A Bibliometric Analysis of Environmental Communication for the 21st Century - Rob Powers

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1 author:

Robert Powers
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Sheffield Hallam University

Faculty of Arts, Computing
Engineering and Sciences
City Campus
Howard Street
Sheffield S1 1WB

MA in Technical Communication
Master's Dissertation

Title	**A Bibliometric Analysis of Environmental Communication Research for the 21st Century**
Author	*Robert Powers*
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Introduction

Note: In this paper, important points or terms are emphasized in **bold**.

This paper addresses the following two research questions:

Q1. What recent changes were there in the field of Environmental Communication as reflected in peer-reviewed academic research published between 2001 and 2012?

Q2. What was the impact of new peer-reviewed journals on this field?

Q1 : Recent Trends in Environmental Communication

Environmental Communication (EC) applies communication theory to environmental issues. The rapid emergence of EC research in the late-twentieth century coincided with an, "enormous growth in public and media attention directed toward [environmental issues]" (Pleasant et al. 2002, p.202). However, in the first decade of the 21st century, the focus on environmental issues seems to have shifted to other pressing issues, such as global terrorism and economic turmoil. Given this loss of focus, it might be assumed that the growth of EC research would have slowed. This paper tests this assumption through a quantitative analysis of recent publication trends in EC research. More specifically, I collected and analyzed a sample of academic articles published over a twelve-year period (2001-2012).

Note: The twelve year study period was established for the following reasons. The previous study on this topic (Pleasant et al. 2002) collected data up to 2000 and therefore it seemed logical to begin collecting data in 2001. Also, as this study was conducted in 2013, complete citation data was only available up to 2012. These two factors determined the study period.

Given the assumption that EC research is still a small but emerging field of research, it seems logical to expect that it would not support a large community of researchers. Therefore, I expect to see only a few authors contributing multiple articles to the bibliographic sample. In addition, given that EC research presumes a certain level of public debate concerning environmental issues, it would tend to be concentrated in democratic countries, which promote liberal values that support such public debate. Therefore, I expect that the majority of EC research will occur in developed countries that have a history of environmental debate.

Q2 : Environmental Communication Journal Impact

As described in the Prologue, prior to 2001, EC research was fragmented among numerous journals. To address this fragmentation and encourage greater collaboration among EC researchers, Pleasant et al. (2002) proposed the introduction of a dedicated EC research

publication. Several years later, two new peer-reviewed EC journals were introduced and therefore this second research question attempts to gauge the impact of these new EC journals.

To answer this question, I examine the citation data trends during the study period (2001-2012) for any conspicuous effects. Prior to performing this analysis, I expected to see a significant increase in paper output due to the launch of the new EC journals. An increase in author collaboration was also expected, as measured by an increase in the number of authors per paper. Finally, I expected to see a consolidation of EC research into the new EC journals.

The evidence presented on this topic may provide a point of departure for future bibliometric research. To this point, I have not found any similar research that addresses the influence of a new journal on an emerging interdisciplinary field. As this question may represent an unexplored area of bibliometric research, it could have broad applications for future investigations into other emerging fields across the spectrum of academic endeavor.

Literature Review

Prologue

While conducting a preliminary survey of Environmental Communication (EC) topics during my initial thesis proposal investigations, I encountered an article by Pleasant et al. (2002), 'The Literature of Environmental Communication'. This article provides an overview of the EC literature based on a bibliography collected using keyword searches of social science citation indexes. Using this bibliography, they conducted a frequency analysis by year, author, journal and keyword. One major finding of this article was the phenomenal growth in the EC field prior to 2001. This finding inspired the first thesis question, Q1 : Recent Trends in Environmental Communication.

This article also inspired the second thesis question, Q2 : Environmental Communication Journal Impact. Prior to 2001, EC research was quite fragmented, as there were no peer-reviewed journals devoted exclusively to EC content, such that relevant papers was spread throughout a number of non-EC specific journals. To address this finding, Pleasant et al. (2002) proposed the introduction of a new peer-reviewed journal dedicated to the dissemination of interdisciplinary EC research. They proposed that such a journal would be beneficial, as it would, "improve the growth, development, and dissemination of EC research" (Pleasant et al. 2002, p.205). Soon after this proposal was made, two new EC journals were launched. The first journal, *Applied Environmental Education and Communication*, was introduced in late 2002 by a consortium of environmental education and communication associations.[1] The second publication, started in 2004 as an annual production called the *Environmental Communication Yearbook*, and was later retitled *Environmental*

[1] AEEC Home Page - http://www.aeec.org/ (accessed 1.20.13).

Communication: A Journal of Nature and Culture, and its publication frequency increased to a quarterly format in 2007, with both incarnations of this publication under the auspices of the International Environmental Communication Association (IECA).[2]

Note: Since just over thirty percent of the records in the bibliometric database (45 papers in total) are from *Environmental Communication*, the analysis presented herein focuses on this journal, rather than *Applied Environmental Education and Communication*, which is represented by only two papers in the database.

Prior to the introduction of these two journals, the field was not totally without dedicated publication outlets. For example, the bi-annual proceedings of the Conference on Communication and the Environment (COCE)[3] contain collections of related literature in two-year increments back to 1991. A citation to a recent conference proceeding can be found in the bibliography (Seitz et al. 2010). Although an analysis of these conference proceedings would no doubt provide valuable insights, this material is not directly comparable with the research performed by Pleasant et al. (2002), which focused exclusively on peer-reviewed journals, and is therefore ignored in this analysis.

This thesis can be considered an extension of the work of Pleasant et al. (2002), not only because their findings provide the historical framework behind the two thesis questions presented in the Introduction, but also because their paper led me to adopt a **Bibliometric** approach. Performing an analysis of the literature using bibliometric methods seemed an efficient use of time and resources. My initial plan was to use the same methodology as Pleasant et al. (2002) and simply extend their data set. However, due to my unfamiliarity with standard bibliometric methods, there remained some uncertainty regarding the reliability and validity of their methodology. Fueling these doubts, one longtime EC researcher (Cantrill 2011), expressed his concern personally about the comprehensiveness of their data collection methods. Therefore, it seemed of paramount importance that I learn more about bibliometrics to lay a solid foundation of understanding for my research. As a result, the Literature Review is focused more on methodology than the EC research topic itself.

Given the scarcity of bibliometric research on the specific topic of EC research, a literature review was conducted with a wider scope. Besides the papers mentioned in the Bibliometrics subsection below, I have also consulted bibliometric research in fields closely related to EC. This was prudent since bibliometric research tends to be field specific, such that research in different fields yields dissimilar results (Pendlebury 2008, p.5). As a result, the following bibliometric studies of communication research informed both the design and analysis of this paper: Barnett et al. (2011), Feeley (2008), Feeley and Moon (2010), Park and Leydesdorff (2009), Pleasant et al. (2002), Reinsch and Reinsch (1996). In terms of bibliometric studies of

[2] IECA Home Page - http://theieca.org/journals (accessed 1.20.13).
[3] COCE proceedings are available online at http://www.esf.edu/ecn/coce.htm.

environmental research, I have only found the following source to date, de Souza & Barbastefano (2011), which is still quite interesting and applicable since it addresses another fast growing environmental field, namely life-cycle analysis. Qualitative literature, such as that by Popoff (2006), was also consulted in the process of this literature review. This material provided valuable background information, divergent perspectives, and, in general, functioned as a counterweight to the preponderance of quantitative research consulted; in other words, it was used for the purpose of triangulation (Jick 1979).

Environmental Communication (EC)

As discussed in the Prologue, the Literature Review focuses on Bibliometrics rather than EC research. To summarize, Bibliometric methods were selected in lieu of a traditional literature review due to time constraints and personal preference. Furthermore, it was my initial desire to approach this topic in an unbiased way, i.e., as a disinterested outsider without a predetermined outlook. However, as the Literature Review progressed, it seemed that a preliminary investigation into the research topic was necessary for the data collection phase of the research. More specifically, as I was planning to collect data using keyword searches of the citation indexes, I needed some logical basis to formulate a list of keywords. Hence, I conducted a preliminary investigation of the EC subject matter, simply as a means of developing a keyword search list. In the end, I decided to use a single keyword search term based in part on the definition that I derive in this section (see the Invisible Colleges subsection for a more detailed discussion of this topic). The discussion that follows summarizes the findings of my preliminary investigation of EC.

In his textbook *Environmental Communication and the Public Sphere*, Cox (2009), a prominent authority in EC, subdivides the field into several subtopics. In the list below, I have relabeled Cox's subtopics, for the sake of conciseness, and regrouped them into the following seven categories based upon the affinity of their communication contexts:

1. Popular Culture & Green Marketing
2. Media and Journalism
3. Social Marketing & Advocacy
4. Collaboration & Conflict Resolution
5. Public Participation
6. Risk Communication
7. Rhetoric and Discourse

This list shows that EC encompasses many forms of communication taking place in various contexts (e.g., public hearings, direct action, and scholarly debate). This list also shows that EC generally follows the subdivisions of traditional communication theory while overlapping the traditional subject matter of other disciplines, such as social science, marketing and

politics. The EC subtopic list presented above also emphasizes the application of various modes of communication to address environmental issues. This final point suggests an inherent bias in the flow of scholarly work from communication theory into environmental practice. To reinforce this point, it would seem equally logical to subdivide the field into seven environmental subtopics. The following list presents one possible formulation:

1. Climate Change
2. Pollution Prevention
3. Resource Reduction
4. Species Extinction
5. Energy Policy
6. Sustainability
7. Environmental Science

This new list seems comprehensive, but it is also quite abstract and topical, whereas the use of concrete action words in the initial subtopic list (e.g., marketing, advocacy, collaboration, and discourse) suggests the importance of directed action to the field. These action words are key, since they reflect Cox's view that EC is an ethical activity, a view encapsulated in the query contained within the title of his highly-cited paper: 'Nature's "Crisis Disciplines": Does Environmental Communication Have an Ethical Duty?' (Cox 2007). From all of this we can infer that EC research is not conducted in a vacuum by disinterested participants; instead, its proponents see it as a means of making a practical impact in the world.

Using the logic presented above, I have derived the following working definition of EC:

> **Environmental Communication** applies communication theory to environmental issues.

This definition has the benefit of being both concise and comprehensive. For instance, it includes different frames of references, such as personal, interpersonal, corporate, and mass media communication contexts. It also encompasses the full range of verbal, textual, and visual communication modes. Therefore, the full-range of communication theories are included in this definition. This definition is also focused on the ethical aspect of EC, since the primary determinant for labeling a particular instance, or category, of communication as EC is in its application to 'environmental issues'. The verb 'applies' seems to strengthen the ethical aspect of the definition, as it emphasizes the actions of the field, over mere theories or issues. All these characteristics correspond well with those that I identified in the initial subtopic list, which makes me confident in the use of this definition.

Bibliometrics

Bibliometrics is one of several terms (e.g., Webometrics, Scientometrics, and Informetrics) applied to the systematic study of communication artifacts using quantitative methods. Webometrics applies similar methods to the study of the Internet. Scientometrics shares much with Bibliometrics, but constrains itself to the study of scientific research output and related policy matters; whereas Bibliometrics is more flexible in its subject matter, as it has also been applied in the Humanities. Scientometrics can be considered a sub-discipline of Bibliometrics; while Informetrics is used as an umbrella term that subsumes all these associated fields.

In the past, Bibliometrics has focused on Science rather than the Humanities. This is not simply a consequence of an affinity of methods, i.e., quantitative, but also due to its reliance on Science Citation Indexes for data. The following section (see SCI Databases) provides a brief synopsis that may elucidate this latter point more clearly. Despite this bias, Bibliometric methods are increasingly being applied to other areas of research, including the humanities. The popularity of bibliometric methods can likely be ascribed to its reliance on objective methods. As one introduction to the field states that, "Bibliometrics turns the main tool of Science, quantitative analysis, [in] on itself" (Pendlebury 2008, p.2).

> "Quantitative analysis of research is **global in perspective**, a 'top-down' review that puts the **work in context**, complementing the **local perspective** of peer review. Quantitative research analysis provides data on all activity in an area, summaries of these data, and a comprehensive perspective on activity and achievements. **Weighted quantitative measures**, such as papers per researcher or citations per paper, remove characteristics, such as the place of production, or past reputation, that color **human perceptions of quality**" (Pendlebury 2008, p.3)

To summarize this quote, the benefits of quantitative analysis are its **comprehensive**, **complementary** and **impartial** nature. Other researchers have cited other benefits to using Bibliometrics, namely, that it is, "economical, accessible, and easy to implement … permits rapid intertemporal comparisons … is capable of examining a higher representation of the universe under investigation (and) adapts well to international comparisons." (de Souza & Barbastefano 2011, p.564)

However, due to its dependence on advanced numeracy, Bibliometrics is not always easily understood or trusted by those outside the discipline. Indeed, the same could probably be said for any quantitative methodology. This characteristic also makes its findings susceptible to misuse by those with an agenda. These two aforementioned disadvantages were obtained from the following quote (disadvantages in **bold**):

> "**Numbers alone can be dangerous** because they have the appearance of being authoritative. **In the face of statistics, many discussions stop.** And that is unfortunate: numbers instead should fuel discussions and help illuminate features in the research landscape that might otherwise be overlooked. And when the purpose of pursuing quantitative analysis of research is for 'window dressing' or to **prove to policymakers, administrators, or funding agencies something decided upon even before the data are collected and analyzed**, such effort works against the true goal of the analysis" (Pendlebury 2008, p.4)

To mitigate possible negative effects from the analysis used in this paper, applied methods are described using the simplest terminology possible, given the complexity of the analysis. A complete discussion of the applied methodology is given in the following section.

SCI Databases

In *Bibliometrics and Citation Analysis* (De Bellis 2009), the author preconditions the rise of Bibliometrics upon the invention of the Science Citation Index (SCI). Although some preliminary Bibliometric research was conducted in the first half of the twentieth-century it was for the most part "neglected" due to a lack of "suitable historical and cultural conditions" (De Bellis 2009, p.10). According to Bellis, World War II provided the spark that ignited the flame of **Big Science**, epitomized by big budget projects supported by government and industry (e.g., Manhattan Project) (De Bellis 2009, p.11). As Big Science flourished under the auspices of public and private sectors, it gradually came increasingly under the influence of both cost accounting and public policy (e.g., NASA). In turn, the pressures on project administrators to justify growing research and development budgets was a primary driver in the rise of research quality measures derived from SCI databases.

The first and unarguably the most influential SCI database, was developed by the Institute for Scientific Information (ISI) under the guidance of its founder Eugene Garfield (De Bellis 2009, pp.37–38). For many years, its citation indexes were published in print format, but they are now available electronically by subscription. The organization Garfield founded was later sold to Thomson Reuters and its SCI databases are now rebranded as the ISI Web of Knowledge (WoK). In recent years, other citation databases have come into existence. Google Scholar and Elsevier's Scopus databases are the two main competitors to the WoK but their use in Bibliometrics remains limited, as researchers tend to use these two databases more as supplementary data sources. Therefore, the WoK database maintains a central position in bibliometric studies as the most trusted and traditional source of quality citation data.

From an Information Science perspective, organizing bibliographic databases by citation relationships (i.e., citations and references) augments traditional keyword searches with a set of bibliographic relationships (De Bellis 2009, p.41). Citation indexes allow researchers to

start with one reference and then move forward in time through a chain of citing articles to discover other related research (Pendlebury 2008, p.3). A citation database contains bibliographic records indexed and organized by their internal references, rather than more arbitrary subject classification schemes.

In bibliometrics research, it is assumed that items with shared references share a cognitive relationship with the cited document, and ipso facto, with each other. In this way, citation tracking can lead to an evaluation of research impact and influence for a "deeper understanding" of underlying "trends in context" (Pendlebury 2008, p.3,7). It has even been said that, "citations connect cited and citing authors in sociocognitive networks open to historical and evaluative judgement" (De Bellis 2009), which makes them useful sources of information for qualitative research. Over the years, citations have been evaluated by historical, sociological, semiotic and philosophical methods, as Bellis amply documents in his book. On the other hand, the citation data stored in SCI databases is probably best suited to quantitative evaluation.

Power Laws – Bibliometric Data Distributions

In chapter four of *Bibliometrics and Citation Analysis* (De Bellis 2009), the author introduces some of the mathematical regularities that have been discovered in bibliometric studies. In general, these so called 'laws' describe, with simple equations, the observed statistical skewness of most bibliographic data.

> "Their common denominator is a striking inequality in the pattern of the information processes under observation: a few authors turn out to be responsible for the largest portion of scientific literature in a given research field [**Lotka's Law**]; a few scientific journals seem to concentrate the literature required to satisfy their needs [**Bradford's Law**]; and a relatively small number of recurrent word units govern their … linguistic habits [**Zipf's Law**]. In more abstract, albeit crude terms, what those regularities assert is that unlike most natural phenomena, as far as the information processes discussed above are concerned, no average productivity value is more likely than any other to have the remaining values neatly distributed around it, but many low-productive sources tend to coexist with few highly productive ones, so the overall source-item frequency distribution is markedly skewed, conforming to a hyperbolic pattern conveniently described by a power law" (De Bellis 2009, pp.76–77)

So, in Bibliometrics studies, it can be assumed that the statistical distribution of author or journal performance on any given subject is not represented by a Normal distribution (Gaussian) but is better described by a power law distribution: $f(x)= ax^n$.

Note: For more sources related to the history of Bibliometrics and its power laws, see Hood and Wilson (2001).

Citations and References – Atomic Units of Bibliometric Analysis

How does a citation differ from a reference? Glänzel defines the relationship between these two terms (Bjurström 2011, p.19) from the perspective of the researcher, as follows: **references** are given while **citations** are received. The use of one term or the other is a matter of perspective; as they are really two sides of the same coin; since document *X* receives a citation from document *Y*, when *Y* makes reference to *X*. Thus, although these two terms are not identical in meaning, they refer to the same unit of analysis (i.e. document *X*) and are thereby used somewhat interchangeably for the remainder of this discussion.

To reiterate, every citation (or reference) signifies a cognitive relationship between two documents. The nature of this relationship can be manifold, as it depends on the intentions of the researcher as expressed within the research paper. As Smith (1981, p.84, as cited by Eom 2009) relates, there are at least fifteen reasons to make reference to previous research:

1. Paying homage to pioneers
2. Giving credit for related works (homage to peers)
3. Identifying methodology, equipment, etc.
4. Providing background reading
5. Correcting one's own work
6. Correcting the work of others
7. Criticizing previous work
8. Substantiating claims
9. Alerting to forthcoming work
10. Providing leads to poorly disseminated, poorly indexed, or uncited work
11. Authenticating data and classes of fact— physical constants, etc.
12. Identifying original publications in which an idea or concept was discussed
13. Identifying original publications or other works describing an eponymic concept or term
14. Disclaiming work or ideas of others (negative claims)
15. Disputing priority claims of others (negative homage).

As seen in this list, references are communication devices primarily used to **deify**, **clarify**, or **decry** other research and/or **validate** one's own. As a result, articles receiving a large number of citations should not be considered as necessarily more 'popular' than other similar research, since individual citations can be either positive or negative in nature. Instead, such articles should be considered as having greater influence (**impact**) in the field, since many researchers feel the need to reference them.

Bibliometrics in Context

References are contained within research articles and these articles have been predominately published in peer-reviewed research journals. In turn, research journals contain various types of information within their pages. Some types contain valuable information, namely, "regular discovery accounts, brief communications (notes), and review articles", while "meeting abstracts (generally not much cited), letters to the editor (often expressions of opinion), and correction notices" generally do not. (Pendlebury 2008, pp.4–5).

