

DC does not differentiate among levels of multiple authorships. Collaborative Coefficient (CC) was designed to remove the above shortcomings pertaining to CI and DC by Ajiferuke et al. (1988). CC is used to measure the extent and strength of collaboration among the selected three ecology journals. It can be expressed mathematically as:

$$CC = 1 - \frac{\sum_{j=1}^{A} (1/j) f_j}{N} \quad (3)$$

Where, f_j = Number of j authored papers
N = total number papers
A = Greatest number of authored papers

6.4. Lotka's Law

Lotka (1926) published his pioneering study on the frequency distribution of scientific productivity. Lotka's law is one among the three classic laws of bibliometrics, used to test the regularity in the publication activity of authors of scientific literature.

It states that, "the number (of authors) making n contributions is about 1/n2 of those making one; and the proportion of all contributors that make a single contribution is about 60 percent", which means that out of all the authors in a given field, 60% will have only one publication, 15% will have two publications, and 7% of authors will have 3 publication and so on (Rowlands, 2005). In other words, within a particular topic, for every 100 authors whose contribution is single article, there will be 25 authors with two articles, 11 authors with three articles, etc. The generalized form of Lotka's law can be expressed as

$$x^n y = k \quad (4)$$

Where y is the frequency of authors making n contributions each and k is a constant.

According to Pao (1985), the following procedure should be followed in studying the application of fit of Lotka's law to a given data sample.

Estimation of parameter 'n'

The first step in the application of Lotka's law is to determine the value of 'n' which is to be determined either by using the Linear Least Square (LLS) regression method or one of its equivalent forms given by the following formula:

$$n = \frac{[N\sum(\ln x)\ln g(x) - \sum \ln g(x) \sum \ln x]}{[N\sum(\ln x)^2 - (\sum \ln x)^2]} \quad (5)$$

Where, N = number of pairs of data considered, x = 1, 2, 3…. x_{max}
X = logarithm of x, i.e. number of articles
Y = logarithm of y, i.e. number of authors

Estimation of parameter 'k'

The value of k, which is the theoretical number of authors with a single article, is determined from the following formula:

$$k = \frac{1}{\sum_{x=1}^{p-1} 1/x^n + 1/((n-1)(p^{n-1})) + \frac{1}{2}pn + n/(24\times(p-1)^{n+1})} \quad (6)$$

Here p is assumed to be 20 and n is the experimentally computed value of the exponent from the observed distribution. Once the value of n and k is determined, then, the number of authors writing 1, 2, 3…x articles is determined.

7. RESULTS AND DISCUSSION

The analysis of the data was done with a view to measuring the growth of literature over the years, au-

thors' productivity, subjects, institutions, and country-wise distribution of papers in the selected three journals, namely, *Ecology Letters, Trends in Ecology & Evolution,* and *Annual Review of Ecology Evolution and Systematics.*

7.1. Growth of Ecology Literature

Table 1 presents the results of cumulative publications of the three journals. It was observed that the growth trend was linear. Fluctuations in publication patterns of ecology literature were noticed throughout the period of study. However, the highest number of publications was recorded in 2003 while the lowest was in 2007. The reason could be the frequency of journals, as there is an inconsistency in the number of issues published (Table 2). Another possible reason could be the shift in research focus from the field of pure ecology to applied specific research areas. Such changes in priority areas are discussed later in the paper.

HistCite™ calculates the total local citation score (TLCS) and the total global citation score (TGCS). TLCS is the number of times a paper is cited by other papers in the local collection, which in the study is the citation scored by the collection of 2946 papers in the three journals. TGCS is the number of times a paper is included in the collection cited in WoS.

The journal-wise total research productivity of ecology journals for the years 2003-2012 is presented in Table 2. It was observed that *Ecology Letters* (vol. 6, 2003 to vol. 15, 2012) ranked first in order, followed by *Trends in Ecology & Evolution* (vol. 18, 2003 to vol. 27, 2012) and then *Annual Review of Ecology Evolution and Systematics* (vol. 34, 2003 to vol. 43, 2012). *Ecology Letters* and *Trends in Ecology Evolution* had a periodicity of 12 issues per annum recording a higher percentage of articles published. At the same time *Annual Review of Ecology Evolution and Systematics* is annual.