Due to the time consuming nature of the submission, review and publishing process, there may be a considerable delay between the conclusion of research and its publication. Therefore, published research is often from several months to a year old when it is published. It then takes additional time, up to a year, for published research to make its way into SCI databases. Furthermore, once a piece of research is finally published, it then takes some time to be consumed and digested by the research community. For example, the authors of the Web of Knowledge (WoK) recommend, "at least five years of publications and citations, since citations take some time to accrue to papers" (Pendlebury 2008, p.4). The average time lag between initial publication and citation accumulation varies widely with the field of study. Hence, bibliometric studies cannot give an accurate picture of current research trends, but only historical information. In addition, different fields have different rates of citation such that two equally influential papers in different fields may have an order of magnitude difference (1:10) in citations accrued. "Even within the same field, one should not compare absolute citation counts of an eight-year-old paper with those of a two-year-old paper, since the former has had more years to collect citations than the latter." (Pendlebury 2008, p.5)

Invisible Colleges

In this paper, I assume that EC research is a unified academic discipline; and by this, I mean that EC research is conducted by a single community of researchers. This type of community is often referred to in the bibliometric literature as an **invisible college** (Price & Beaver 1966; Merton & Garfield 1986). In the standard definition, invisible colleges represent "the informal affiliation of scientists with common interests" … "across existing formal social structures" (Price (1961,1963) as cited by Lievrouw 1989, pp.618–620). In this definition, scientists are understood to be elite researchers "embedded" within formal institutions. In reaction to this formulation, Lievrouw (1989, p.622) de-emphasized the structural aspects by redefining the term from a communication perspective, as "a set of informal communication relations among scientists or other scholars who share a specific common interest or goal".

In an invisible college, the "interest or goal" must relate to the subject matter upon which the research community is focused. For example, chemists seek to understand chemistry, physicists physics, and linguists language. In turn, EC researchers seek to understand (and apply) EC. According to this logic, I must conclude that invisible colleges can be identified

solely by their corresponding research topic; and if all researchers in a specific field are members of the same invisible college, then there are no researchers with the same interest who are not also members of the same invisible college. Therefore, for any given research topic there is only a single corresponding research community. In other words, there must always be a 1:1 ratio between the number of invisible colleges and all active research topics.

Since I have now established that the research topic is the primary factor in the definition of an invisible college, I would modify Lievrouw's definition by removing the term "a set of informal communication relations", since these relationships seem like an incidental byproduct of the pursuit of the research goal. Of course, to function most effectively, an invisible college requires frequent communication between its members; but these 'communication relations' seem like an unnecessary part of the definition. For instance, it is easy to imagine a case where a scientist or scholar has no contact with other members of a research community and yet still manages to contribute to the research topic.

According to Lievrouw's definition, only 'scientists and scholars' are permitted membership in invisible colleges. I assume that only current and former professional researchers are eligible for induction. It also seems unclear how one would measure the shared level of 'interest' or 'goal'-seeking in a collection of researchers. These terms are quite vague and not operational. I assume here that a researcher must have successfully published at least one research paper on a topic, to be eligible for membership in an invisible college.

In the preceding paragraphs, I accepted some parts of Lievrouw's definition of an invisible college and rejected other parts. In its place, I propose the following revised definition:

> An **invisible college** is a community of professional researchers that have published research on the same topic.

According to this definition, the community of EC researchers forms an invisible college.

I will now discuss the relationship between an invisible college and its associated published research. As I have already established, an invisible college and its research topic form an inseparable union. Due to this, a keyword search in the academic literature for a specific research topic must return a search result that reflects the literature of the corresponding invisible college. Consequently, the information contained within the metadata of such a bibliometric sample can be used to describe the characteristics of the invisible college that produced it. It is for this reason that a search for the term **environmental communication** in peer-reviewed academic journals should logically return an accurate sample of papers from the EC research community. Ultimately, it is upon this theoretical basis that I justify the data collection methodology introduced in the section that follows.

Research Approach

The general approach is a positivist one with a particular reliance on bibliometric methods. At its core, bibliometrics involves the application of statistical analysis to academic literature. Along the way, I was guided by leading researchers in the field, such as Eugene Garfield, the founder of the ISI Web of Knowledge (Garfield 1971; Garfield 1980; Garfield 1998).

Paradigm

For the data collection and analysis phase, I adopted a strictly quantitative stance. Approaching the question from a quantitative paradigm, the first phase of my research utilized statistical methods, such as those of Pleasant et al. (2002). Related research published during the study period (2001 - 2012) was collected by conducting keyword searches of online indices (ISI Web of Knowledge and Elsevier's Scopus citation databases). For the data presentation and discussion phases, I used both quantitative and qualitative methods, quantitative methods to approach the bibliographic data and qualitative methods to explain the significance of the results within the EC research setting.

Validity & Reliability

To assure valid and reliable results, I used standard methods whenever possible. I also correlated my results with previous research, e.g., Pleasant et al. (2002).

Ethics

I am unaware of any significant ethical issues that impact my research. For example, there did not seem to be any ethical considerations regarding the collection and use of citation data. As an unpublished thesis, this paper is unlikely to have a significant distribution or impact. As a result, the potential external ethical stakes are quite low. On the other hand, to the extent that this research is well received, it could have potential positive effects for my career, especially if I decide to pursue work in the fields of data analysis or knowledge management. From a utilitarian perspective, this research may have significant positive implications on a personal level and most likely limited repercussions beyond my immediate relations and myself.

Methodology

In bibliometric research, commercial citation indexes are the traditional data source (Strotmann & Zhao 2010, p.194). Following this convention, data was collected using topical keyword searches in both the Scopus and ISI Web of Knowledge citation indexes. The resulting datasets were later cleansed, reformatted and merged into a single consolidated bibliometric database. This database was then analyzed with spreadsheet software. Statistical measures, such as cumulative totals, averages and standard deviations, were calculated on relevant factors, such as publication output, author collaboration and citations. Tables and

figures were also created to aid in the analysis and presentation of final results. These visual aids can be found in Appendix A. The following two sources were fundamental to the design, execution and analysis of the applied methodology: Pleasant et al. (2002) and Andrés (2009).

At the start of this analysis, I hoped to utilize more advanced bibliometric methods, such as co-reference, co-citation, and social network analysis. Visualization methods such as multi-dimensional factor analysis mapping might also have been advantageous. The paper by Vargas-Quesada et al. (2009) provides a summary of the application of visualizations to bibliometric investigations. Unfortunately, there was simply not enough time to apply these techniques, but the simple statistical analysis presented herein still yielded robust results.

Methods

Data Collection

Data collection proceeded over two rounds in February and June 2013, as described in the first two subsections of Appendix B : Methodology Notes. Both times, I performed the same keyword search for documents within the Web of Knowledge[4] (WoK) and Scopus[5] online citation databases. The keyword search was a topical search for the term **environmental communication** within the document title, abstract, and keyword (i.e. subject classification) fields of each citation database. In both databases, I filtered the results by published date (prior to 2013), but not by document type, and saved the search queries for future use and reference.

The justification for the keyword search method presented above is the premise that the boundaries of the EC research topic can be defined by the presence of a key topic phrase within the literature. In other words, I assume that the keyword search term **environmental communication** defines the boundaries of this research topic within the citation databases. See the end of the Invisible Colleges subsection of the Literature Review for my argument supporting this view. I also discuss this topic in the Data Collection subsection of the Results.

The rationale for using two citation databases (Scopus and WoK) can be summarized by the research motto "one database is not enough" (Mayr & Umstätter 2007, p.7). This motto succinctly encapsulates the empirical findings that any particular citation search in a single database yields only 40% of all relevant citations.

Using two citation databases should increase the yield above 40%, with the increased yield (Y_T) determined by the overlap between the two databases according to the following formula:

[4] http://apps.webofknowledge.com (accessed by institutional login on multiple dates)
[5] https://www.scopus.com/home.url (accessed by institutional login on multiple dates)

$$Y_T = \frac{(0.4 * 2)\ (Y_1 + Y_2 - Y_3)}{Y_1 + Y_2 + 2 * Y_3}$$

… where Y_1 and Y_2 represent the number of records collected from the two citation databases and where Y_3 represents the number of duplicate records between Y_1 and Y_2.

Data Management

Note: See Appendix B : Methodology Notes for details.

Following each round of data collection, I examined the data for consistency, deleted irrelevant records and merged duplicate records. Several copies of the collected data were also retained in the original export formats for redundancy. The data cleansing procedure was conducted using Zotero[6] reference management software and this database was exported to a spreadsheet for data analysis.

Data Analysis – Authors

Note: See Appendix B : Methodology Notes for details.

Data analysis began with a focus on author collaboration, as measured by the number of authors per article, a metric that I refer to as the author count (A#). The total, median, and standard deviation of the author count (A#) is shown in Table 1. The frequency distribution was then assembled and plotted in pie chart format, as shown in Figure 3. The average author counts (A#) per paper per year are presented in bar chart form in Figure 4 with a linear trend line and its equation. The distribution of papers by author count (A#) and by year is presented as a 3D bar chart in Figure 5. The most productive authors are listed in Table 2.

A discussion of this analysis is presented in the Authors - Collaboration, Authors – Productivity, and Authors - Geography subsections of the Results.

Data Analysis – References

Note: See Appendix B : Methodology Notes for details.

No analysis was performed on this data, as I could not find a suitable software tool (see related discussion in Data Analysis – BibExcel in Appendix B : Methodology Notes).

Data Analysis – Citations

Note: See Appendix B : Methodology Notes for details.

[6] See http://www.zotero.org/ for more details.

Data analysis continued with citation counts. The following metrics were calculated:

- Max Citations (**MCs**) – Most citations (using either Scopus or WoK citation counts)
- MCs per Years Published (**MCs/YP**) - Max Citations (**MCs**) divided by the number of years since publication (**YP**=2013-PY).
- Google Scholar Citation (**GSCs**) and **GSCs** per Years Published (**GSCs/YP**)

Statistics were then calculated on these metrics (see Table 3). The data was then grouped into value ranges and plotted (see Figure 6 and Figure 7). The top scoring articles for each metric are shown as Table 4, Table 5, Table 6, and Table 7.

Next, I prepared several charts to analyze these metrics over time. The first two charts show the number of papers (# Papers), MCs and MCs/YP for every year of the study period. The first chart (see Figure 8) shows these values for all journals while the second chart (see Figure 9) shows these same variables but only for a single journal: *Environmental Communication: A Journal of Nature and Culture*. The third chart (see Figure 10) is similar to the first chart except that it plots GSCs and GSCs/YP values. Next, I normalized the MCs/YP values shown in the first two charts by dividing each instance by the total number of articles published that year. Using this data, I created a fourth chart (see Figure 11).

A discussion of these figures is presented in the Citations - Statistics, Citations - Metrics, and Citations - Metrics x Time subsections of the Results.

Data Analysis – Journals

Note: See Appendix B : Methodology Notes for details.

The analysis continued with an examination of the journals that contributed EC articles. First, I created a summary table comparable to Tables 1 & 2 of Pleasant (2002), as shown in Table 8. I then added citation metrics based on the analysis in the previous section. The remainder of the journal analysis involved an investigation of high-citation journals, with the results presented in Table 9, Figure 12, and Figure 13.

These tables and figures are discussed in the Journals - Metrics subsection of Results.

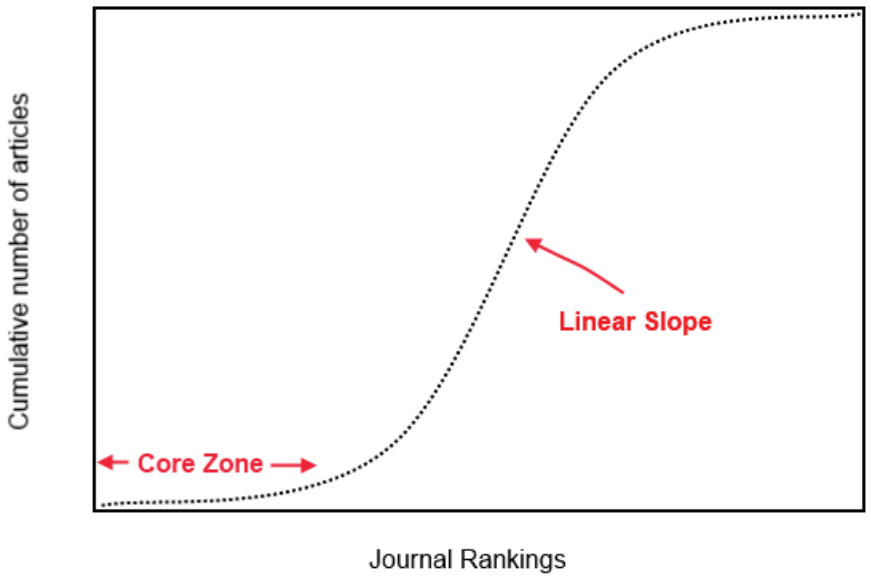
Data Analysis – Journals - Bradford Distribution

As quoted previously in the Power Laws – Bibliometric Data Distributions subsection of the Literature Review, for any given research field, " [only] a few scientific journals seem to concentrate the literature required to satisfy their needs" (De Bellis 2009). Samuel C. Bradford was the first to quantify this phenomenon, circa 1934. The Bradford Distribution is the counterpart to his Law of Scattering, also known as the 80/20 rule, i.e., 80% of citations occur in only 20% of published scientific research on any given topic. Since Bradford's Laws have been successfully applied in both the Sciences and the Humanities, in this paper I assume

that they also apply to EC research. In the process of developing this view and before applying the methods that follow, I consulted the following references (Leimkuhler 1967; Gupta et al. 1997; Mayr & Umstätter 2007; Nicolaisen & Hjørland 2007), which discuss both theoretical and practical aspects of the Bradford Distribution. I proceed by describing the general method involved in deriving a Bradford Distribution and then discuss my specific application of this method.

The Bradford Distribution is derived according to the following general method, as presented in *Measuring Academic Research* (Andrés 2009, pp.31–34). For any given research topic, a literature search is first conducted to produce a subject-specific bibliography. A list of journals is then compiled from this bibliography with journals ranked in ascending order by the frequency of occurrence. This ranking is also referred to as journal 'productivity'. Journals with equal frequency rankings (i.e. productivity) are then grouped and their article counts summed. Cumulative article totals are then calculated by ascending journal rankings. Next, the journal rankings (log x-axis) are plotted against the cumulative article totals (linear y-axis) to reveal the Bradford Distribution for the collected bibliography. In the ideal case, plotting the Bradford Distribution will reveal an S-shaped curve, as shown in Figure 4.3 in *Measuring Academic Research* (Andrés 2009, pp.31–34), and as replicated in Figure 1 below.

Figure 1 : Ideal Bradford Distribution (S-shaped Curve)
[Recreated from Figure 4.3 in *Measuring Academic Research* (Andrés 2009, pp.31–34)]



To reiterate, Figure 1 shows the cumulative article totals by decreasing journal productivity. As a separate but related part of Bradford's method, the ranked journal list is divided into an indeterminate but small number of zones with each zone containing an equivalent number of articles. Journals of equal productivity are assigned to the same zone. The zone containing the most productive journals is called the core zone. This zone is identified in the bottom-left

portion of Figure 1 with a slowly increasing slope on the S-shaped curve. According to Bradford's method, the number of journals in the non-core zones (zones 1,2,3,...) can be approximated by a ratio of $1:k:k^2:\ldots$ where k equals the number of journals in zone 1 divided by the number of journals in the core zone, while subsequent zones contain k times as many journals as preceding zones. The non-core zones occupy the remainder of the curve, beginning with the middle-region, which exhibits a near linear slope, as noted on Figure 1. The tail of the S-shaped curve mirrors the core zone, as it exhibits a slowly decreasing slope. When examining the Bradford Distribution, it is important to remember that the journal rankings on the x-axis use a logarithmic scale, so that the width of the core zone is exaggerated in comparison with non-core zones.

For this paper, I computed and compared the statistical fitness of the collected data to the ideal Bradford Distribution described above. I also performed the same analysis on the journal ranking data tabulated in Tables 1 and 2 of 'The Literature of Environmental Communication' (Pleasant et al. 2002, p.201). Although they used multiple keywords to compile a 'comprehensive' data set, while I compiled a limited dataset using a simple topical search, these are the only two papers on the topic of EC that share a bibliometric approach. Despite their differences, it was hoped that a comparison of the Bradford Distributions derived from these two disparate data sets might still prove instructive. For example, if there was a consolidation of the EC literature since 2000, this might be evident by a better fit to a Bradford distribution in the more recent data. In addition, since mature areas of research have been shown empirically to distribute journal articles in a Bradford Distribution, it follows that the relative maturity of an emergent field (such as EC) might be estimated by its fitness to the Bradford distribution. This same fitness might also support the claim that EC is a unified field of research (i.e., an invisible college), as I argue in the Invisible Colleges subsection of the Literature Review.

To derive the Bradford Distribution for both these datasets, I used the method described in chapter 4 of *Measuring Academic Research* (Andrés 2009, pp.34–37). This method applies the mathematical models derived by Leimkuhler (1967) and (Egghe and Rousseau 1986, 1990 as cited in Andrés 2009). The specific procedures and calculations are listed in Appendix C : Bradford Distribution Derivation. The output from steps 1-10 are recorded in Table 10 and Table 11. The chart prepared in step 11, is Figure 14. These results are discussed in the Journals – Bradford Distribution subsection of Results.

In non-ideal Bradford Distributions, i.e., those derived from actual data, there are two possible types of divergence from the ideal distribution, the journal articles can either be clustered in too few journals (i.e., overconcentrated) or scattered over too many journals (i.e., overdiluted), and these effects may be present simultaneously within different segments of the distribution. In the core zone, these deviations indicate whether the subject field is served by too many (overdiluted) or too few (overconcentrated) core journals. In non-core zones, these deviations

indicate the extent and manner in which relevant research is dispersed in non-core journals. For emerging fields, the observed Bradford Distribution may differ from the ideal for multiple reasons including insufficient/excessive number of core journals, a lack of established communication channels, competition (rather than cooperation) between researchers, or other non-equilibrium conditions. Unfortunately, due to the complex nature of the phenomena, the shape of the observed Bradford Distribution can only hint at underlying causes.

Data Analysis – Word Frequency

Note: See Appendix B : Methodology Notes for details.

Following the precedent set by Pleasant et al. (2002), I performed a word frequency analysis on the collected bibliographic metadata. This analysis was conducted on three data field types: Titles (TI), Abstracts (AB) and Author Addresses (AA1/2). Unlike the previous study by Pleasant et al. (2002), the Keywords (KW) data field was not analyzed; as the majority of records had null values for this field and the validity of the existing keywords was unknown.

Text analysis was conducted using an online text analysis tool called Voyant (Sinclair & Rockwell 2009), as shown in Figure 2 below. This tool was selected for its cost (free), ease of access (online), intuitive user-interface, and abundance of visualizations.[7]

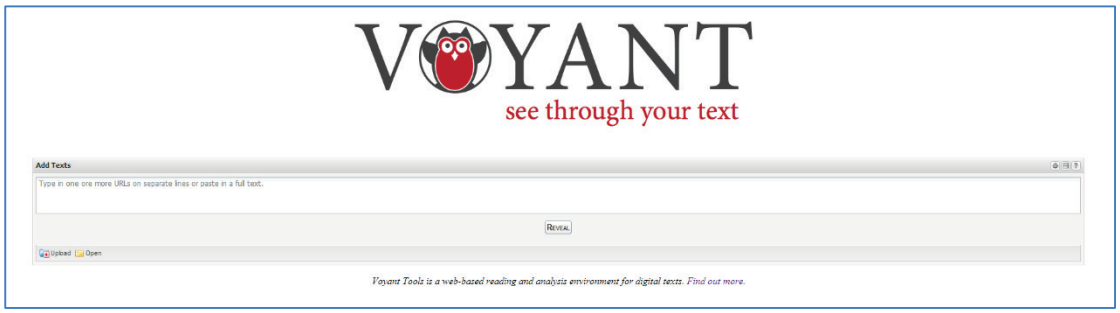


Figure 2 : Voyant Text Analysis Tool (Sinclair & Rockwell 2009)

The results of this text analysis are provided on a separate page for each data field type:

- Titles (TI): Table 12 and Figure 15
- Abstracts (AB): Table 13 and Figure 16
- Author Addresses (AA1/2): Table 14 and Figure 17

This analysis is discussed in the Word Frequency subsection of Results.

Data Analysis – Geographic Analysis

Once the Author Address word frequency analysis was complete, I decided to take the analysis a step further and geolocate the most frequent geographic terms. The first step in this

[7] An introduction to this tool is available @ http://hermeneuti.ca/voyeur. The list of available visualizations are provided @ http://hermeneuti.ca/voyeur/tools.

analysis involved geoparsing the same text input file I had analyzed previously using Voyant. For this purpose, I used another online tool, the Edinburgh Geoparser[8]. Within this tool, I uploaded the author address data, selected the geonames-local gazetteer, and geotagged the data. I then copied the geotagged output to a spreadsheet and populated the high-frequency geographic terms obtained previously with the corresponding latitude/longitude obtained from the Edinburgh Geoparser.

I then uploaded this spreadsheet data to the Google Maps Engine[9] to create a map of high-frequency geographic terms in the Author Address data. Using this initial map, I consolidated the data by conflating identical or similar reference data (e.g. USA, states). The final map identifies the most frequent geographic terms within the author address fields for the collected EC bibliography. One figure shows these locations on the globe (see Figure 18) while the other figure shows locations only within the continental United States (see Figure 19). Both of these figures were taken from the same Google Map and show the modified word frequency counts next to each location pin, which represent approximate locations only.

This analysis is discussed in the Authors - Geography subsection of Results.

Results

The first research question presented in the Introduction involves an assessment of recent trends in Environmental Communication (EC) research (see Q1 : Recent Trends in Environmental Communication). The second question concerns the impact of a new peer-reviewed journal on the field (see Q2 : Environmental Communication Journal Impact). To address these two questions, I first conducted a Literature Review on the topics of EC and Bibliometrics. Using the knowledge gained, I utilized Methods that involved the collection and analysis of bibliometric data derived from a set of EC articles published over a 12-year period (2001-2012). The final output of this bibliometric analysis is provided in Appendix A as a series of Tables and Figures. The following discussion explains the results presented in Appendix A, with the goal of answering the research questions presented in the Introduction and in the light of previous related research.

Data Collection

As explained in the Data Collection subsection of Methods, EC research papers were collected from two citation databases (WoK and Scopus) using a keyword search for the term **environmental communication** within the metadata of peer-reviewed articles. Initially, I adopted this keyword search method simply to circumscribe clear boundaries for the investigation. Later, I developed a supporting theory, as described in the Invisible Colleges

[8] Available @ http://scargill.inf.ed.ac.uk/geoparser.html
Description @ http://www.ltg.ed.ac.uk/clusters/Edinburgh_Geoparser.
[9] Available @ https://mapsengine.google.com/map/

subsection of the Literature Review. This data collection strategy is different from the exhaustive methodology presented by Pleasant et al. (2002), as they sought "to compile a relatively comprehensive and systematic account of the literature of environmental communication" (p199). I have pursued the opposite course by deliberately collecting a limited dataset of papers that are explicitly related to EC research. This approach was confirmed in practice; as it achieved a 95% rate of accuracy; with only eight articles discarded due to their irrelevance, as compared with a final sample size of 145 articles. As 57 of these vetted records were present in both citation databases (WoK and Scopus), I estimate that the total number of EC papers that meet the keyword search criteria should be in the range of 250 papers. Dividing the sample size by this total population estimate results in an estimated yield of 58% (145/250). The formula used to derive the estimated yield is shown in the final paragraph of the Data Collection subsection of Methods.

The missing papers can be accounted for by the imperfect nature of citation indexes. For example, the WoK has been criticized for its bias towards English-language journals and especially American publications (Bjurström 2011, p.26). This bias tends to exclude papers published in languages other than English. The WoK has also been criticized for its, "limited coverage of emerging interdisciplinary fields" which do not have a "clear core" because "research articles in these fields are published in a wide range of journals" (Strotmann & Zhao 2010, p.195). Since EC likely falls under the category of "emerging interdisciplinary fields" this may also be a contributing factor. Despite these missing records, research has shown that the relative completeness of a subject specific bibliography does not significantly affect some bibliometric attributes (Wilson 1998; Wilson 1999). As a result, I am confident that my bibliometric analysis remains valid.

Authors - Collaboration

As explained in the Data Analysis – Authors subsection of Methods, author collaboration is measured by the number of authors per article, which I refer to here as the author count (A#). In Table 1 and Figure 3, some general authorship statistics are presented. For the study period (2001-2012), there were 271 (non-unique) authors with an average author count (A#) equal to 1.87 authors per article.

The author count (A#) distribution is shown as a pie graph in Figure 3 with the raw data also shown in Table 1. This distribution summarizes the extent of author collaboration for the collected sample of EC literature. These results show that a slim majority of papers (54%) had only a single author, 23% two authors, 11% three authors, and 12% four or more authors. Similar results were presented by Pleasant et al. (2002, p.202) for the period prior to 2001: 62% one author, 24% two authors, 9% three authors, 5% four or more authors. These two data sets differ in that the current results show fewer (8% less) single author papers and more multiple-authored papers (8% more), which indicates an increase in author collaboration. The

next pair of figures present this same author collaboration data, with the added dimension of time. Figure 4 shows an irregular increase (see dotted trend line) in yearly average author collaboration (i.e. author count); while Figure 5 reveals a marked increase in multi-authored papers over the study period.

Authors – Productivity

Author productivity was first introduced as a dimension of analysis in the Data Analysis – Authors subsection of Methods. A list of the most productive authors is shown in Table 2 in descending order by number of articles published and by h-index. There seems to be a high-correlation between these two metrics with the top producing authors also having high h-index scores. These results show that the top three most productive authors only contributed three articles to the data sample; while on the next tier, 13 authors contributed just two articles each. These article counts are significantly lower than those reported by Pleasant et al. (2002, p.203 - Table 3) with many more authors contributing more than three articles. In addition, there seems to be no overlap between the authors listed in that paper and mine. These inconsistencies may be accounted for by, "the large number of articles in the risk-related journals" (Pleasant et al. 2002, p.202), since these journals do not dominate my data sample to the same extent. Looking at author affiliations in Table 2, exactly half (8 of 16) of these authors are associated with University Communication Departments. The author at the top of this list (Branden Johnson) is associated with a non-profit research organization.[10] The remaining seven authors are associated with University Environmental Programs.

Authors - Geography

In terms of geographic location, author address maps were prepared, as discussed in the Data Analysis – Geographic Analysis subsection of Methods. The list of top producing authors in Table 2 shows that exactly 75% (12 of 16) authors are located in the USA with the remainder in Germany, Australia, and Spain. The US authors in this table tend to be located in the West (CA, CO, MT, NM, OR, TX, UT), with only three located in the Northeast (MI, NC, NH). These same geographic trends were repeated in the maps produced from the text analysis of Author Address data for all authors. Figure 18 shows that EC research is concentrated in the USA, with some contribution from other developed countries, namely Australia, Canada, Hong Kong, Germany, UK, Spain, and Sweden. Figure 19 shows that the majority of US authors are located in the West, with the remainder located in the Northeast.

These geographic patterns may reflect the intensity of environmental debate at national and international levels. For example, the western United States contains the greater portion of natural resources and wilderness. As a result, environmental issues may be more contentious in this portion of the country, resulting in a need for EC research. Alternatively, researchers with an interest in EC may prefer to live in the West and as a result are concentrated in that

[10] See organization description @ http://www.decisionresearch.org/about/

half of the country. At the international level, more autocratic and/or developing countries may not foster the conditions for EC research in particular, or research in general. It is also true that the citation databases are biased towards journals published in English. However, this bias may not be unjustified due to both the relative quantity and quality of such scholarship.

Citations - Statistics

The next dimension to examine, after EC authorship, are EC citation patterns. As described in the Methods section, I collected citation data from Scopus, WoK and Google Scholar. I then constructed various metrics to aid in both article and journal level comparisons of the citation data, normalized and then validated these metrics.

The first set of citation statistics, includes raw citation counts (MCs and GSCs) and normalized citation counts (MCs/YP and GSCs/YP) which are both summarized in Table 3. Pearson Correlation Coefficients (*r*) for both pairs of citation metrics were in the range of 0.8, which indicates a strong correlation. Table 3 shows that 145 articles accrued 511 MCs and 1132 GSCs, a ratio of 1:2.22. The same set of articles collected 118 MCs/YP and 296 GSCs/YP, a ratio of 1:2.52. In both cases, the Google Scholar citation figures more than doubled the citation figures obtained from the standard SCIs (Scopus and WoK). The calculated GSC to MC ratios presented above correlates well with previous research (Meho & Yang 2007, as cited by Harzing 2008); and may be explained by additional, "conference papers, doctoral dissertations, master's theses and books and book chapters" in the GSC figures. Another factor that may skew these ratios involves the underreporting of small research fields and non-English literature in WoK citation data (Harzing 2008).

Citations - Metrics

Figure 6 is a clustered bar chart that shows the distribution of EC papers in six citation ranges. This figure shows that, of the papers that received at least one citation, the majority of papers accrued less than six citations, 57 in terms of MCs (39%) and 43 in terms of GSCs (30%). This was followed by a steep decline in the next citation range (6-10) with a leveling off in the last three citation ranges (11-15, 16-20 and >20). For these last three citation ranges and in terms of MCs, the papers in these ranges each collected four to five citations. For GSCs, the fourth (11-15) and fifth (16-20) citation ranges included eight and seven papers respectively, while the sixth range (>20) actually increased to include 17 papers. This last statistic is simply due to the over 2:1 ratio of GSCs to MCs, as described in detail in the previous paragraph, with papers in the lower citation ranges (6-20) in terms of MCs being pushed up into the highest citation range (>20) in terms of GSCs. The highest cited EC papers, as sorted by GSCs and MCs, are provided in Table 4 and Table 5.

Figure 7 is similar to Figure 6, however the citation ranges represent time normalized values (MCs/YP and GSCs/YP). As with Figure 6, the majority of papers received no citations at all,

62 in terms of MCs (43%) and 49 in terms of GSCs (34%). In terms of MCs/YP, there is a rapid decline in the number of papers in each range from a high of 48 (33%) of papers in the <1.0 range to a low of zero in the <6.0 range, with a slight uptick in the last range (>=6.0) with six papers. The GSCs/YP data follows the same general pattern as the MCs/YP data, but the paper counts are more irregular. The final range (>=6.0) represents highly cited EC papers, as sorted by GSCs/YP in Table 6 and MCs/YP in Table 7. In both tables, articles published in the same year are coded with the same color in the PY column. In these tables, there are no articles published prior to 2006, which seems to indicate that more recent articles have a higher impact than older articles. However, this conclusion may be premature based on the argument contained at the end of the next subsection.

Citations - Metrics x Time

The next set of results examine EC citation trends year by year over the study period. This set of results provides more details concerning the raw and normalized citation counts presented in the preceding paragraphs. These results also address the second research question, especially in terms of the *Environmental Communication* journal, which launched in 2007.

Figure 8 presents annual EC paper counts for all journals during the study period (2001-2012). This figure shows a low paper output for the first six years (2001-2006), with 5.2 papers per year on average. This is followed by a very significant increase in the last six years (2007-2012) with nearly four times as many papers published, 19.0 papers per year. Dividing the ratio between these two average annual paper outputs (19.0/5.2=3.68) by the number of years in the study period (12) we get an annual average growth rate for the study period of 31%. This is very close to the annual average growth rate of 32 % reported by Pleasant et al. (2002, p.201) for the 1985 to 1995 time period. However, the annual growth patterns within these two time periods are very different, as the 1985-1995 period grew steadily year-over-year while my data shows a small decline during the 2001-2005 timeframe (-3%), explosive growth (156%) in 2006-2007, and more subdued growth (12%) in 2008-2012.

These results suggest that, following fifteen years of steady growth from 1985-2000 (Pleasant et al. 2002), EC research plateaued in 2001-2005. This lack of growth could be explained by a loss of focus on environment issues during this period, as suggested in the discussion related to the first research question, see Q1 : Recent Trends in Environmental Communication in the Introduction. This lacklustre period was followed by a sudden jump in EC paper output in 2006-2007, which coincides with the introduction of the new EC journal: *Environmental Communication*.

A little more than half of the increase in paper output during the 2007-2012 period (+7.5 papers per year) is accounted for by the introduction of this new journal. Logically, the other half of the increase (+6.3 papers/year) must be accounted for by papers in other journals. I

presume that the increase in paper output in these other journals is related to the launch of the new EC journal. The new EC journal may have had a positive influence on researchers in other fields or perhaps the papers it rejected simply found their way into these other journals. Regardless, these results suggest a strong correlation between the introduction of the new EC journal and the growth observed in paper output in the last six years of the study period (2007-2012). This result was forecast in the discussion related to the second research question, see Q2 : Environmental Communication Journal Impact in the Introduction.

As shown in Figure 8 and Figure 9, the increase in raw citation counts (MCs) during the post-2006 period corresponds to the increase in EC paper output. Interestingly, in 2007, 82% of MCs (59/72) were accounted for by the new EC journal. However, this percentage dropped sharply to a low of just 7% (3/43) by 2011. During this time period the EC paper output remained relatively stable. This all suggests that the quality of journal content dropped during the first six years of publication (possible) and/or the journal suffered from poor management or declining interest during this period (more probable). Further investigation is required to determine the exact cause. As shown in Figure 10, during this same period, the raw citation count (GSCs) increased dramatically from a low of 122 in 2007 to a peak of 230 in 2009 and back down to 68 by 2012. The peak in 2009 is accounted for by a single article, 'Media Legitimacy And Corporate Environmental Communication', which represents the highest cited article in the database with a total of 136 GSCs, as shown in Table 4.

The normalized citation metrics (MCs/YP and GSCs/YP) tell a different story. Figure 8 shows steadily increasing MCs/YP values from 2005 to 2011 with a drop in 2012. The steady increase seems to indicate that EC papers received an increasing number of citations in successive years. However, after some consideration, I suspect that this result may be an artefact of the normalized citation metrics themselves. Since the majority of citations tend to accrue to papers soon after their publication, papers published in more recent years would tend to produce higher values, since their citation counts (MCs and GSCs) would be divided by a smaller (YP) value. The drop in the MCs/YP value in 2012 also occurs in the raw citation counts for that year. It is therefore likely that the articles published in that year are still in the process of collecting citations. As a result, I must conclude that these normalized citation metrics are likely not as useful as I had hoped, since they should not be used to compare articles (or journals) published in different years. However, this metric can still be used to compare different data sets within the same year.

Figure 11 : Normalized ∑ (Max Citations / Years Published) presents the MCs/YP values divided (i.e., normalized) by the paper counts in each year. Over the twelve-year period, this graph shows an increase (dotted trend line) in the values for All Other Journals (AOJ) and a steady decline for the new EC journal. If I am correct that the MCs/YP metric is biased towards more recent research then this explains at least part of the former trend, i.e.,

increasing values for AOJ. However, the latter trend, i.e., decreasing values for the new EC journal, indicates that it is in a downward spiral of irrelevancy for reasons unknown. As stated previously, a different form of investigation would be required to determine causal variables.

Journals - Metrics

Next, we move to the investigation of citation patterns at the journal-level. Table 8 lists all the journals found in the EC bibliographic database. These journals are sorted by the sum of the MCs of their contributing articles. *Environmental Communication* tops the list with 45 papers that collected 134 MCs, for an average of 2.98 MCs/paper. Compare this with the *Journal of Cleaner Production*, which contributed just three papers that collected 52 MCs, for an average of 17.33 MCs/paper. The median average for all journals with at least one citation is 4 MCs/paper, which puts the new EC journal in the lower half of journals for this metric. Pleasant et al. (2002, p.201) prepared a similar table which listed journals by the number of contributing articles. Only three of 17 journals from their table are also present in Table 8: *Risk Analysis*, *Science Communication* and *Public Understanding of Science*. This result provides strong evidence for a significant shift in EC publication patterns in the 21st century.

A new normalized journal-level MCs metric is also included in Table 8: (∑ MCs/YP) / ∑ #. This journal impact metric is introduced in the Data Analysis – Journals subsection of Methods, where I refer to it as the Synthetic Impact Factor (SIF). In Table 9, I compare these SIF values to JIF values for journals with ∑ MCs/YP values equal to or greater than two. The first Pearson Correlation Coefficient calculation shown at the bottom of this table (r = 0.33) indicates that there is only a weak correlation between the SIF and JIF metrics. The second Pearson Correlation Coefficient value (r = -0.63) shows a stronger correlation between the *Log (SIF-JIF)* values and the *Log (∑ #)* values which means that as the number of papers increases the difference between the SIF and JIF metrics also tends to decrease. A graphical representation of this relationship is shown by the trend lines in Figure 12 and by the solid lines in Figure 13. According to these results, I should be confident in the utility of the SIF metric. However, as I argued in the previous subsection, the time normalized citation metrics are suspect and therefore I must reject all of the analysis presented in this paragraph.

Journals – Bradford Distribution

Next, we move to a discussion of the actual and ideal Bradford Distributions. The derivation of the Bradford Distribution has already been explained in the Data Analysis – Journals - Bradford Distribution subsection of Methods. As a result, I need only explain the final output of this portion of the analysis, as represented in Figure 14. For the period prior to 2001 (Pleasant et al. 2002), the data presented in the figure (red) seems closely linked to the ideal Bradford Distribution (purple) along the entire extent of the curve. Since both axes in Figure 14 are plotted in log base 2 format, the S-shaped curve is flatter than it would appear with linear axes, as in Figure 1. For this data set, the core zone extends to the point just after the

cumulative paper count reaches 265, i.e. past journal rank 11, exactly where the cumulative journal count (r0) equals 20. In the core zone, the cumulative paper counts are slightly higher than would be expected in the first few journal ranks and then slightly lower than the ideal in the remainder of the core zone. The cumulative paper counts in the non-core zone are also slightly lower than the ideal Bradford Distribution predicts. This pattern indicates that prior to 2001 the EC literature was overconcentrated in the top three journals: *Risk Analysis*, *International Journal of Mass Emergencies and Disasters*, and the *Journal of Communication*.

For the period after 2001, the collected data presented in the figure (blue) diverges from the ideal Bradford Distribution (green) within the core zone. For this data set the core zone extends to the third data point (journal rank = 3) where the cumulative paper count reaches 57. Since the total number of articles in my data set (145) is much less than the total number of articles in the data set collected by Pleasant et al. (1083), the core zone is also smaller, both by journal rank (3, 11) and cumulative paper count (57, 265). In addition, unlike the previous data set, the cumulative paper counts are higher than the ideal Bradford distribution for the full extent of the core zone and up to journal rank 5, where the two curves meet. This pattern indicates that after 2001, the EC literature was overconcentrated in the top four journals: *Environmental Communication*, *Science Communication*, *Japan Tappi Journal*, and the *International Communication Gazette*. This result indicates that there may be room for the introduction of another core EC journal to distribute the journal articles in a more ideal distribution. A similar conclusion was reached in a retrospective Bradford Distribution analysis of the field of Informetrics (Mayr & Umstätter 2007). In this case, it would probably be best to wait for the field to mature to the point where a new journal is necessary, rather than simply possible.