Analysis of collected data showed that the literature on the subject 'ecology' was published in nine different forms *i.e.* Articles, Letters, Reviews, Editorial Materials, Corrections, Article; Proceedings Papers, Biographical-Items and Review; Book Chapters. It was observed that in the cumulative source-wise distribution of the three journals, articles stood first with 1,223 (41.51%) records, followed by Review with 773 (26.24%) records, Letters with 548 (18.60%) records, Review; Book chapters with 207 (7.03%) records, Editorial Materials with 151 (5.13%) records, Corrections with 40 (1.36%) records, Article; Proceedings

Table 1. Cumulative distribution of ecology literature for the three selected journals

Year	No. of Records	Cum. Records	%	Cum. %	TLCS	TGCS
2003	317	317	10.76	10.76	1072	29755
2004	297	614	10.08	20.84	1131	30544
2005	305	919	10.35	31.19	1034	30797
2006	297	1216	10.08	41.28	898	23887
2007	270	1486	9.16	50.44	724	18556
2008	277	1763	9.40	59.84	680	17178
2009	289	2052	9.81	69.65	523	14021
2010	273	2325	9.27	78.92	372	9158
2011	307	2632	10.42	89.34	268	5576
2012	314	2946	10.66	100.00	79	2222
Total	**2946**		**100**			

Cum. – Cumulative; % - Percentage; TLCS - Total Local Citation Score; TGCS - Total Global Citation Score

Papers with 2 (0.07%), records and Biographical items with 2 (0.07%) records.

7.2. Authorship Pattern and Collaborative Measures in Ecology Literature

Collaborative research can be effectively measured from the number of authors in papers. Such studies can be conducted to understand global trends, national trends, or trends in different subjects. However, the extent of collaboration may not be revealed from the citations. Efforts in this direction have been made by Ajiferuke et al. (1988) who attempted to define 'good collaboration' measurers. With a view to identifying the extent of research conducted by individuals in collaboration with each other, the number of authors mentioned in the papers was counted and analysed. Table 3 gives the distribution of articles on the basis of authorship pattern (cumulative) of the three journals. Multiple authorship was dominant in the present study (Saravanan et al., 2012) which indicates that researchers normally prefer co-operative and collaborative works (Parker, 2013). The other factors such as nature of the project, magnitude of instrumentation, popularity, and the rate of expansion of the area of science may also affect this tendency. It was found that two authored papers (30.31%) were followed by three authored papers (19.89%), while the contribution of sole-authored papers (15.61%) was low. In essence, this shows a clear trend towards multi-authored papers (84.39%). This proves that our second hypothesis of "Multiple authors are predominant over single authors" is valid.

The Degree of Collaboration (DC) was almost uniform through the years studied (standard deviation <0.05) while the Collaborative Coefficient (CC) (average 0.56) and the Collaborative Index (CI) (average 3.65) were more variable as evident in Table 3. The average DC 0.84 indicates that collaboration was high among the authors in the journals under study. The CC is increasing year to year which shows the increase in the productivity of multi-authored papers.

The role of funding agencies was also assessed as this may significantly affect the course and discipline of research. The National Science Foundation, USA had funded many of the research works that were carried out in the journals during the study period.

Table 2. Year-wise distribution of articles in the three selected ecology journals

Year	EL (Records)	TEE (Records)	AREES (Records)	Total
2003	156	137	24	317
2004	139	134	24	297
2005	148	130	27	305
2006	143	131	23	297
2007	122	115	33	270
2008	133	114	30	277
2009	142	114	33	289
2010	148	107	18	273
2011	155	130	22	307
2012	167	126	21	314
Total	**1453**	**1238**	**255**	**2946**
Percentage	**49.32**	**42.02**	**8.66**	**100.00**

EL - Ecology Letters; TEE - Trends in Ecology & Evolution; AREES - Annual Review of Ecology Evolution and Systematics