Word Frequency

The final dimension of analysis involves word frequencies in article titles and abstracts. The author address results were presented previously in the Authors - Geography subsection, so they are not discussed in this subsection. The word frequency analysis was conducted following the procedures outlined in Data Analysis – Word Frequency. The results of the title field analysis are shown in Table 12 and Figure 15, while the results of the abstract field analysis are provided in Table 13 and Figure 16. The word clouds shown in the figures include all the terms in the tables, as they are based on the same word frequency analysis, and are included here as visual aids.

The high-frequency word lists shown in Table 12 and Table 13 have 18 words in common, including the following seven words, which are all within the top 10 words in both tables: **change**, **climate**, **information**, **media**, **public**, **research**, and **study**. As these seven words are those most likely to be found in both article titles and abstracts, they would seem to represent the most common concepts in the collected bibliography. The environmental term **climate**

change accounts for the majority of instances of the two constituent terms, i.e., **climate** and **change**, as it is found in 11 titles (8% of all articles) and 22 abstracts (15% of all articles). Likewise, **information**, **media**, and **public** seem to form a trio of communication related concepts. The final pair, **research** and **study**, are likely present in any collection of academic articles, as they describe academic activity. Two other shared terms, **approach** and **analysis**, seem to perform a similar linguistic function. The shared terms, **environment** and **communications**, can be disregarded, as they are simply variations on the keyword search terms, i.e., **environmental** and **communication**. After accounting for the first set of seven common words and removing four more, we are left with a second set of seven common (lower-frequency) words: **energy**, **issues**, **management**, **new**, **risk**, **science** and **sustainability**. The slightly vague word **issues** occurs 62 times in the abstracts, and 32 times, it is prefixed by the term **environmental**. The common words **energy**, **management**, **new** and **science** occur with roughly the same frequency (34-39 times) in the abstracts, as shown in Table 13. The last two common words **risk** and **sustainability** have the lowest frequency of the 18 most common words.

I now compare the word frequency results with similar information from Pleasant et al. (2002, p.204, Table 4). Comparing the words found in article titles, there are 19 new words in Table 12 including: **climate**, **change**, **corporate**, **crisis**, **research**, **energy**, **reporting** and **waste**. These new words may reflect rising trends in EC research. Similarly, eight words are missing from Table 12: **social**, **nature**, **community**, **coverage**, **ecological**, **policy**, **health**, and **mass**. These words may reflect fading trends in EC research. Table 12 contains 15 words in common with the previous study by Pleasant et al. (2002, p.204, Table 4). The following three common words experienced the largest rank increase: **study** (+13), **management** (+9), and **information** (+5). The following four common words experienced the largest rank decrease: **risk** (-21), **development** (-15), **science** (-13) and **news** (-11). These movements in word-frequency ranking may also point to rising and fading trends in EC research.

Alternatively, some of these results might also be explained by differences in the data collection methodologies. For example, the large decrease in table rank for the title word **risk**, can be explained by the greater number of articles (48) from the journal *Risk Analysis* in the data collected by Pleasant et al. (2002, p.201, Table 2); as compared to my dataset which contains only 3 articles from this journal. Therefore, although these word-frequency results are suggestive of changing trends in EC research, due to the methodological differences between the two studies, no definitive conclusions can be made.

Conclusions

EC Research

The topic of this thesis paper is Environmental Communication Research in the 21st Century. As defined in the Literature Review, Environmental Communication (EC) applies communication theory to environmental issues. I have shown that EC research is a rapidly growing field practiced by an interdisciplinary community of academics on a global scale. The foremost publications include the proceedings of the bi-annual Conference on Communication and the Environment (COCE)[11] and *Environmental Communication: A Journal of Nature and Culture*, with the latter publication being a major focus of this paper.

Bibliometrics

Bibliometric methods are quantitative in nature and can therefore be applied comprehensively, complementarily and impartially. Bibliometric studies also rely on accurate data sources, correct analysis and interpretation, and an audience with sufficient numeracy to interpret the results. For more on this topic see the Bibliometrics subsection of the Literature Review.

This paper leveraged Bibliometric methods in an analysis of EC research articles collected from the Scopus and Web of Knowledge citation databases. These methods were selected in lieu of performing a traditional literature review, as described in the introduction to the Environmental Communication (EC) subsection of the Literature Review.

EC Research Data

As described in the Data Collection subsection of Results, the selected keyword search method achieved a 95% rate of accuracy and an estimated yield of 58% of all EC journal articles published during the study period (2001-2012). The high rate of accuracy achieved seems to validate the supposition that a simple topical search for the term **environmental communication** would return a representative sample of EC research, as I argue in the Invisible Colleges subsection of the Literature Review.

As the estimated yield using these two citation databases (58%) is only 18% higher than the theoretical yield of 40% for one citation database, the marginal increase in yield seems rather low in comparison with the increased effort required in collecting and merging data from these two citation database sources. Due to these marginal returns, if similar research were to be conducted in the future, I would suggest selecting only one citation database source. Comparing the quality and comprehensiveness of both citation database sources, Scopus seems to be a better source of EC articles in comparison with the Web of Knowledge. I come to this conclusion after considering the problems associated with the WoK database, as outlined in the second paragraph of the Data Collection subsection of Results.

[11] COCE proceedings are available online at http://www.esf.edu/ecn/coce.htm.

EC Research Growth

During the study period (2001-2012), EC research grew rapidly as measured by the increase in total paper output. The average annual growth rate for this period was 31%, which is nearly identical to the 32% annual rate of growth from 1985 to 1995 (Pleasant et al. 2002, p.201). However, the growth patterns during these two time periods were dissimilar, as growth was steady prior to 2001, stalled between 2001-2005, grew rapidly from 2006-2007, and then slowed from 2008-2012.

The observed growth rates seem to match the assumptions and expectations made in the Introduction. In the first case (see Q1 : Recent Trends in Environmental Communication), EC paper output declined slightly during the 2001-2005 period and this may be due to a loss of focus on environmental issues during this period. In the second case (see Q2 : Environmental Communication Journal Impact), the rapid growth experienced in EC-related journal articles after 2005 correlates well with the launch of the new EC journal: *Environmental Communication*.

EC Research Authorship

Author collaboration, as measured by the number of authors per article, was the first characteristic of the collected sample of EC literature to be analyzed. As presented in the Authors - Collaboration subsection of Results, the author count (A#) was 1.87 authors per article. The author count distribution for the same period was equally split between single author and multi-author papers, as shown in Figure 3. In comparison with previous research on this same topic, Pleasant et al. (2002, p.202), the data showed fewer single author papers (8% less) and more multiple-authored papers (8% more), which indicates an increase in author collaboration between these two periods. The increase in author collaboration was even more evident within the study period, as shown in Figure 4 and Figure 5.

These results match the expectation expressed in the second research question (Q2 : Environmental Communication Journal Impact) that author collaboration would increase with the introduction of the *Environmental Communication* journal. Although the introduction of this new journal may not have been the only cause, it was likely the most significant contributing factor.

Author productivity was another dimension of analysis, as described in the Authors – Productivity subsection of Results, with the most productive authors listed in Table 2. The article counts for these authors were quite low in comparison with previous research, Pleasant et al. (2002, p.203 - Table 3). This result may be explained by the fact that my data sample was focused exclusively on EC research while the previous research paper by Pleasant et al. was dominated by journal articles from other fields, such as risk-analysis, which exhibit different publication trends. The fact that there was no overlap in authors between these two

papers lends credence to this notion. This result also fulfills the expectation that only a few authors would contribute multiple articles, as mentioned in the discussion related to the first research question (Q1 : Recent Trends in Environmental Communication).

Geographic authorship patterns are presented and explained in the Authors - Geography subsection of Results. The majority of EC authors are located in the United States and primarily in western States, as shown in Figure 19. As shown in Figure 18, other EC authors are located in Australia, Canada, Hong Kong, Germany, UK, Spain, and Sweden. These results match the expectation that EC research would tend to be concentrated in developed countries with a history of environmental debate, as predicted in the discussion related to the first research question (Q1 : Recent Trends in Environmental Communication).

EC Research Citations

As described in the Citations - Statistics subsection of Results, several metrics were constructed using citation data from the Scopus, WoK and Google Scholar databases. For these metrics, I found that the Google Scholar citation figures more than doubled the citation figures derived from the Scopus and WoK databases. This result was explained by the inclusion of additional document types in the GSC figures.

As presented in the Citations - Metrics subsection of Results, most EC articles received no citations, as shown in Figure 6. Conversely, only 13 EC articles (9% of total) received more than ten citations (MCs), as shown in Table 5. The time normalized citation metrics (MCs/YP and GSCs/YP) display a similar pattern to the raw citation count metrics. These results are not unexpected as they conform to the normal skewed pattern for bibliometric data, as discussed in the Power Laws – Bibliometric Data Distributions subsection of the Literature Review.

The highest scoring articles in terms of GSCs/YP and MCs/YP, are shown in Table 6 and Table 7 respectively. It seems that more recent articles have a high impact, as measured by the annualized rate by which these articles accrue citations, since there are no articles published prior to 2006 in these two tables. Figure 8 shows a similar pattern with steadily increasing MCs/YP values from 2005 to 2011. However, as described in the Citations - Metrics x Time subsection of the Results, these two results may simply be an artefact of the normalized citation metrics themselves. I conclude that the normalized citation metrics cannot be trusted and should therefore not be used to compare articles (or journals) published in different years. As a result, I also rejected the analysis in Table 9, Figure 12 and Figure 13.

Regarding the second research question (Q2 : Environmental Communication Journal Impact), the new EC journal seems to have had a significant impact on the field, as shown in Figure 8 and Figure 9. Referencing the data behind these tables, *Environmental Communication* collected 82% of all citations (MCs) in 2007, with its share of all citations (MCs) then quickly

dropping to a low of just 7% by 2011. This suggests that the quality of journal content also dropped during the first six years of publication and/or the journal suffered from poor management or declining interest during this period. This rapidly declining citation impact for the new EC journal is an unexpected result that warrants further study.

EC Research Journals

Citation metrics were also used to analyze journal impact, as described in the Journals - Metrics subsection of the Results. The new EC journal (*Environmental Communication*) is the top journal in terms of total citations with 134 MCs, as shown in Table 8. This result supports the expectation that this new EC journal would have a significant impact on the field, as discussed in Q2 : Environmental Communication Journal Impact.

The list of EC journals in Table 8 had only 3 journals in common with a similar table prepared by Pleasant et al. (2002, p.201), which may indicate a significant shift in EC publication patterns in the 21st century. The actual and ideal Bradford Distributions for the two time periods are presented in Figure 14. Prior to 2001, EC research was overconcentrated in the three journals: *Risk Analysis*, *International Journal of Mass Emergencies and Disasters*, and the *Journal of Communication*. From 2001 to 2012, EC research was overconcentrated in four journals: *Environmental Communication*, *Science Communication*, *Japan Tappi Journal*, and the *International Communication Gazette*. Due to this overconcentration, I conclude that there may be room for the introduction of another EC journal, but also that it would be best to wait until this becomes a necessity rather than just a possibility.

EC Research Topics

The word-frequency analysis is presented in the Word Frequency subsection of Results. The top words shared by both abstracts and titles were **change**, **climate**, **information**, **media**, **public**, **research**, **study, energy**, **issues**, **management**, **new**, **risk**, **science** and **sustainability**.

Comparing word frequency results with previous research (Pleasant et al. 2002) proved problematic due to differences in methodology, such that no definitive conclusions can be made concerning changing trends in EC research topics.

Final Reflections

This paper shows that simple bibliometric methods are useful for surveying fields of research. Through this research, I gained some limited understanding of EC research trends, in several analytical dimensions, including its growth as a function of paper output, journal distribution, author collaboration, and geographic patterns. However, I found the word frequency results difficult to interpret due to my ignorance of the research topic. As an outsider to the field, I was forced to interpret these results without much context, which was a major weakness.

Ironically, over the past few years, I have learned much more about Bibliometric methods than the Environmental Communication topic, since the Literature Review was focused on this methodology. I also learned that compiling accurate datasets is both vital and laborious work. Besides this, I learned that advanced bibliometric methods, such as co-citation analysis, are out of reach for novice researchers such as myself, due to the steep learning curve involved and the lack of functional software tools.

From a personal perspective, I found that I need tight deadlines to achieve maximum productivity, i.e., that I tend to procrastinate if given the chance. Although I enjoy research and analysis, I dislike academic writing due to the rigid formatting requirements and other conventions. In terms of my professional practice, I cannot see much value in this thesis work, unless I pursue academic writing, which is unlikely. Looking forward, I am still interested in Environmental Communication and Data Analysis as two possible career paths. This thesis work may still prove valuable if I decide to pursue one of these options in the future.

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Appendix A

Table 1 : Author Count (A#) Statistics

271	TOTAL
1.87	MEAN
1.20	STDEV

A#	∑A#	% of TOTAL
1	78	53.8%
2	34	23.4%
3	16	11.0%
4	11	7.6%
5	3	2.1%
6	3	2.1%

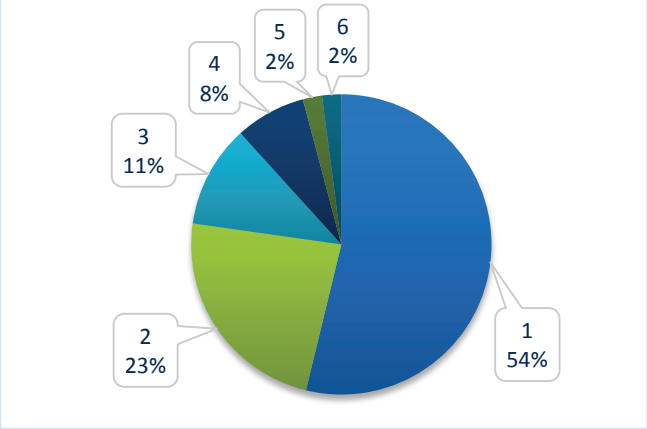


Figure 3 : Author Count (A#) Distribution

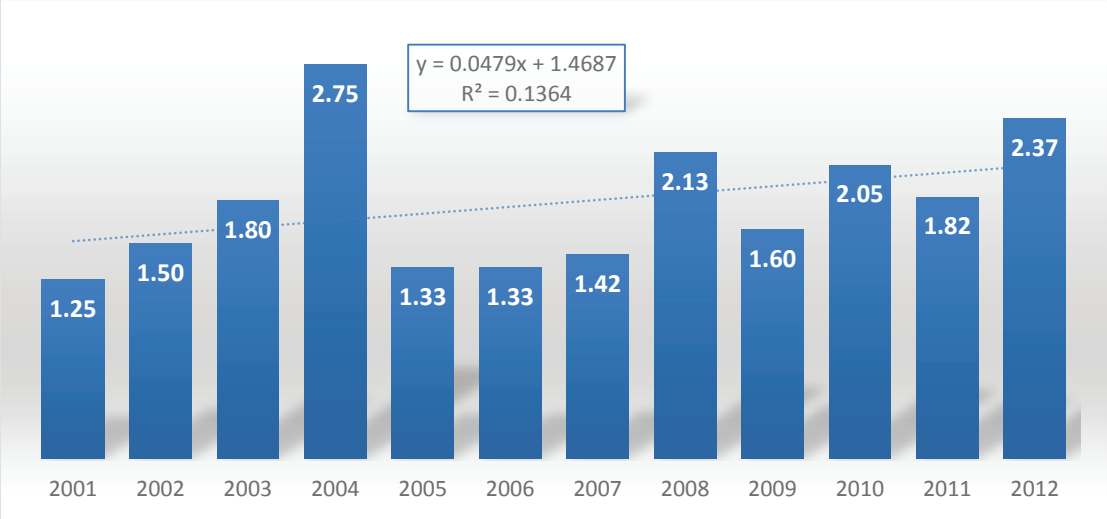


Figure 4 : Average Author Counts (A#) by Year

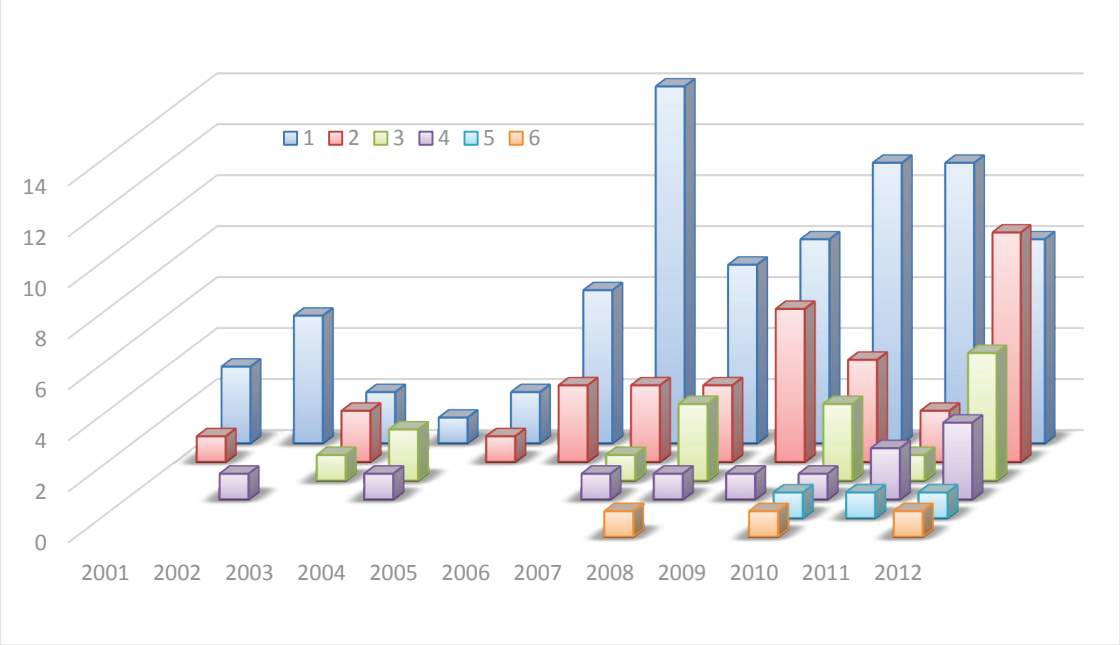


Figure 5 : Number of Papers by Author Count (A#) and by Year

Table 2 : Most Productive Authors

Author	Number of Articles	h-index	Affiliation	City	State	Country
Johnson, Branden B.	3	11	Decision Research	Eugene	OR	USA
Peterson, Tarla Rai	3	9	Texas A and M University, Department of Wildlife and Fisheries Sciences	College Station	TX	USA
Milstein, Tema	3	4	University of New Mexico, Department of Communication and Journalism	Albuquerque	NM	USA
Reusswig, F.	2	5	Potsdam Institut fur Klimafolgenforschung	Potsdam	-	Germany
Hart, Philip Solomon	2	4	University Michigan Ann Arbor, Department of Communication Studies	Ann Arbor	MI	USA
Endres, Danielle	2	4	University of Utah, Department of Communication	Salt Lake City	UT	USA
Peeples, Jennifer A.	2	3	Utah State University, Department of Languages, Philosophy, and Speech Communication	Logan	UT	USA
Lodhia, S.K.	2	3	University of South Australia, Centre for Accounting, Governance and Sustainability	Adelaide		Australia
Caron, Rosemary M.	2	2	University of New Hamsphire Durham, Department of Health Management and Policy	Durham	NH	USA
Clarke, Tracylee	2	1	California State University, Department of Communication	-	CA	USA
Besel, Richard	2	1	California Polytechnic State University, San Luis Obispo, Communication Studies Department	San Luis Obispo	CA	USA
Sprain, Leah	2	1	University of Colorado at Boulder, Department of Communication	Boulder	CO	USA
Schwarze, Steve	2	1	University of Montana, Department of Communication Studies	Missoula	MT	USA
Kinsella, William J.	2	1	North Carolina State University	Raleigh	NC	USA
Piñeiro, C.	2	1	Universidad Autónoma de Madrid, Departamento de Ecologia	Madrid	-	Spain
Díaz, M. J.	2	1	Universidad Autónoma de Madrid, Departamento de Ecologia	Madrid	-	Spain