Table 3. Authorship pattern (cumulative) of the three ecology journals

NA	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	TA	%	AP
1	69	61	55	54	49	47	34	22	40	29	460	15.61	460
2	116	99	107	96	99	91	88	60	73	64	893	30.31	1786
3	67	65	64	56	43	46	59	59	66	61	586	19.89	1758
4	37	28	29	44	25	29	38	44	42	41	357	12.12	1428
5	16	17	18	18	19	26	29	32	26	46	247	8.38	1235
6	3	9	11	9	13	11	13	17	14	21	121	4.11	726
7	3	6	8	5	6	7	2	10	12	8	67	2.27	469
8	2	2	6	3	7	3	2	6	6	10	47	1.60	376
9	0	2	3	3	1	3	5	5	6	2	30	1.02	270
10	0	2	2	2	1	1	2	8	8	2	28	0.95	280
11	0	1	1	1	0	0	4	2	2	5	16	0.54	176
12	2	1	0	0	1	1	1	0	1	6	13	0.44	156
13	0	0	0	2	1	1	2	2	0	6	14	0.48	182
14	1	2	1	0	1	3	2	2	1	5	18	0.61	252
15	0	0	0	0	0	0	3	1	0	1	5	0.17	75
16	1	0	0	0	0	0	0	0	1	1	3	0.10	48
17	0	1	0	1	1	0	0	2	0	0	5	0.17	85
18	0	1	0	1	1	1	0	0	2	1	7	0.24	126
19	0	0	0	0	1	0	0	0	0	0	1	0.03	19
20>	0	0	0	2	2	7	4	1	7	5	28	0.95	831
TMA	248	236	250	243	222	230	254	251	267	285	2486	100	10738
TA	317	297	305	297	271	277	288	273	307	314	2946		
DC	0.78	0.79	0.82	0.82	0.82	0.83	0.88	0.92	0.87	0.91	Ave= 0.84		
CC	0.48	0.51	0.52	0.53	0.53	0.55	0.59	0.65	0.61	0.65	Ave= 0.56		
CI	2.65	2.99	2.98	3.35	3.37	3.90	3.86	4.21	4.32	4.87	Ave=3.65		

NA – Number of authors; TA – Total authors; % - Percentage; AP – Authorship pattern; TMA – Total Multi authors; DC – Degree of Collaboration; CC - Collaborative Co-efficient ; CI – Collaborative index

7.3. Most Productive Authors and Lotka's Inverse Square Law (Cumulative of Three Ecology Journals)

Author productivity is a measure for ranking authors according to their publication output. From 2003 to 2012, 2,946 papers were published by 6,697 authors

in the three selected journals. Table 4 shows the top 15 most productive authors during 2003-2012. Among the top 15 authors who contributed to the three journals, 8 were from the USA, 3 from Australia and one each from the Netherlands, Germany, Finland, and Canada. The highest records were for H.P. Possingham with 22 (0.20%, 35 TLCS and 1214 TGCS). The other most productive authors, in decreasing order, are also provided in Table 4.

The productivity of the paper contribution of the selected three ecology journals was verified to find the conformity with Lotka's inverse square law using Pao's (1985) method. This was done using equations (4-5) to know the values of '*n*' and '*k*'.

Here '*n*' is substituted with the value 2.94 and '*k*' is calculated as 0.82 using the equation (6), while '*p*' is assumed to be 20. By replacing the values of '*n*' and '*k*' in the above table the difference is calculated. Here the D is minimum and hence Lotka's law is confirmed to the present data set. From Table 5 it is clear that the maximum absolute difference value D_{max} which represents the maximum deviation is identified as 0.006. The table value or critical value of D in K-S test at 0.05 level of significance is 0.0166. When the calculated value of D, i.e. 0.006, is less compared to the table value 0.328, it is clear that the calculated value of D comes within the critical value of D. Thus the distribution of author productivity of the present data set confirms Lotka's law in Table 5.

7.4. Subject-wise Contribution of Ecology Literature

The purpose of subject wise analysis is to identify the performance of researchers in various subject headings in ecology and its sub-fields. We have used Library of Congress Subject Headings along with three of our domain experts in ecology, and grouped the subject ecology in to 25 disciplines during the study

Table 4. Top productive authors vs. citations (first 15 authors)

Author	Country	Records	Percentage	TLCS	TGCS
Possingham HP	Australia	22	0.20	35	1214
Etienne RS	Netherlands	18	0.17	106	940
Holt RD	USA	15	0.14	144	2303
Reich PB	USA	15	0.14	53	1118
Elser JJ	USA	14	0.13	61	1111
Enquist BJ	USA	14	0.13	79	1212
Hillebrand H	Germany	14	0.13	100	1316
Kokko H	Finland	14	0.13	29	590
Laurance WF	Australia	14	0.13	17	412
Lindenmayer DB	Australia	13	0.12	15	399
Agrawal AA	Canada	12	0.11	49	738
Chase JM	USA	12	0.11	93	1562
Duffy JE	USA	12	0.11	107	995
Hastings A	USA	12	0.11	73	1625
Ricklefs RE	USA	12	0.11	81	1240

TLCS - Total Local Citation Score; TGCS - Total Global Citation Score

period. The subject-wise analysis was carried out in accordance with Budilova et al. (1997).

To analyze the changes in the focus areas of publications in ecology, we sub-divided the study period into two blocks of five years and extracted the number of publications and their percentages, journal-wise, for the three studied journals (Table 6). We observed a decrease in publications in all the three journals in the disciplines of Movement, Interactions & Behavioural Ecology, Physico-Chemical Ecology, Soil Ecology, and Biogeography, while increase in publications was observed in the disciplines of Freshwater Ecology, Arid Zone Ecology, Fire Ecology, and Forest (Plant) Ecology. The total output of 2,946 subject keywords was classified and as expected the highest contributions were in the disciplines of Biodiversity and Evolutionary Ecology in the selected three ecology journals in the 2003-2007 block, while in the 2008-2012 block the highest contributions are from Biodiversity and Movement, and Interactions & Behavioural Ecology in the selected three ecology journals.

7.5. Institution-wise Distribution of Ecology Literature

Analysis of references reveals that most of the research works in ecology were being pursued in universities and other higher educational institutions. Research institutes/laboratories were more active in the field of ecology. 2,946 papers were published in the

Table 5. K-S test on observed and theoretical distribution of authors (cumulative of three ecology journals)

x	y	X	Y	xX	XY	Observed	cum observed	Expect	Cum Exp	D
1	4793	0	3.68	0.00	0.00	0.72	0.72	0.82	0.82	-0.104
2	1048	0.30	3.02	0.09	0.91	0.16	0.87	0.11	0.93	-0.055
3	382	0.48	2.58	0.23	1.23	0.06	0.93	0.03	0.96	-0.030
4	194	0.60	2.29	0.36	1.38	0.03	0.96	0.01	0.97	-0.015
5	112	0.70	2.05	0.49	1.43	0.02	0.97	0.01	0.98	-0.006
6	57	0.78	1.76	0.61	1.37	0.01	0.98	0.00	0.98	-0.001
7	30	0.85	1.48	0.71	1.25	0.00	0.99	0.00	0.99	0.001
8	31	0.90	1.49	0.82	1.35	0.00	0.99	0.00	0.99	0.003
9	9	0.95	0.95	0.91	0.91	0.00	0.99	0.00	0.99	0.003
10	15	1.00	1.18	1.00	1.18	0.00	1.00	0.00	0.99	0.005
11	8	1.04	0.90	1.08	0.94	0.00	1.00	0.00	0.99	0.005
12	8	1.08	0.90	1.16	0.97	0.00	1.00	0.00	0.99	0.006
13	1	1.11	0.00	1.24	0.00	0.00	1.00	0.00	0.99	0.006
14	5	1.15	0.70	1.31	0.80	0.00	1.00	0.00	0.99	0.006
15	2	1.18	0.30	1.38	0.35	0.00	1.00	0.00	0.99	0.006
18	1	1.26	0.00	1.58	0.00	0.00	1.00	0.00	0.99	0.006
22	1	1.34	0.00	1.80	0.00	0.00	1.00	0.00	0.99	0.006
Total	**6697**	**14.71**	**23.28**	**14.78**	**14.07**				**Max D**	**0.006**