Table 3 : Citation Statistics

Max Citations (MCs)		Google Scholar Citations (GSCs)		= GSCs / MCs
145	COUNT OF Max Citations	145	COUNT OF GSCs	
511	SUM of Max Citations	1132	SUM of GSCs	
3.52	AVERAGE of Max Citations	7.81	AVERAGE of GSCs	2.22
1.00	MEDIAN of Max Citations	3.00	MEDIAN of GSCs	3.00
6.43	STDEV of Max Citations	15.23	STDEV of GSCs	2.37
MCs/YP		**GSCs/YP**		**= GSCs / MCs**
145	COUNT OF MCs / YP	145	COUNT OF GSCs / YP	
118	SUM of MCs / YP	296	SUM of GSCs / YP	
0.81	AVERAGE of MCs / YP	2.04	AVERAGE of GSCs / YP	2.52
0.29	MEDIAN of MCs / YP	1.00	MEDIAN of GSCs / YP	3.50
1.46	STDEV of MCs / YP	3.92	STDEV of GSCs / YP	2.68

Pearson Correlation Coefficient (r) between MCs & GS	Pearson Correlation Coefficient (r) between MCs/YP & GS/YP
0.81	0.78

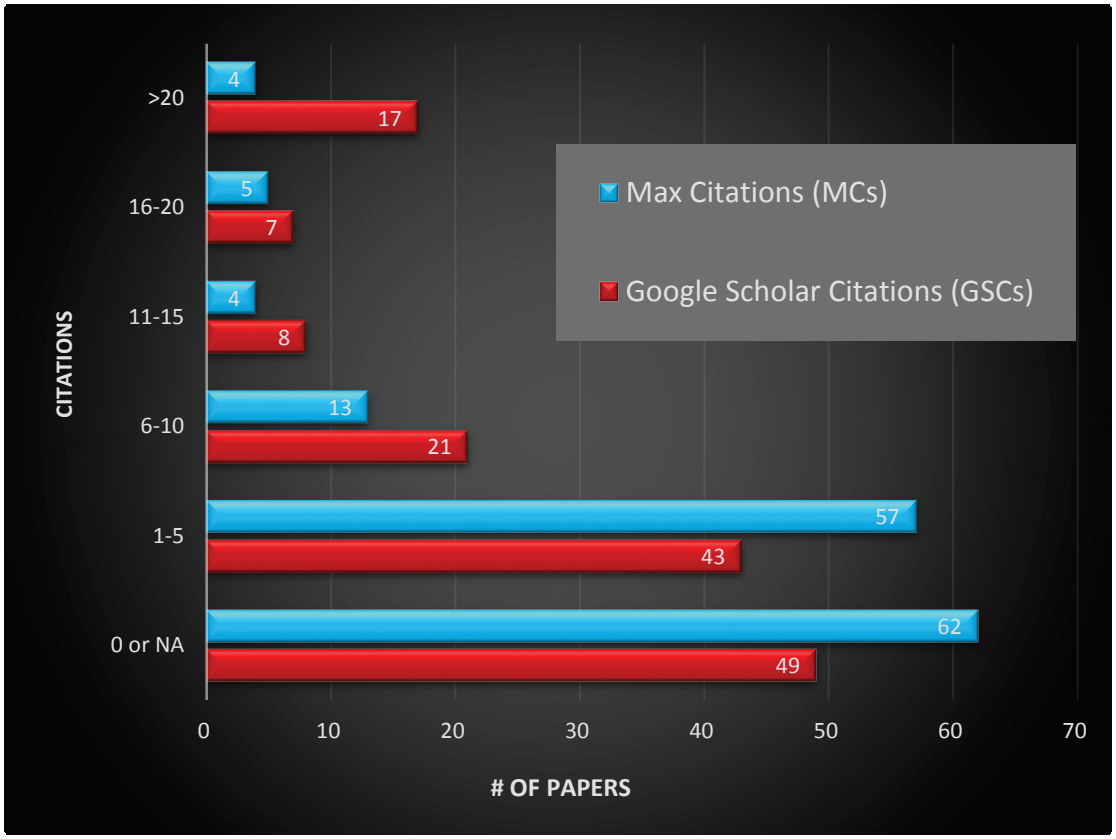


Figure 6 : Papers Grouped by Citation Ranges

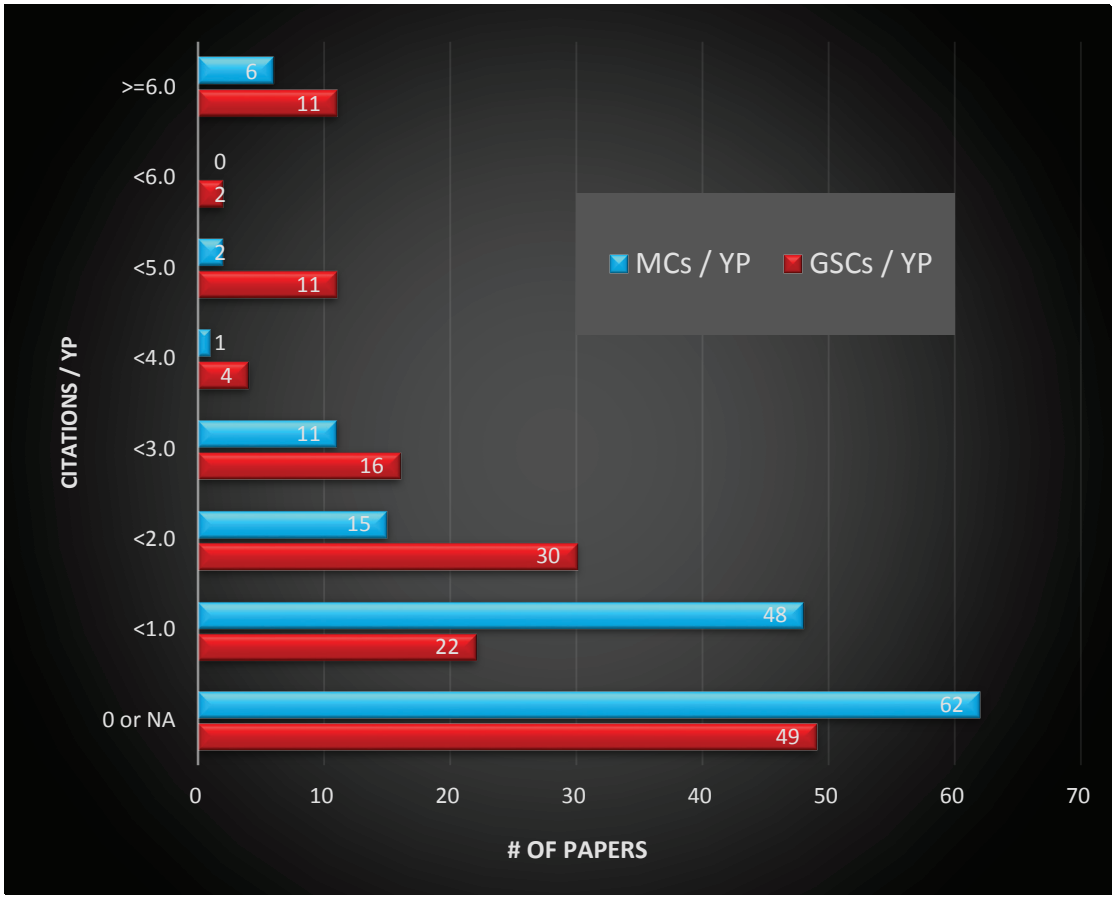


Figure 7 : Papers Grouped by Citations / Years Published (YP) Ranges

Table 4 : Articles with Highest GSCs (Google Scholar Citations)

Title	PY	Journal	Cited By (Scopus)	Times Cited (WoK)	Max Citations (MCs)	MCs / YP	Google Scholar Citations (GSCs)	GSCs / YP
Media legitimacy and corporate environmental communication	2009	Accounting Organizations and Society	36	32	36	9.00	139	34.75
The soft side of ecodesign	2006	Journal of Cleaner Production	42	28	42	6.00	75	10.71
From Environmental Campaigns to Advancing the Public Dialog: Environmental Communication for Civic Engagement	2010	Environmental Communication	18	13	18	6.00	46	15.33
Corporate environmental reporting media: A case for the World Wide Web	2004	Electronic Green Journal	12		12	1.33	39	4.33
Evaluating the effects of ideology on public understanding of climate change science: How to improve communication across ideological divides?	2010	Public Understanding of Science	18	13	18	6.00	32	10.67
How standard is standardized MNC global environmental communication?	2007	Journal of Business Ethics	9	9	9	1.50	32	5.33
Performing Critical Interruptions: Stories, Rhetorical Invention, and the Environmental Justice Movement	2001	Western Journal of Communication	17	13	17	1.42	32	2.67
An exploration of corporate attitudes to the significance of environmental information for stakeholders	2003	Corporate Social Responsibility and Environmental Management	20		20	2.00	29	2.90
Environmental management accounting: A case study research on innovative strategy	2006	Journal of Business Ethics	10	8	10	1.43	28	4.00
Consumer influence on internet-based corporate communication of environmental activities: The UK food sector	2005	British Food Journal	9		9	1.13	25	3.13
Exploring technical and cultural appeals in strategic risk communication: The Fernald radium case	2003	Risk Analysis	9	7	9	0.90	25	2.50
Stepwise environmental product declarations: ten SME case studies	2008	Journal of Cleaner Production	10	8	10	2.00	24	4.80
Communication, media and environment: Towards reconnecting research on the production, content and social implications of environmental communication	2011	International Communication Gazette	12		12	6.00	21	10.50
What environmental and technological risk communication research and health risk research can learn from each other	2009	Journal of Risk Research	9	1	9	2.25	21	5.25
Tipping Point Forewarnings in Climate Change Communication: Some Implications of an Emerging Trend	2008	Environmental Communication		12	12	2.40	21	4.20
Low-cost networking for dynamic window systems	2004	Energy and Buildings	8		8	0.89	21	2.33
Communicating air quality information: Experimental evaluation of alternative formats	2003	Risk Analysis	16	16	16	1.60	21	2.10
One or Many? The Influence of Episodic and Thematic Climate Change Frames on Policy Preferences and Individual Behavior Change	2011	Science Communication	5	4	5	2.50	20	10.00

Table 5 : Articles with Highest MCs (Maximum Citations)

Title	PY	Journal	Cited By (Scopus)	Times Cited (WoK)	Max Citations (MCs)	MCs / YP	Google Scholar Citations (GSCs)	GSCs / YP
The soft side of ecodesign	2006	Journal of Cleaner Production	42	28	42	6.00	75	10.71
Media legitimacy and corporate environmental communication	2009	Accounting Organizations and Society	36	32	36	9.00	139	34.75
Nature's "Crisis Disciplines": Does Environmental Communication Have an Ethical Duty?	2007	Environmental Communication		29	29	4.83	7	1.17
Conjoint analysis for environmental evaluation: A review of methods and applications	2008	Environmental Science and Pollution Research	5	21	21	4.20	0	0.00
An exploration of corporate attitudes to the significance of environmental information for stakeholders	2003	Corporate Social Responsibility and Environmental Management	20		20	2.00	29	2.90
From Environmental Campaigns to Advancing the Public Dialog: Environmental Communication for Civic Engagement	2010	Environmental Communication	18	13	18	6.00	46	15.33
Evaluating the effects of ideology on public understanding of climate change science: How to improve communication across ideological divides?	2010	Public Understanding of Science	18	13	18	6.00	32	10.67
Performing Critical Interruptions: Stories, Rhetorical Invention, and the Environmental Justice Movement	2001	Western Journal of Communication	17	13	17	1.42	32	2.67
Communicating air quality information: Experimental evaluation of alternative formats	2003	Risk Analysis	16	16	16	1.60	21	2.10
Corporate environmental reporting media: A case for the World Wide Web	2004	Electronic Green Journal	12		12	1.33	39	4.33
Communication, media and environment: Towards reconnecting research on the production, content and social implications of environmental communication	2011	International Communication Gazette	12		12	6.00	21	10.50
Tipping Point Forewarnings in Climate Change Communication: Some Implications of an Emerging Trend	2008	Environmental Communication		12	12	2.40	21	4.20
Interactional perspective on environmental communication in construction projects	2009	Building Research and Information	11	1	11	2.75	19	4.75
Environmental management accounting: A case study research on innovative strategy	2006	Journal of Business Ethics	10	8	10	1.43	28	4.00
Stepwise environmental product declarations: ten SME case studies	2008	Journal of Cleaner Production	10	8	10	2.00	24	4.80

Table 6 : Articles with Highest GSCs/YP (Google Scholar Citations / Years Published)

Title	PY	Journal	Cited By (Scopus)	Times Cited (WoK)	Max Citations (MCs)	MCs / YP	Google Scholar Citations (GSCs)	GSCs / YP
Media legitimacy and corporate environmental communication	2009	Accounting Organizations and Society	36	32	36	9.00	139	34.75
Go green! Should environmental messages be so assertive?	2012	Journal of Marketing	2		2	2.00	16	16.00
From Environmental Campaigns to Advancing the Public Dialog: Environmental Communication for Civic Engagement	2010	Environmental Communication	18	13	18	6.00	46	15.33
The soft side of ecodesign	2006	Journal of Cleaner Production	42	28	42	6.00	75	10.71
Evaluating the effects of ideology on public understanding of climate change science: How to improve communication across ideological divides?	2010	Public Understanding of Science	18	13	18	6.00	32	10.67
Communication, media and environment: Towards reconnecting research on the production, content and social implications of environmental communication	2011	International Communication Gazette	12		12	6.00	21	10.50
Promiscuous corroboration and climate change translation: A case study from the Marshall Islands	2012	Global Environmental Change-Human and Policy Dimensions	6	4	6	6.00	10	10.00
One or Many? The Influence of Episodic and Thematic Climate Change Frames on Policy Preferences and Individual Behavior Change	2011	Science Communication	5	4	5	2.50	20	10.00

Table 7 : Articles with Highest MCs/YP (Max Citations / Years Published)

Title	PY	Journal	Cited By (Scopus)	Times Cited (WoK)	Max Citations (MCs)	MCs / YP	Google Scholar Citations (GSCs)	GSCs / YP
Media legitimacy and corporate environmental communication	2009	Accounting Organizations and Society	36	32	36	9.00	139	34.75
From Environmental Campaigns to Advancing the Public Dialog: Environmental Communication for Civic Engagement	2010	Environmental Communication	18	13	18	6.00	46	15.33
The soft side of ecodesign	2006	Journal of Cleaner Production	42	28	42	6.00	75	10.71
Evaluating the effects of ideology on public understanding of climate change science: How to improve communication across ideological divides?	2010	Public Understanding of Science	18	13	18	6.00	32	10.67
Communication, media and environment: Towards reconnecting research on the production, content and social implications of environmental communication	2011	International Communication Gazette	12		12	6.00	21	10.50
Promiscuous corroboration and climate change translation: A case study from the Marshall Islands	2012	Global Environmental Change-Human and Policy Dimensions	6	4	6	6.00	10	10.00

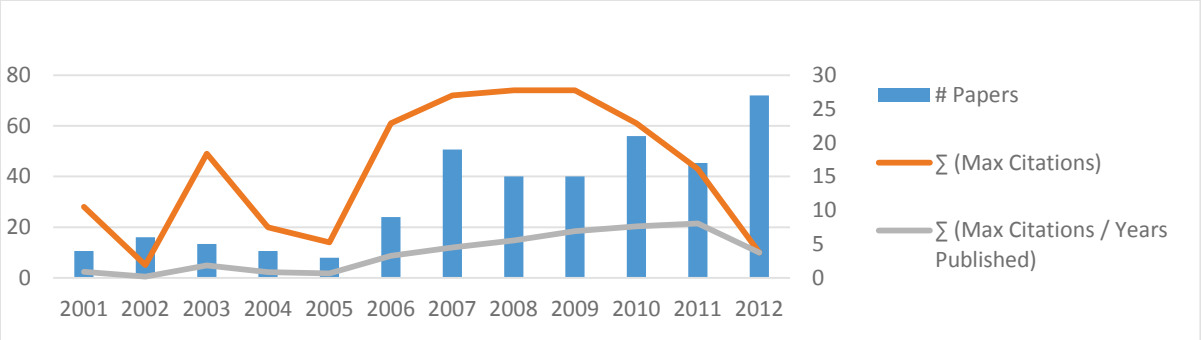


Figure 8 : Papers and Citations (All Journals)

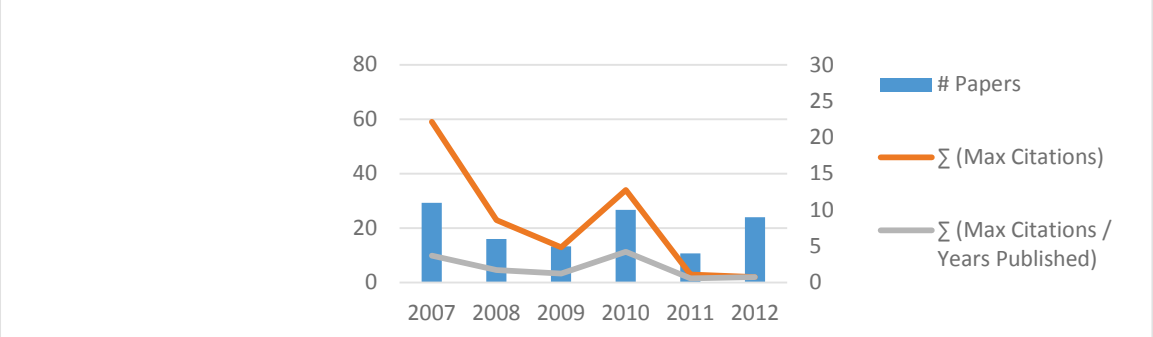


Figure 9 : Papers and Citations (Environmental Communication Journal)

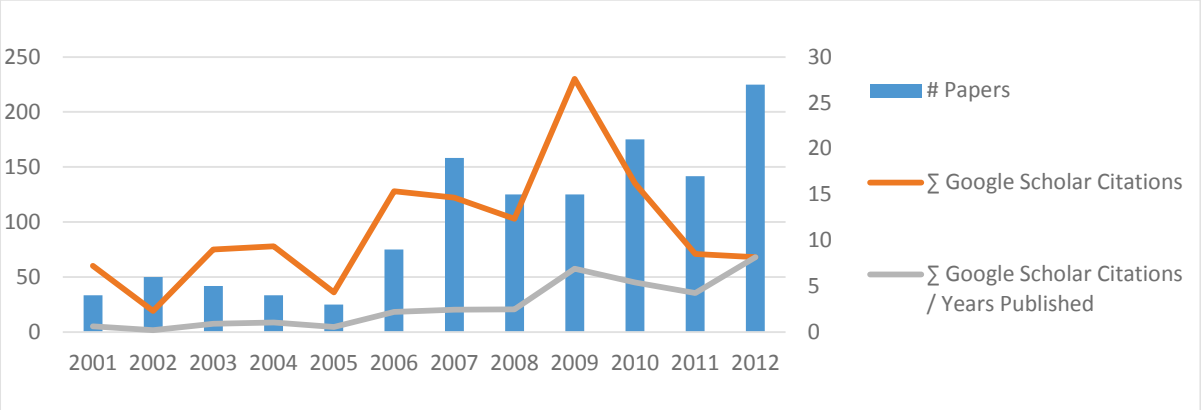


Figure 10 : Papers and Google Scholar Citations (All Journals)