Table 6. Discipline-wise publications and their percentages (in parentheses), journal-wise arranged in two blocks of 5 years (2003-07 and 2008-12)

Ecology Disciplines	2003-2007			2008-2012		
	EL	TEE	AREES	EL	TEE	AREES
Movement, Interactions & Behavioural Ecology	57 (8.01)	41 (7.48)	21(16.03)	51 (6.88)	39 (5.65)	18 (14.52)
Population Ecology	39 (5.48)	11 (2.01)	5 (3.82)	11 (1.48)	41 (5.94)	7 (5.65)
Forest (Plant) Ecology	137 (19.24)	20 (3.65)	4 (3.05)	197(26.59)	58 (8.41)	7 (5.65)
Physico-chemical Ecology	10 (1.40)	8 (1.46)	5 (3.82)	6 (0.81)	6 (0.87)	4 (3.23)
Soil Ecology	14 (1.97)	11 (2.01)	8 (6.11)	10 (1.35)	7 (1.01)	7 (5.65)
Conservation Biology	15 (2.11)	13 (2.37)	0 (0.00)	9 (1.21)	7 (1.01)	1 (0.81)
Environmental Science & Ecotoxicology	18 (2.53)	11 (2.01)	2 (1.53)	8 (1.08)	10 (1.45)	4 (3.23)
Landscape Ecology	32 (4.49)	22 (4.01)	2 (1.53)	26 (3.51)	11 (1.59)	1 (0.81)
Biodiversity	213 (29.92)	181 (33.03)	10 (7.63)	241(32.52)	189 (27.39)	9 (7.26)
Biogeography	10 (1.40)	10 (1.82)	4 (3.05)	10 (1.35)	9 (1.30)	1 (0.81)
Fire Ecology	8 (1.12)	8 (1.46)	0 (0.00)	9 (1.21)	14 (2.03)	1 (0.81)
Ecosystem Ecology	44 (6.18)	37 (6.75)	7 (5.34)	31 (4.18)	41 (5.94)	9 (7.26)
Climate science	10 (1.40)	12 (2.19)	5 (3.82)	11 (1.48)	18 (2.61)	2(1.61)
Evolutionary Ecology	20 (2.81)	101 (18.43)	26(19.85)	9 (1.21)	147 (21.30)	16 (12.90)
Paleoecology	10 (1.40)	3 (0.55)	7 (5.34)	10 (1.35)	14 (2.03)	4 (3.23)
Conservation Genetics	11 (1.54)	3 (0.55)	4 (3.05)	11 (1.48)	10 (1.45)	9 (7.26)
Arid (Zone) Ecology	2 (0.28)	4 (0.73)	0 (0.00)	8 (1.08)	7 (1.01)	1 (0.81)
Montane/Alpine/Arctic Ecology	9 (1.26)	5 (0.91)	1 (0.76)	6 (0.81)	9 (1.30)	2 (1.61)
Freshwater Ecology	10 (1.40)	7 (1.28)	2 (1.53)	11 (1.48)	13 (1.88)	2 (1.61)
Marine Ecology	11 (1.54)	9 (1.64)	0 (0.00)	9 (1.21)	10 (1.45)	3 (2.42)
Methods	10 (1.40)	11 (2.01)	9 (6.87)	19 (2.56)	11 (1.59)	6 (4.84)
Ecological History	5 (0.70)	5 (0.91)	1 (0.76)	7 (0.94)	4 (0.58)	1 (0.81)
Human/Social Ecology	10 (1.40)	6 (1.09)	5 (3.82)	21 (2.83)	7 (1.01)	6 (4.84)
Ecological Economics	4 (0.56)	2 (0.36)	1 (0.76)	5 (0.67)	2 (0.29)	2 (1.61)
Conservation Policy	3 (0.42)	7 (1.28)	2 (1.53)	5 (0.67)	6 (0.87)	1 (0.81)
Grand Total	**712 (100)**	**548 (100)**	**131(100)**	**741 (100)**	**690 (100)**	**124 (100)**

EL - Ecology Letters; TEE - Trends in Ecology & Evolution; AREES - Annual Review of Ecology Evolution and Systematics

journals during 2003-2012 with contributions from 7,536 institutions. The University Calif. Davis, USA was the topmost contributor in the list (Table 7) with 130 papers (1.73%, TLCS 561 and TGCS 12027), and remaining institution names with records are given below.

It is evident that American and British institutions contributed to 80% (12 out of 15 institutions) of the publications. It is of significance that ecologists have accepted that most of the impact of environmental and ecological damages will be felt higher in Africa and South Asia; no institutions from this region were listed in the top fifteen. In the Geographic distribution of articles (Table 8) the same trend was observed, though China occupies the 15th position.

7.6. Geographical Distribution of Ecology Literature

Geographical analysis of papers revealed that during the period of study contributions from the selected three ecology journals numbered 2,946 from 82 countries (Table 8). The USA (1,551 papers, 32.05%, TLCS 4074 and TGCS 105045) has come in the top position followed by the UK. In another work by Biradar and Mathad (2000) the USA also has occupied the first position nation-wise in terms of papers. Nearly 90% of the publications have been contributed by authors from 15 countries; none of these countries is from the third world, clearly indicating the dominance of advanced countries in carrying out ecological research. We attribute this to better infrastructure, laboratory, and library facilities in the advanced countries. Language barriers do not seem to be an issue here as we can see that not all the countries in the list are English speaking (of course in many of the publications, collaborations and

Table 7. Institution wise distribution of contribution (Cumulative of three ecology journals) (first 15 institutions)

Institution	Country	Records	%	TLCS	TGCS
University Calif. Davis	USA	130	1.73	561	12027
University Calif. Santa Barbara	USA	98	1.30	410	8699
University Queensland	Australia	81	1.07	158	4846
University Calif. Berkeley	USA	78	1.04	226	5908
University Sheffield	England	69	0.92	120	3107
University Minnesota	USA	68	0.90	227	5336
Cornell University	USA	65	0.86	207	3969
University Oxford	England	64	0.85	137	2996
University British Columbia	Canada	63	0.84	289	6280
University Florida	USA	63	0.84	210	4567
University Cambridge	England	62	0.82	114	3203
University London - The Imperial College of Science, Technology, and Medicine	England	62	0.82	110	2703
Stanford University	USA	60	0.80	148	3718
Duke University	USA	59	0.78	166	3273
Smithsonian Tropical Research Institute	Panama	53	0.70	147	2956

TLCS - Total Local Citation Score; TGCS - Total Global Citation Score

joint authorship would have included native English speaking persons). Though the third world countries are endowed with rich traditional knowledge, unfortunately such knowledge has not been translated into scientific outputs.

7.7. General Observations on Ecology Literature

A general picture of the selected three ecology journals from Web of Science® is given in Table 9. A reference to a text or part of a text identifying the document in which it may be found, or the format of such a reference—which would typically include the author, title, and bibliographic description of the document—is called Citation. The method of calculating the citation rate that is followed by Web of Science® is accomplished by counting the number of references to the cited journal, but treating duplicate references from the same source article as only a single citation link.

'h-index' is an index that quantifies both the actual scientific productivity and the apparent scientific impact of a scientist. Hirsch (2005) postulated that "[a] scientist has an index h if h of his or her Np papers has at least h citations each and the other (Np –h) papers have less than h citations each. The value of h is equal to the number of papers (N) in the list that have N or more citations" (Dhiman, 2012; Liao & Huang, 2014).

In Table 9, *Ecology Letters* has an h index of 130; it means that 130 of the documents have been cited at least 130 times. The published documents with fewer citations than h, in this case less than 130, are considered but would not count in the h index. The h-index of *Trends in Ecology and Evolution*, and *Annual Review of Ecology Evolution and Systematics*, are 146 and 97, respectively.