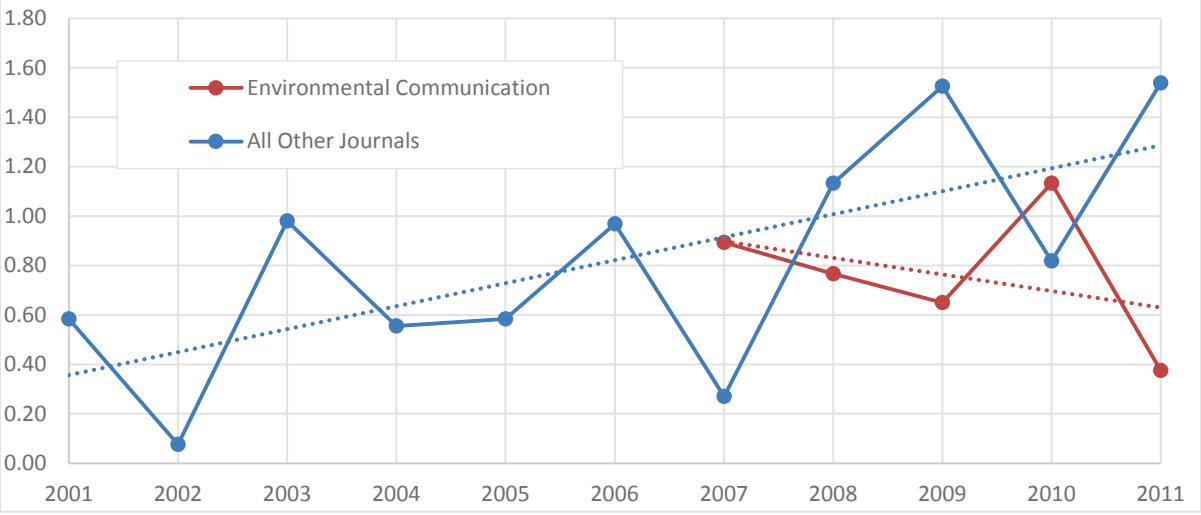


Figure 11 : Normalized ∑ (Max Citations / Years Published)

Table 8 : Journals (sorted by ∑ MCs)

Journals	(∑ #)	∑ MCs	∑ MCs/YP	(∑ MCs/YP) / ∑ #
Environmental Communication	45	134	32.52	0.72
Journal of Cleaner Production	3	52	8.00	2.67
Accounting Organizations and Society	1	36	9.00	9.00
Risk Analysis	3	25	2.50	0.83
Public Understanding of Science	3	24	6.79	2.26
Environmental Science and Pollution Research	1	21	4.20	4.20
International Communication Gazette	4	21	10.50	2.63
Corporate Social Responsibility and Environmental Management	1	20	2.00	2.00
Journal of Business Ethics	2	19	2.93	1.46
Western Journal of Communication	1	17	1.42	1.42
Electronic Green Journal	1	12	1.33	1.33
Building Research and Information	1	11	2.75	2.75
Science Communication	7	10	3.52	0.50
Journal of Risk Research	1	9	1.80	1.80
British Food Journal	1	9	1.13	1.13
Energy and Buildings	1	8	0.89	0.89
Business Strategy and the Environment	2	7	1.75	0.88
Corporate Environmental Strategy	1	6	0.50	0.50
Global Environmental Change-Human and Policy Dimensions	1	6	6.00	6.00
Communication Monographs	1	6	3.00	3.00
European Environment	1	5	0.63	0.63
BioScience	1	5	0.42	0.42
Conservation Letters	1	5	2.50	2.50
Frontiers in Ecology and the Environment	2	4	0.57	0.29
Applied Environmental Education and Communication	2	4	1.17	0.58
Media International Australia	2	4	0.80	0.40
Corporate Communications	1	4	0.80	0.80
International Journal of Life Cycle Assessment	1	4	1.33	1.33
Quality - Access to Success	1	3	1.50	1.50
Written Communication	1	3	0.75	0.75
International Journal of Environment and Sustainable Development	1	3	0.50	0.50
Society & Natural Resources	1	3	0.30	0.30
IEEE Transactions on Professional Communication	1	2	0.29	0.29
Journal of Marketing	1	2	2.00	2.00
Local Environment	2	1	0.25	0.13
Information Society	1	1	0.25	0.25
International Journal of Biodiversity Science and Management	1	1	0.14	0.14
Semiotica	1	1	0.20	0.20
Journal of Public Deliberation	1	1	0.33	0.33
American Communication Journal	2	1	0.17	0.08
Allgemeine Forst und Jagdzeitung	1	1	0.10	0.10
Pollution Atmospherique	1	0	0.00	0.00
Social Marketing Quarterly	1	0	0.00	0.00
Quality Progress	2	0	0.00	0.00
Journal of Environmental Health	1	0	0.00	0.00
Telematics and Informatics	1	0	0.00	0.00
Alternatives Journal	1	0	0.00	0.00
Communication Teacher	1	0	0.00	0.00
Information Technologies in Environmental Engineering	1	0	0.00	0.00

Journals	(∑ #)	∑ MCs	∑ MCs/YP	(∑ MCs/YP) / ∑ #
Forest Systems	1	0	0.00	0.00
African Journal of Business Management	1	0	0.00	0.00
Southern Communication Journal	1	0	0.00	0.00
Journalism	1	0	0.00	0.00
Wasser und Abfall	1	0	0.00	0.00
Journalism & Mass Communication Quarterly	1	0	0.00	0.00
Public Relations Review	1	0	0.00	0.00
Kami Pa Gikyoshi/Japan Tappi Journal	5	0	0.00	0.00
Communicatio	1	0	0.00	0.00
Waste Management & Research	1	0	0.00	0.00
Athenea Digital	1	0	0.00	0.00
Ambiente e Sociedade	1	0	0.00	0.00
English Teaching	1	0	0.00	0.00
International Journal of Productivity and Quality Management	1	0	0.00	0.00
Journal of Coastal Research	1	0	0.00	0.00
Mass Communication and Society	1	0	0.00	0.00
Sport Management Review	1	0	0.00	0.00
Environmental Hazards-Human and Policy Dimensions	1	0	0.00	0.00
VTT Tiedotteita - Valtion Teknillinen Tutkimuskeskus	1	0	0.00	0.00
Nihon Enerugi Gakkaishi/Journal of the Japan Institute of Energy	1	0	0.00	0.00
Journal of Environmental Education	1	0	0.00	0.00
PIK Report	1	0	0.00	0.00
Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie	1	0	0.00	0.00
Gaia-Ecological Perspectives for Science and Society	1	0	0.00	0.00
Lebensstile und globaler energieverbrauch: Analyse und strategieansätze zu einer nachhaltigen energiestruktur	1	0	0.00	0.00
Grand Total	**145**	**511**	**117.51**	0.81

Table 9 : Impact Factor Analysis for High Citation Journals

ISSN	Journals	∑ #	∑ MCs	∑ MCs/YP	Synthetic Impact Factor (SIF) = (∑ MCs/YP) / ∑ #	2012 Journal Impact Factor (JIF)	DIF = SIF-JIF	Log (DIF)	Log (∑ #)
0361-3682	Accounting Organizations and Society	1	36	9.00	9.00	1.867	7.13	0.85	0
1748-0485	International Communication Gazette	4	21	10.50	2.63	NA	NA	NA	
0363-7751	Communication Monographs	1	6	3.00	3.00	0.768	2.23	0.35	0
1755-263X	Conservation Letters	1	5	2.50	2.50	4.356	1.86	0.27	0
0944-1344	Environmental Science and Pollution Research	1	21	4.20	4.20	2.618	1.58	0.20	0
0272-4332	Risk Analysis	3	25	2.50	0.83	2.278	1.44	0.16	0.4771213
0022-2429	Journal of Marketing	1	2	2.00	2.00	3.368	1.37	0.14	0
1075-5470	Science Communication	7	10	3.52	0.50	1.436	0.93	-0.03	0.845098
0959-3780	Global Environmental Change-Human and Policy Dimensions	1	6	6.00	6.00	5.236	0.76	-0.12	0
0961-3218	Building Research and Information	1	11	2.75	2.75	1.989	0.76	-0.12	0
0959-6526	Journal of Cleaner Production	3	52	8.00	2.67	3.398	0.73	-0.14	0.4771213
0963-6625	Public Understanding of Science	3	24	6.79	2.26	1.724	0.54	-0.27	0.4771213
1535-3958	Corporate Social Responsibility and Environmental Management	1	20	2.00	2.00	1.69	0.31	-0.51	0
0167-4544	Journal of Business Ethics	2	19	2.93	1.46	1.253	0.21	-0.68	0.30103
1752-4032	Environmental Communication	45	134	32.52	0.72	0.645	0.08	-1.11	1.6532125
	Grand Total	**145**	**511**	**117.51**	0.81				

Pearson Correlation Coefficient (r) for MCs/YR/Paper x JIF = 0.33

This result indicates that highly cited articles are not being cited simply because they were published in higher-impact journals. Perhaps the authors themselves have more impact or maybe the topic is unique for these journals and therefore garners more attention?

Pearson Correlation Coefficient (r) for Log (DIF) x Log (∑ #) = -0.63

This result indicates that the greater the number of papers the smaller the difference between the JIF and my impact measure (MCs/YR/Paper)

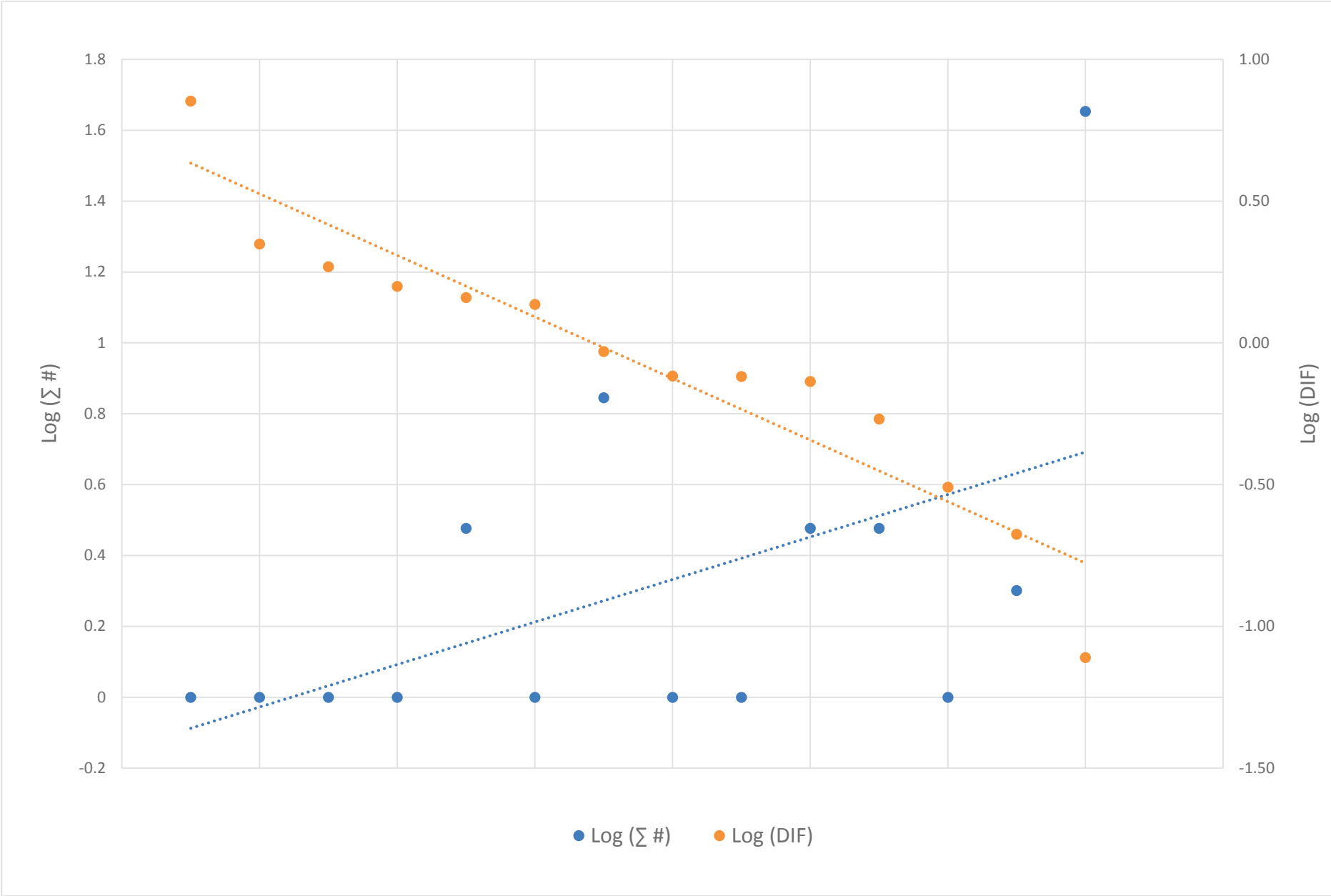
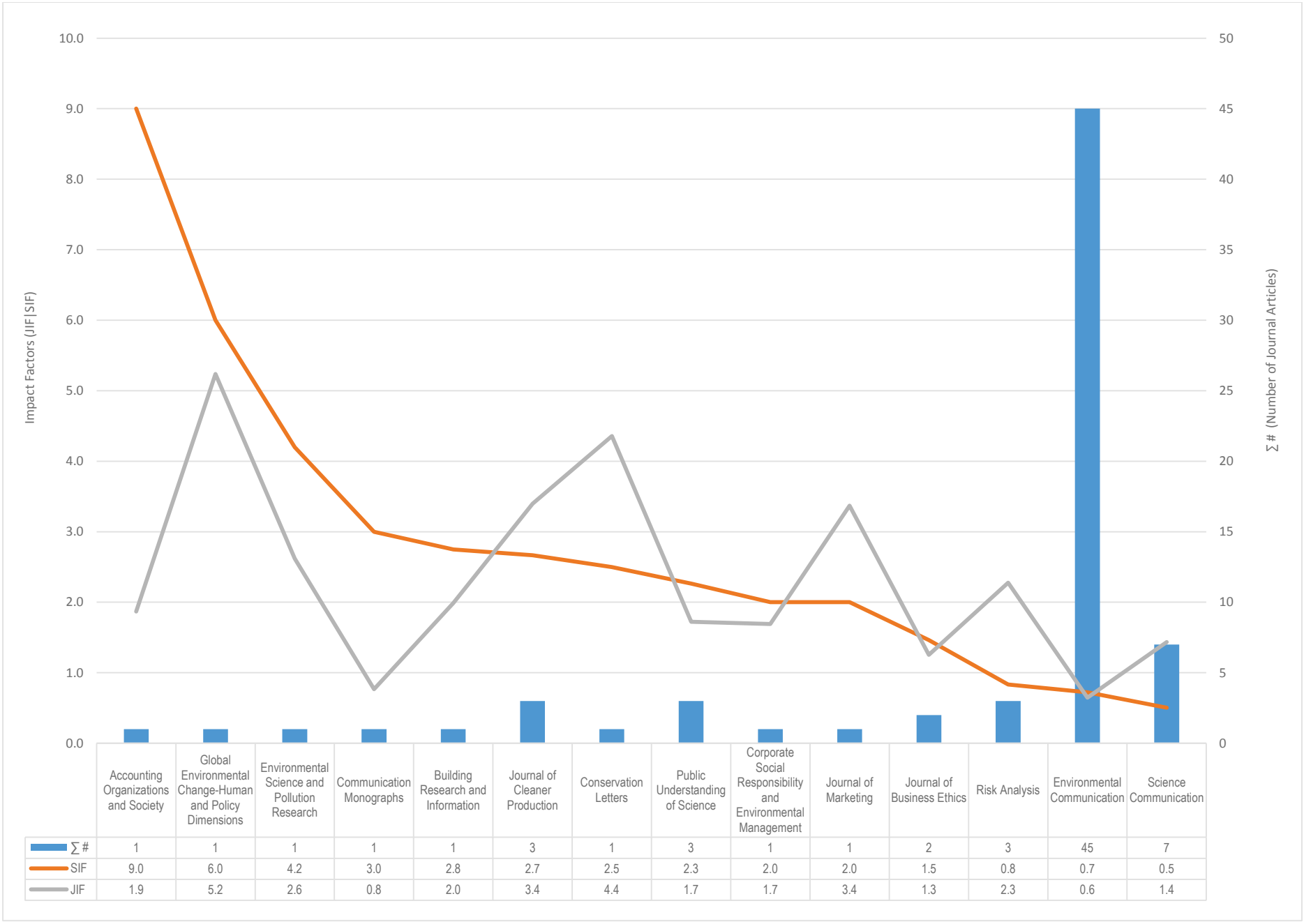


Figure 12 : Impact Factor Analysis for High Citation Journals ~ Log (DIF) x Log (∑ #)



	Accounting Organizations and Society	Global Environmental Change-Human and Policy Dimensions	Environmental Science and Pollution Research	Communication Monographs	Building Research and Information	Journal of Cleaner Production	Conservation Letters	Public Understanding of Science	Corporate Social Responsibility and Environmental Management	Journal of Marketing	Journal of Business Ethics	Risk Analysis	Environmental Communication	Science Communication
∑#	1	1	1	1	1	3	1	3	1	1	2	3	45	7
SIF	9.0	6.0	4.2	3.0	2.8	2.7	2.5	2.3	2.0	2.0	1.5	0.8	0.7	0.5
JIF	1.9	5.2	2.6	0.8	2.0	3.4	4.4	1.7	1.7	3.4	1.3	2.3	0.6	1.4

Figure 13 : Impact Factor Analysis for High Citation Journals ~ JIF, SIF and ∑ #

Table 10 : Bradford Distribution Calculations (EC Research ~ 2001-2012)

Tabulated data from EC bibliography (2001-2012)						Step 8 - Comparison		
Rank (n)	# of articles	# Journals	Cumulative Journals	Cumulative # papers	Bradford	P = 3	# journals	# papers
1	45	1	1	45	24	r0	3	57
2	7	1	2	52	38	r1	30	104
3	5	1	3	57	48	r2	41	150
4	4	1	4	61	55		74	
5	3	3	7	70	71			
6	2	8	15	86	94		yo	48.333
7	1	59	74	145	145		a	33.076
							b	1.070
k =	4.31	r0=	3.10					
P =	3	r1=	9.29	Sum2	12		Pearson - r	0.982
Ym =	45	r2=	27.87	Sum3	40		CHISQR	0.02%
		r3=	83.60	Sum4	124			
		r4=	250.79	Sum5	375			
		r5=	752.37	Sum6	1127			

Table 11 : Bradford Distribution Calculations (EC Research ~ Prior to 2001)

Reconstructed from Tables 1 & 2 in Pleasant et al. (2002)						Step 8 - Comparison		
Rank (n)	# of articles	# Journals	Cumulative Journals	Cumulative # papers	Bradford	P = 3	# journals	# papers
1	48	1	1	48	38	r0	20	271
2	41	1	2	89	71	r1	128	677
3	17	1	3	106	100	r2	351	1083
4	14	1	4	120	126		499	
5	13	2	6	146	171			
6	12	1	7	158	190		yo	361.000
7	11	2	9	180	225		a	243.458
8	10	2	11	200	256		b	0.169
9	9	3	14	227	296			
10	8	3	17	251	330		Pearson - r	0.986
11	7	2	19	265	350		CHISQR	0.00%
12	6	3	22	283	378			
13	5	13	35	348	471			
14	4	16	51	412	552			
15	3	72	123	628	751			
16	2	79	202	786	867			
17	1	297	499	1083	1083			
k =	4.41	r0=	20.11					
P =	3	r1=	60.33	Sum2	80			
Ym =	48	r2=	181.00	Sum3	261			
		r3=	543.01	Sum4	804			
		r4=	1629.04	Sum5	2433			
		r5=	4887.11	Sum6	7321			