Table 8. Geographical distribution of contributions (Cumulative of three ecology journals) (first 15 countries)

Country	Records	Percentage	TLCS	TGCS
USA	1551	32.05	4074	105045
UK	674	13.93	1441	40907
Canada	347	7.17	1092	27036
Australia	332	6.86	680	19961
France	220	4.55	536	15141
Germany	183	3.78	417	10486
Netherlands	158	3.27	388	9703
Switzerland	148	3.06	326	10997
Sweden	125	2.58	299	7951
New Zealand	102	2.11	262	7080
Spain	94	1.94	277	7129
Finland	88	1.82	181	4415
Unknown	87	1.80	101	2845
Norway	59	1.22	133	3812
Peoples R China	47	0.97	33	1485

TLCS - Total Local Citation Score; TGCS - Total Global Citation Score

Table 9. General observations on ecology literature in three ecology journals

Citation Report	Results found	Sum of Times Cited	Sum of Times Cited without self-citations	Citing Articles	Citing Articles without self-citations	Average Citations per Item	h-index
Ecology Letters	1453	79067	76345	47647	46699	54.42	130
Trends in Ecology and Evolution	1238	77570	76144	58229	57486	62.66	146
Annual Review of Ecology Evolution and Systematics	255	28340	28187	24879	24791	111.14	97

8. FINDINGS AND CONCLUSIONS

This paper examines the authorship pattern, Degree of Collaboration, Collaborative Coefficient, Collaborative Index, and the Conformity of Lotka's law in the present data set. The present work has taken up a detailed analysis of 2,946 papers from ecology literature over a ten year period (2003-2012) based on three leading journals, viz., *Ecology Letters, Trends in Ecology & Evolution*, and *Annual Review of Ecology Evolution and Systematics*. The year 2003 showed the maximum number of contributions (317 records). The study reveals that the categories of article distributions are remarkable in the selected three journals. The trend towards collaborative research is increasing; here also multi-authored papers (84.39%) number more than single-authored papers (15.61%). Degree of collaboration (0.84), Collaboration Coefficient (0.56), and Collaborative Index (3.65) were calculated. Country-wise analysis indicates that the USA was in the top position (32.05%). The findings of research institution-wise papers showed that University Calif. Davis, USA contributed more and ranks first with 130 papers. The h-index of *Ecology Letters, Trends in Ecology & Evolution*, and *Annual Review of Ecology Evolution and Systematics* are 130, 146, and 97, respectively.

The first hypothesis was tested with our findings as shown in Table 6 and the hypothesis was found to be validated. The trends did change remarkably, as also the thrust areas, within a time span of ten years. This is understandable as researchers in scientific disciplines tend to follow the issues that are in focus during a given time period. We feel that with advances in and easier access to communication facilities, the public becomes increasingly curious about many of the newer issues and developments, and these lead to more and more questions that have to be answered by the scientists. This process is dynamic, resulting in shifting of preferences for disciplines. While this is true for a few disciplines, biodiversity has remained the chief focus, indicating that this discipline has continued to be a highly-studied one all through the ten-year period. This is because studies on floral and faunal diversity are essential to understanding the life processes in both disturbed and undisturbed areas, hence finding its relevance in every possible situation.

Though the domain experts are in a better position to orient the subjects studied and the broad themes addressed, we understood, on interaction with experts, that scientists now need to focus more in the areas of climate change and pollution control. With more industrialisation and urbanisation, which lead to depletion and degeneration of natural landscapes and generation of by-products that may harm the globe in the longer run, focus may shift towards studying their effects and tackling them effectively. Both climate change and pollution control, in addition to the ever-required studies on biodiversity, do offer areas of future focus.

The first caveat of our work is that this study may not be completely indicative of current trends in the robust field of ecology, as the entire scope is restricted to the selected journals. There are many other journals dedicated to specific areas of the field, which may, when considered in totality, provide different results. Yet the work provides a reasonable glimpse of the works in the field of ecology, using reputable journals indicating the direction in which the field is

trending. It will be interesting to replicate this work in a few years from now, incorporating more journals, to observe the changes in publication patterns in this discipline. It must be stressed that the discipline and topic studied during the period for the three journals (which can be extended to any publication in any discipline) will follow the course of the funding agency and the parent organizations.

The authors are convinced that the trends evinced in such findings would broadly reflect trends in the dynamic discipline of ecology.

ACKNOWLEDGEMENTS

We are grateful to Dr. R. Sevukan, Head & Associate Professor, Department of Library and Information Science, Pondicherry University, Puducherry for his valuable suggestions. We would like to thank the editor and two anonymous reviewers for their valuable and fruitful comments on the earlier version of the manuscript.