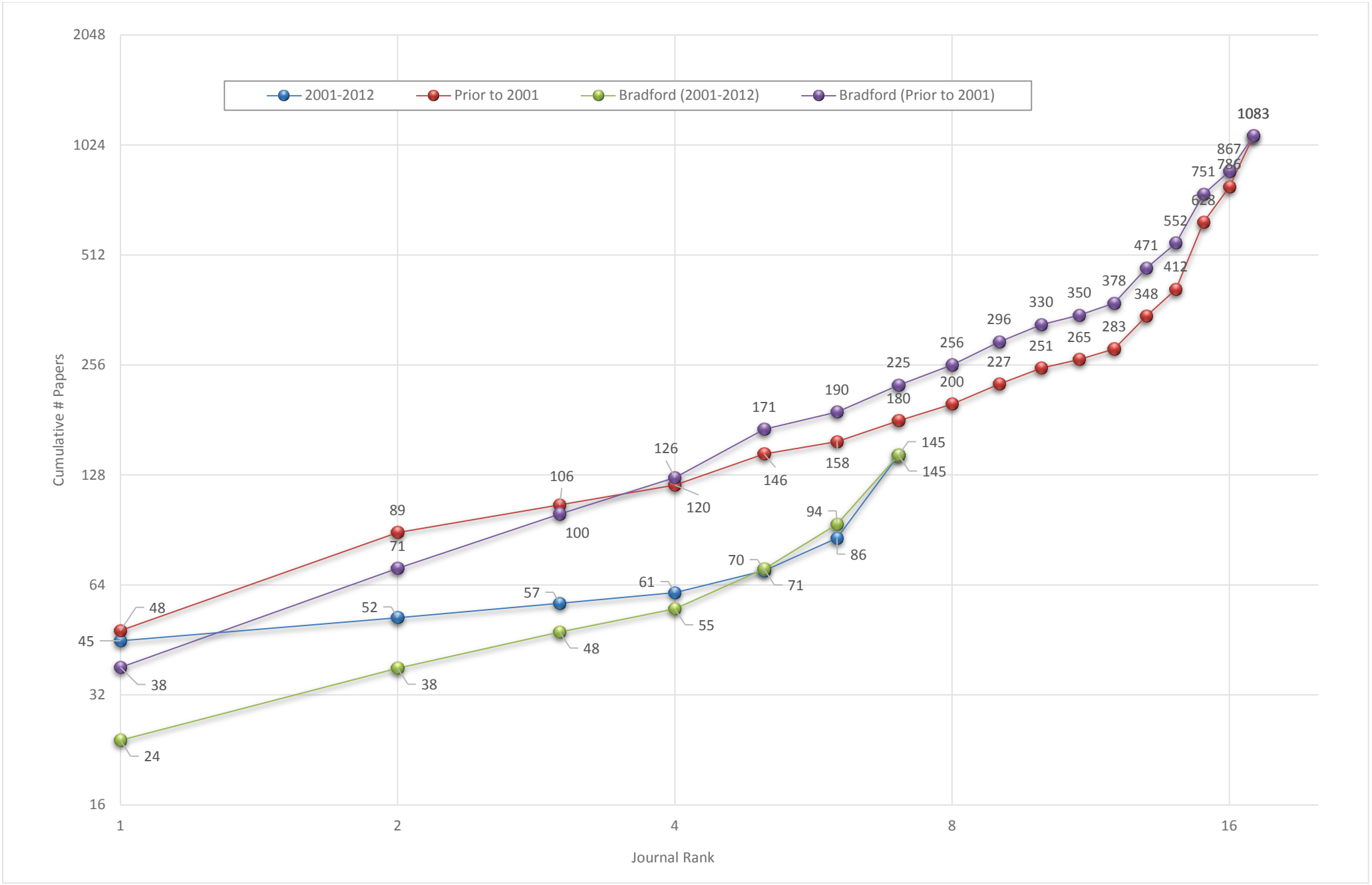


Figure 14 : Bradford Distributions (Observed vs Ideal) for Two Environmental Communication (EC) Research Datasets (Pre & Post 2001)

Table 12 : Word Frequency Analysis - Title Field - Word Count > 3

Word	Count
climate	14
public	14
change	12
media	9
case	8
information	8
study	8
corporate	7
crisis	7
research	7
analysis	6
communicating	6
energy	6
environment	6
management	6
reporting	6
rhetoric	6
waste	6
communications	5
new	5
science	5
approach	4
content	4
development	4
global	4
green	4
issues	4
news	4
quality	4
rhetorical	4
risk	4
scientific	4
sustainability	4
sustainable	4

Figure 15 : Word Frequency Analysis - Title Field - Word Cloud

Table 13 : Word Frequency Analysis – Abstract Field - Word Count > 21

Word	Count
research	90
change	68
public	67
information	64
climate	63
issues	62
environment	53
media	53
study	50
social	48
essay	46
paper	44
companies	42
analysis	41
management	39
new	38
energy	36
article	34
science	34
communications	33
studies	33
use	33
stakeholders	32
used	30
results	28
approach	27
different	27
project	27
role	27
based	26
political	26
nature	25
risk	24
understanding	24
using	23
forest	22
issue	22
sustainability	22

Figure 16 : Word Frequency Analysis - Abstract Field - Word Cloud

Table 14 : Word Frequency Analysis – Author Address Fields - Word Count > 5

Word	Count
usa	118
united	48
state	46
states	43
washington	19
new	18
san	14
canada	13
germany	13
australia	11
carolina	11
nc	11
ny	11
ca	10
utah	10
albuquerque	8
dc	8
ilmenau	8
kingdom	8
mexico	8
nm	8
tx	8
ut	8
wa	8
arizona	7
az	7
mn	7
oregon	7
raleigh	7
botswana	6
city	6
lake	6
luis	6
massachusetts	6
obispo	6
pullman	6
salt	6
texas	6

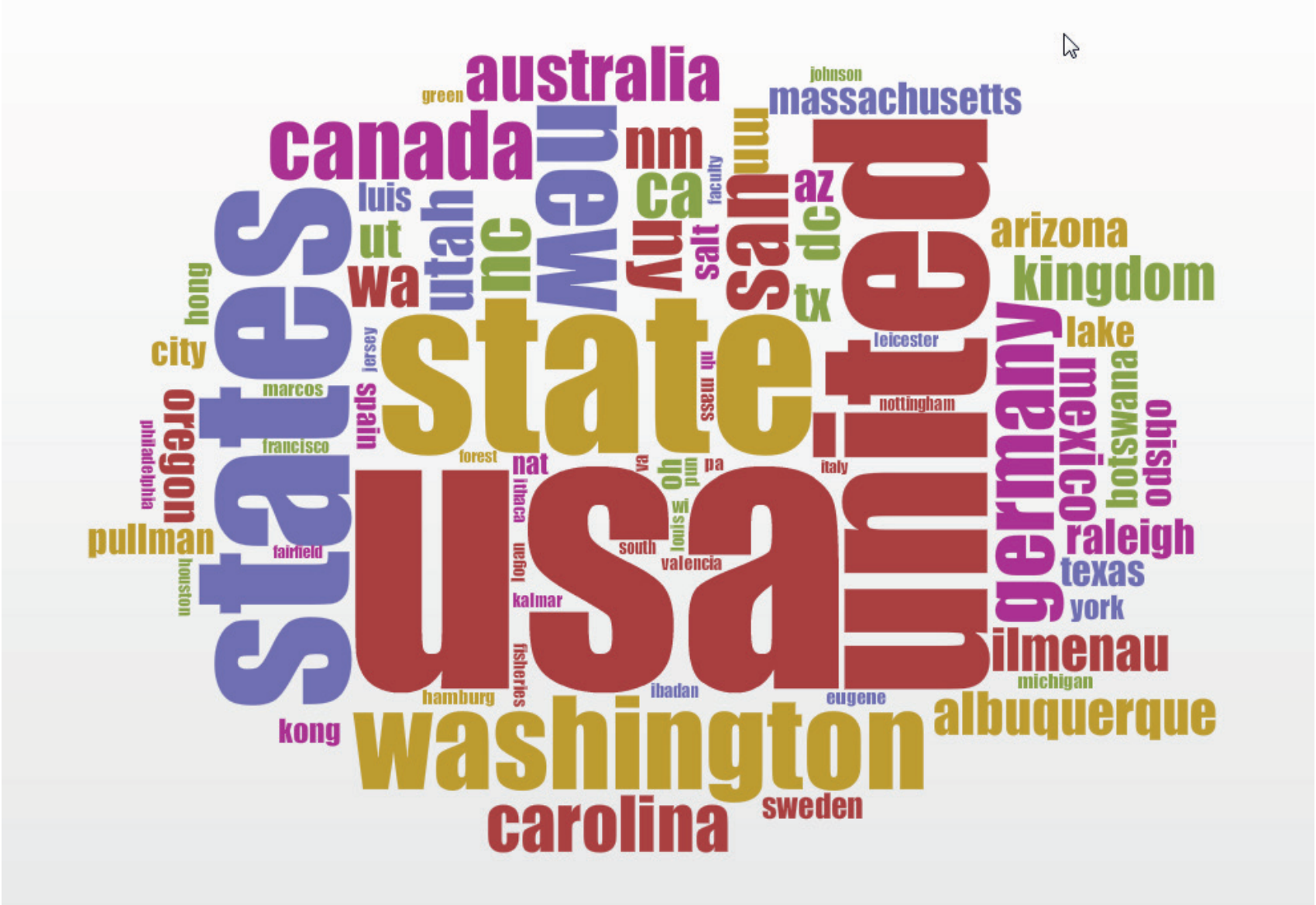


Figure 17 : Word Frequency Analysis - Author Address Fields - Word Cloud

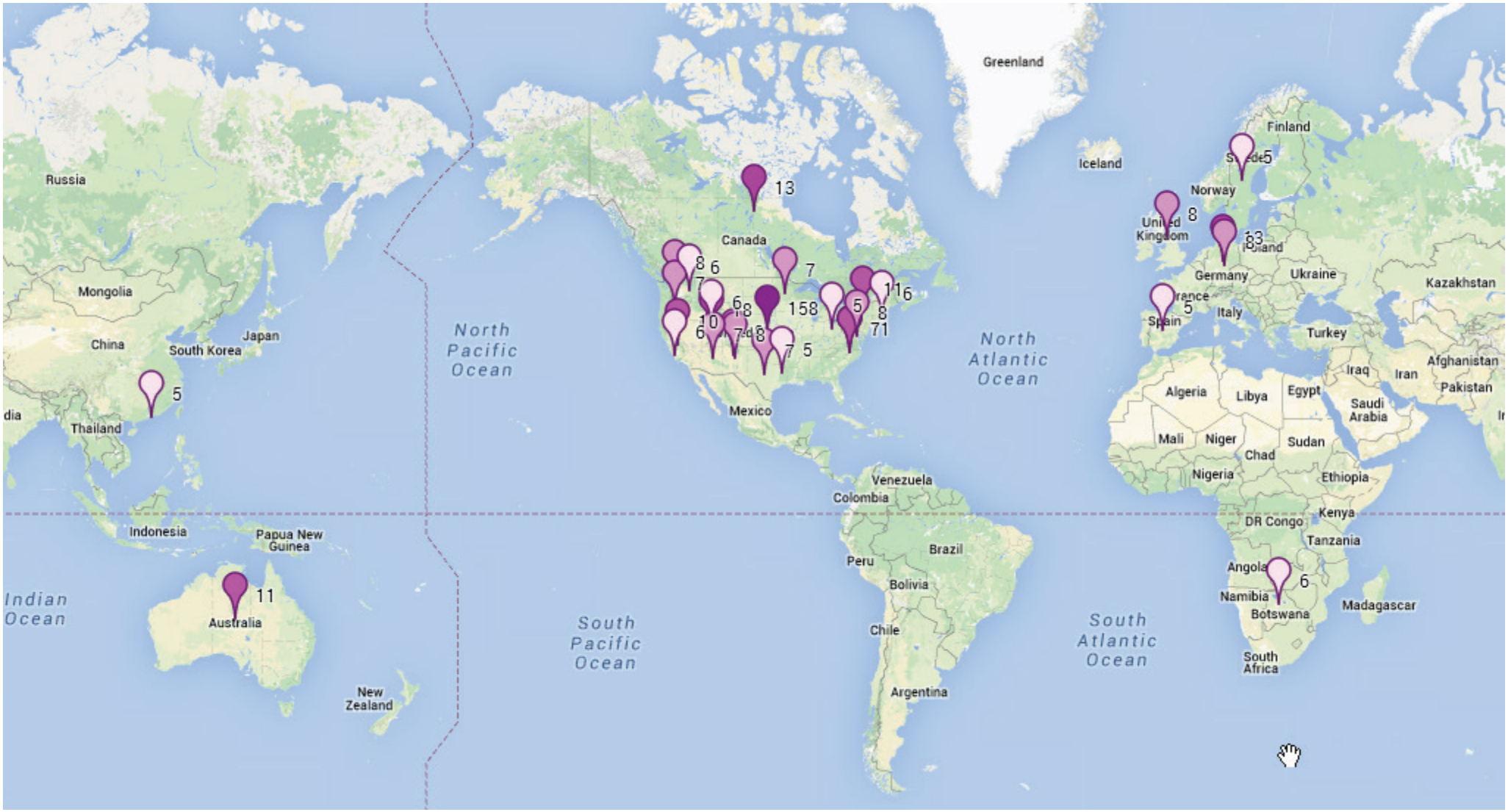


Figure 18 : High-Frequency Geographic Terms in Author Address Fields – World Map

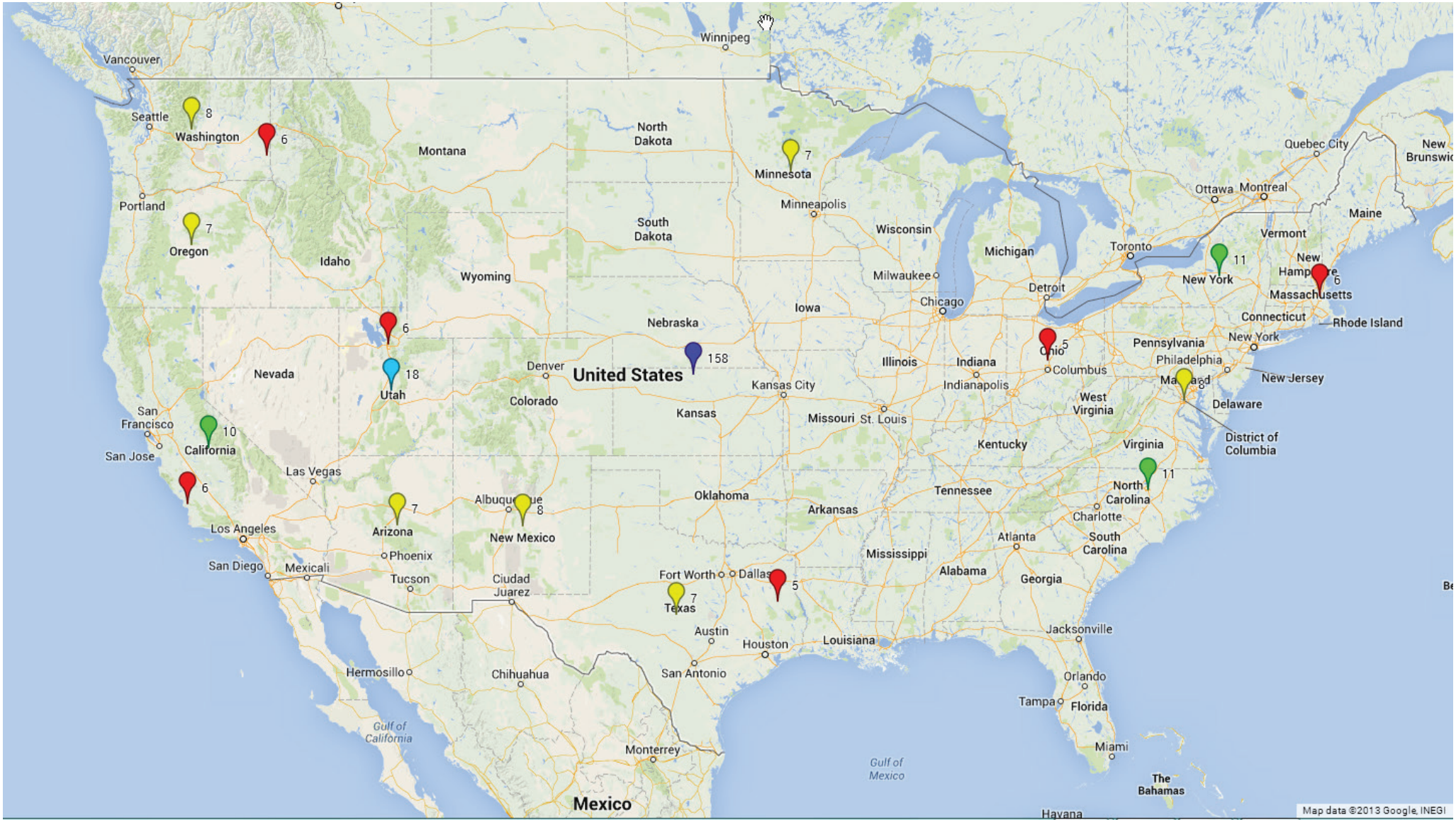


Figure 19 : High-Frequency Geographic Terms in Author Address Fields – USA Map

Appendix B : Methodology Notes

Data Collection – Round 1 – Feb 2013

For Scopus, I selected all subject areas, as shown in Figure 20. The Scopus keyword search returned 177 primary documents (see Figure 21), 279 secondary documents, and 587 documents citing the primary documents (obtained using the 'View Cited by' selection).

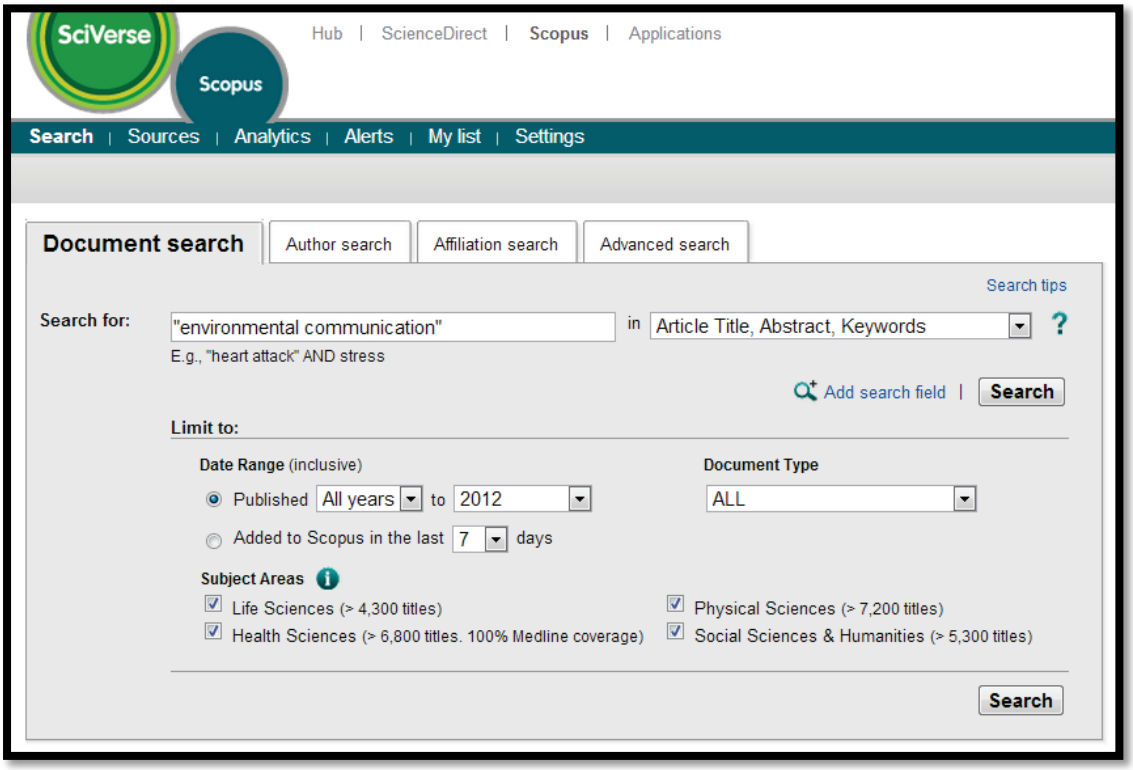


Figure 20 : Scopus Search Settings

Figure 21 : Scopus Search Results

For WoK, I searched 'All Databases' using the 'Topic' search option, which is equivalent to a search on document title, abstract, and keyword.[12] These search settings are shown in Figure 22. The WoK keyword search returned 132 primary documents (see Figure 23). I then clicked on the 'Create Citation Report' button and selected 'Citing Articles' which returned a result of 424 documents citing the primary documents, as shown in Figure 24.