REFERENCES

Ajiferuke, I., Burrel, Q., & Tague, J. (1988). Collaborative coefficient: A single measure of the degrees of co-authorship in research. *Scientometrics, 14*(5-6), 421-433.

Arunachalam, S., & Manorama, K. (1988). How good are Indian ecology journals? *Journal of Information Science, 14*(3), 175-179.

Biradar, B. S., & Mathad, S. (2000). Bibliometric analysis of ecological literature. *SRELS Journal of Information Management, 37*(3), 199-214.

Borgman, C. (1989). Bibliometrics and scholarly communication: Editor's introduction. *Communication Research, 16*(5), 583-599.

Bradford, S. C. (1934). Sources of information on specific subjects. *Engineering: An Illustrated Weekly Journal, 137*, 85-86.

Budilova, E. V., Drogalina, J. A., & Teriokhin, A. T. (1997). Principal trends in modern ecology and its mathematical tools: An analysis of publications. *Scientometrics, 39*(2), 147-157.

Dhiman, A. K. (2012). *h-index - A superior tool over Impact Factor to assess individual contribution*. Paper presented at the Metrics Based Research Assessment and Evaluation: Proceedings of the National Workshop on Using Different Metrics for Assessing Research Productivity, New Delhi.

Feather, J., & Sturges, P. (Eds.). (1997). *International encyclopedia of Information and Library Science.* London: Routledge.

Garfield, E., Paris, S., & Stock, W. (2006). HistCite: A software tool for informetric analysis of citation linkage. *Information - Wissenschaft und Praxis, 57*(8), 391-400.

Goodland, R. J. (1975). The tropical origin of ecology: Eugen Warming's Jubilee. *Oikos, 26*(2), 240-245.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National Academy of Sciences of the United States of America, 102*(46), 16569-16572.

Karpagam, R., Gopalakrishnan, S., Babu, B. R., & Natarajan, M. (2012). Scientometric analysis of stem cell research : A comparative study of India and other countries. *Collnet Journal of Scientometrics and Information Management, 6*(2), 229-252.

Lawani, S. M. (1980). *Quality collaboration and citations in cancer research: A bibliometric study.* Ph.D. Dissertation. Florida State University, USA.

Liao, J., & Huang, Y. (2014). Global trend in aquatic ecosystem research from 1992 to 2011. *Scientometrics, 98*(2), 1203-1219.

Lotka, A. J. (1926). The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences, 16*(12), 317-325.

Pao, M. L. (1985). Lotka's law: A testing procedure. *Information Processing and Management, 21*, 305-320.

Parker, J., Allesina, S., & Lortie, C. (2013). Characterizing a scientific elite (B): Publication and citation patterns of the most highly cited scientists in environmental science and ecology. *Scientometrics, 94*(2), 469-480.

Pritchard, A. (1969). *Statistical bibliography: An interim bibliography*. London: New Western Polytechnic School of Librarianship.

Rowlands, I. (2005). Emerald authorship data, Lotka's law and research productivity. *Aslib Proceedings, 57*(1), 5-10.

Saravanan, G., Dominic, J., & Savithry, T. K. (2013). *Re-*

search trends in tropical ecology 2007-2011: A bibliometric analysis. Paper presented at the Libraries in the Changing Dimensions of Digital Technology Festschrift in Honour of Prof. D. Chandran, Professor & Head, Department of Library and Information Science, S.V. University, Tirupati, New Delhi.

Sengupta, I. N. (1985). Bibliometrics: A bird's eye view. *IASLIC Bulletin, 30*(4), 167-174.

Stiling, P. (1999). *Ecology: Theories and application*. Upper Saddle River: Prentice Hall.

Subramanyam, K. (1983). Bibliometric studies of research collaboration: A review. *Journal of Information Science, 6*(1), 33-38.

Thanuskodi, S., & Venkatalakshmi, V. (2010). The growth and development of research on ecology in India: A bibliometric study. *Library Philosophy and Practice (e-journal)*, 359. http://digitalcommons.unl.edu/libphilprac/359.