[12] See the *"Searching the Topic Field"* on this "Web of Knowledge℠ Help" website: http://images.webofknowledge.com/WOKRS512B4/help/WOK/hs_topic.html

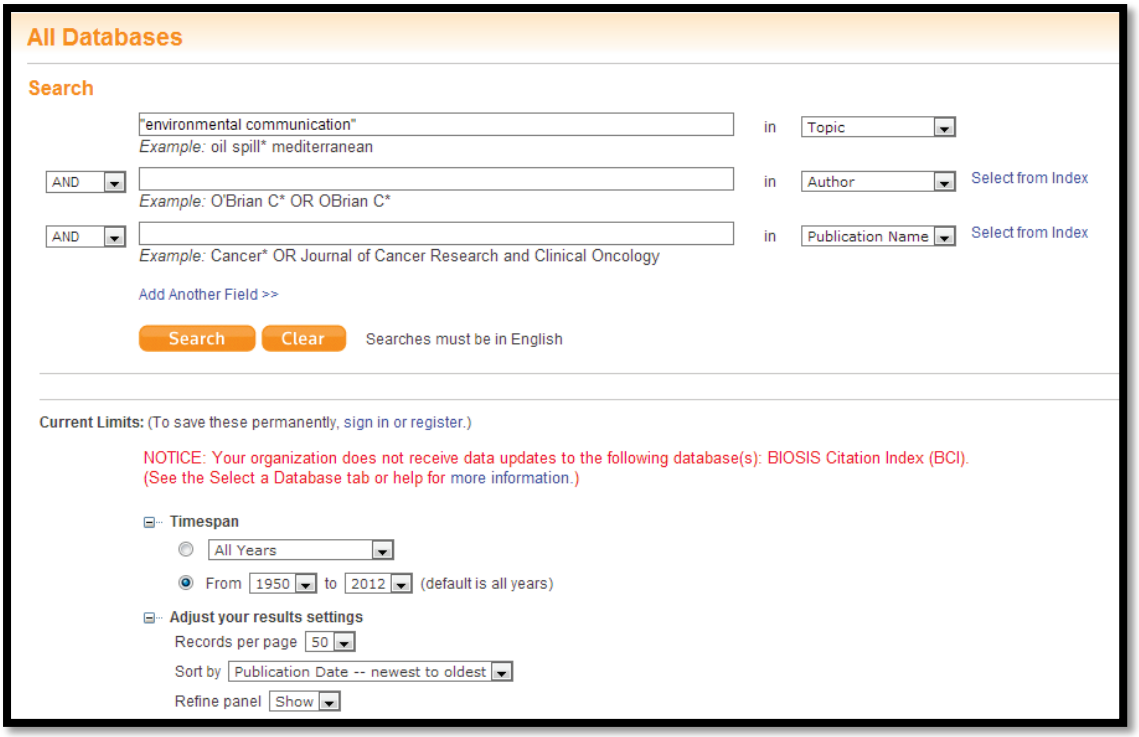


Figure 22 : WoK Search Settings

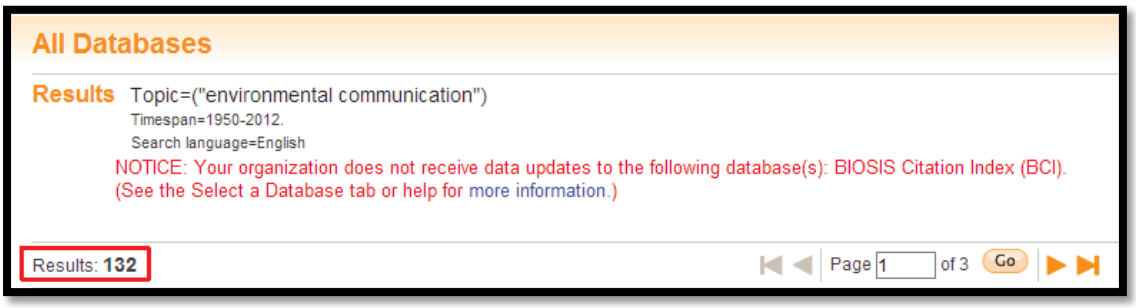


Figure 23 : WoK Search Results – Primary Articles

Figure 24 : WoK Search Results – Citing Articles

Data Collection – Round 2 – Jun 2013

The second round of data collection followed some of the same methods as the first round. The main purpose of collecting a second round of data was to update the results, since over four months had passed. In this second round, the WoK keyword search returned 159 primary documents, compared with 132 in the first round. This represents a difference of 27 documents, which seems significant. This discrepancy might be accounted for by the WoK granting my host institution access to additional databases in the interim. The Scopus keyword search returned 180 primary articles, compared with 177 in the first round. These three additional records could be accounted for by recent titles being added to the database.

Data Analysis – BibExcel

Before attempting to analyze the collected data, I performed some initial Internet research to find software packages suitable for bibliometric analysis. I settled upon BibExcel[13], since it is freeware specifically designed to process bibliographic data. It is also fairly well documented and includes tutorials. Unfortunately, I could not get the software to work with my Scopus data, despite many hours of troubleshooting. I eventually abandoned this effort and imported the data into Microsoft Excel instead. Due to the many hours lost on this failed effort, I was also forced to abandon my initial goal of performing advanced co-citation analysis with network mapping visualizations on the EC journal article citation data.

In the process of troubleshooting BibExcel, I exported my data from Zotero and imported it into EndNote[14] and JabRef [15] reference management software. I also upgraded the citation data within the Journals subfolder in Zotero to include the 'Cited References' field. Since the first round of data was missing the 'Cited References' field, different export formats were used in this second round to collect a complete set of data for each record. In the WoK database, I collected these complete record sets using the Web of Science (WoS) database, which is accessed from a tab on the same WoK website[4]. The keyword search parameters remained the same as in the first round, except that the published date changed from '1950-2012' to '1970-2012' inclusive. After excluding books and conference papers from the record set, I retrieved 107 primary articles with complete citation data from the WoS.

Data Analysis – Microsoft Excel

Once I abandoned BibExcel in favor of Microsoft Excel, the analysis proceeded much more quickly. First, I exported the data from the Journals folder (in Zotero) in RIS format. I then merged all the author (AU) and keyword (KW) fields using a text editor, as there were many instances of these fields. Next, I imported this modified file into Excel and converted rows to columns for each record, using the paste transpose function; and then edited each row so that all the data matched the RIS field headings at the top of the worksheet. I then applied conditional highlighting (in red) to identify blank cells within the data. Sorting the data by Published Year (PY) allowed me to identify and purge 31 records published prior to 2001. These records were also moved out of the Journals folder in Zotero. I then sorted the Excel data by article title (TI) and added a key column (#) to the Transposed worksheet with every row in the table having a unique integer key value between 1 and 146, as shown in Figure 25.

I then copied the Transposed worksheet, see Figure 25, renamed it to Authors1, deleted all but the key (#) and author (AU) columns and sorted the new table by author. I paste-linked the data from the Transposed worksheet into Authors1, so that any changes to the base data would be reflected here. I repeated this same procedure throughout the spreadsheet. At this point, I found another duplicate record that I removed from both the spreadsheet and the Journals folder in Zotero. I renumbered the Transposed worksheet and applied new keys. The new journal article record total in both locations came to 145, which was the final tally.

[13] See http://www8.umu.se/inforsk/Bibexcel/ for details.
[14] See http://www.myendnoteweb.com/ for details.
[15] See http://sourceforge.net/projects/jabref/ for details.

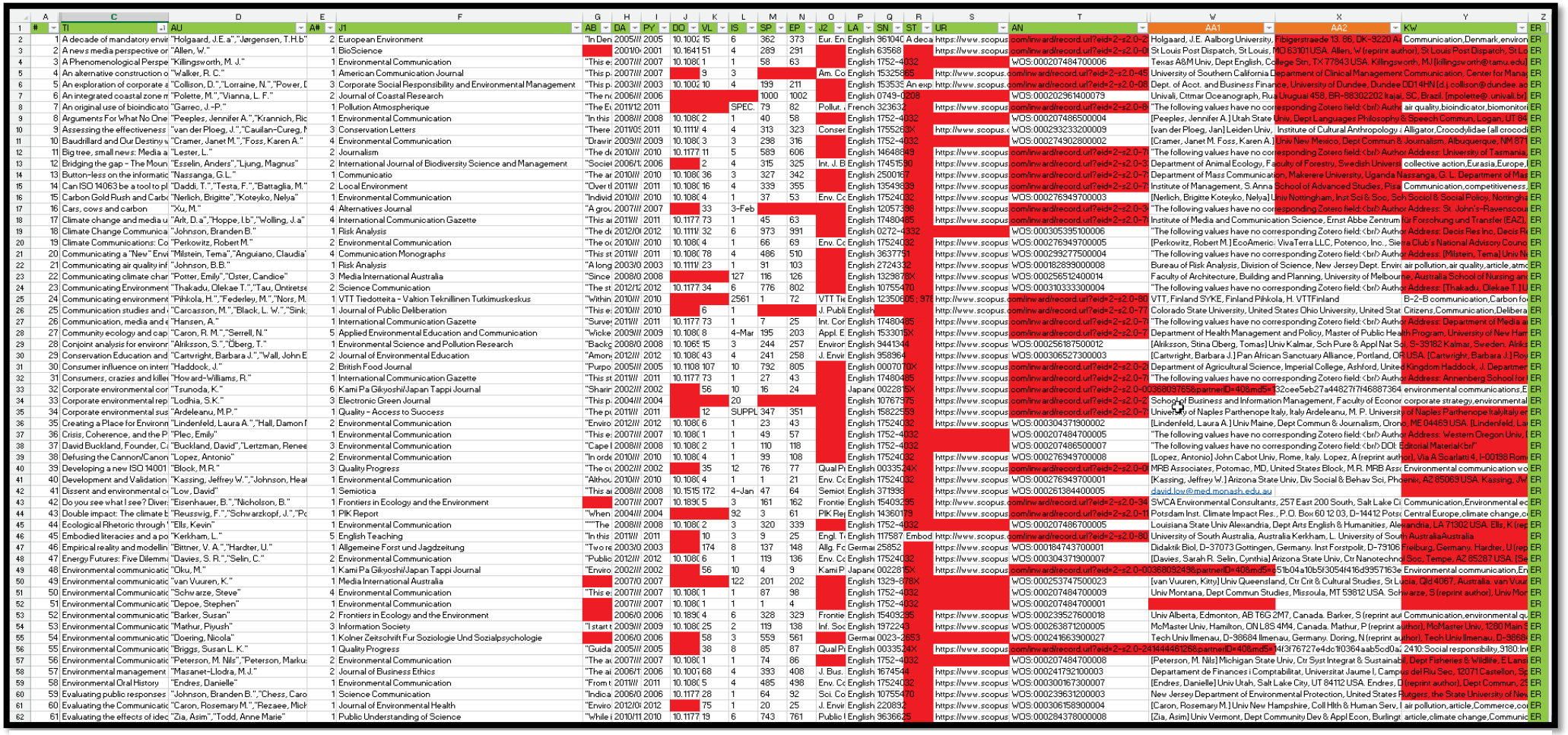


Figure 25 : Microsoft Excel - Transposed Data

Data Analysis – Authors

I proceeded to parse the author (AU) column and calculate the number of authors per paper. These values were recorded in the author number (A#) column and the total, median, and standard deviation was calculated, as shown in Table 1. The frequency distribution was then assembled and plotted in pie chart format, as shown in Figure 3. An additional worksheet (Authors2) was created to calculate the average author numbers (A#) per paper per year. This information is presented in bar chart form in Figure 4 with a linear trend line and its equation. An additional worksheet (Authors3) was created to calculate the distribution of papers by author number (A#) and by year. This information is presented as a 3D bar chart in Figure 5.

An additional worksheet (Authors4) was created to determine the number of unique authors. In this worksheet, the author names from the Authors1 worksheet were consolidated into a single column and sorted alphabetically. During this process, I found that one record had the same name repeated twice. I contacted this author for clarification but did not receive a reply, so I simply deleted the duplicate name. I then searched the sorted author column for matches and highlighted duplicates. For near duplicates, I copied the row with more information into its match and updated the author name for that record in the Transpose worksheet and Zotero. I then added and parsed the Author Address data (AA1, AA2) from the Transpose worksheet.

Following this procedure, an additional worksheet (Authors5) was created to obtain a frequency distribution showing the most productive authors and their geographic distribution. This worksheet was created using the pivot table function to identify unique author names and calculate their individual paper output. The paper output was calculated using a simple count procedure such that each name on a paper was given credit for a whole paper. This whole counting method was used rather than a fractional counting method for papers with multiple authors. I then sorted the table by the 'Number of Articles' field to yield a list of the most productive authors. For authors with two or more papers, I also conducted an Author Search on Scopus (and WoK) and retrieved their h-index, institutional affiliation, city, state and country. This information is shown in Table 2 : Most Productive Authors.

Data Analysis – References

Next, I parsed the notes fields in the Transpose worksheet to create separate columns with the following sets of headings {database source}: {Scopus} CODEN, Cited By, REF SCO; {WoK} ISI DD#, Times Cited, Cited Reference Count, REF WOK. These columns were moved to a new 'REF1' worksheet. Three more columns were added (REF1,REF2,REFS) to count and sum rows containing references. The REFS column (equal to REF1+REF2) was then summarized in a pivot table showing the number of papers with zero, one or two sets of references. The list of papers without references was then compared with the equivalent list in the Zotero database. One additional paper was found in the 'REF1' worksheet, so the reference information in Zotero was transferred over. After this change, only 14 of 145 papers (<10%) were found to be without references. The list of papers with references (131 papers in total) was then examined for parsing irregularities and appropriate corrections were made. In the end, no further analysis was conducted on the reference fields (REF SCO, REF WOK) as I could not find a suitable software tool (see related discussion in Data Analysis – BibExcel in Appendix B : Methodology Notes).

Data Analysis – Citations

I then copied the REF1 worksheet and renamed it REF2. The columns containing reference information were removed from this worksheet, leaving only the Key (#), Title (TI), Cited By, and Times Cited columns. I added a new column 'Max

Citation (MCs)' which returned the largest value in the citation columns (Cited By, Times Cited) for each row and sorted the worksheet by these values. After adding the Published Year (PY) column to the REF2 worksheet, I added a new column 'MCs/YP' which divided the Max Citations (MCs) by the number of years since publication (YP=2013-PY). Dividing the citation value (MCs) by the number of years published (YP) essentially normalizes the citation values, and thereby allows for the comparison of papers published in different years. Later, I added Google Scholar Citation (GSC) values that I collected using the Zotero Scholar Citation plugin[16]. Statistics were then calculated on MCs, MCs/YP, GSC, and GSC/YP, see Table 3 : Citation Statistics. The data in these same columns were then grouped into value ranges and these grouped citation counts were plotted as clustered bar charts, see Figure 6 and Figure 7. Next, I sorted the REF2 worksheet by MCs, MCs/YP, GSCs, and GSCs/YP. After each sort, I copied the top articles to a new worksheet named REF3. This data can be found in Table 4, Table 5, Table 6, and Table 7.

Next, I summarized the REF2 data on a new worksheet (REF4) using pivot tables and matching charts. The first two tables show the number of papers (# Papers), MCs and MCs/YP for every year of the study period (2001-2012). The first chart (see Figure 8) shows these values for all journals while the second chart (see Figure 9) shows these same variables but only for a single journal: *Environmental Communication: A Journal of Nature and Culture*. The third chart (see Figure 10) is similar to the first chart except that it shows GSCs and GSCs/YP. On another worksheet (REF5), I normalize the same MCs/YP values shown in the first two charts by dividing each instance by the number of articles published that year. Using this data, I created a fourth chart (see Figure 11 : Normalized ∑ (Max Citations / Years Published)). These tables and charts were produced to help answer the second research question, i.e., the impact of a new EC journal on the field, through an examination of the annual citation patterns.

Data Analysis – Journals

After the analysis of authors and citation related fields, the next data field that I examined was the Journal field (J1). I created a new worksheet called 'Journals1" that contains the following columns: keys (#), journal (J1), published year (PY), MCs, and MCs/YP. I then sorted this data by the J1 and then PY columns, to display the records by journal and published year.

Next, I created a new pivot table on the 'Journals2' worksheet, to summarize the data in 'Journals1' by journal title (J1). This table is comparable to Tables 1 & 2 of Pleasant (2002). Two additional columns were also added, showing the total number of citations (∑MCs, ∑MCs/YP) accrued by each journal in the dataset. I then sorted this table by ∑MCs and added subtotals, as shown in Table 8. The final column shown in Table 8 normalizes the ∑MCs/YP values by dividing by the number of papers contributed by each journal (∑#).

The values in this final column (∑MCs/YP/∑#) reflect the journal impact relative to the number of contributing papers. For a journal contributing only a single article to the data set, this metric is equal to the MCs/YP value of that single article. For journals contributing multiple articles to the data set, this metric is equal to the average of the MCs/YP values of all those articles. For the remainder of this paper, I refer to this journal impact metric as the Synthetic Impact Factor (SIF). As I wished to confirm the validity of the SIF, I compared a sample of SIF values with the Journal Impact Factor (JIF) values published by the ISI Web of Knowledge in their latest (2012) Journal Citation Report.[17]

[16] See https://addons.mozilla.org/en-US/firefox/addon/zotero-scholar-citations/ for details.
[17] See http://thomsonreuters.com/journal-citation-reports/ for details.

First, I copied the Journals2 worksheet and renamed the new worksheet 'Journals3'. I then converted the pivot table to a regular table using the copy and paste values functions. I then filtered the journal list to show only journals with a ∑MCs/YP value greater or equal to two, i.e., high citation journals. I then collected JIF data for this subset of journals using the search function on the ISI Web of Knowledge website.[18] The JIF and ISSN data for each journal was then copied over to the respective columns in Journals3. The JIF value of only one journal could not be found (International Communication Gazette), and so it was not considered in the subsequent analysis. The list of these journals and the collected JIF data is shown in Table 9.

Next, I made a direct comparison of the SIF and JIF metrics, by calculating the Pearson Correlation Coefficient (r) for the subset of high citation journals. As the result was not conclusive, I continued my analysis by plotting scatter diagrams in various configurations looking for trends in the data. By this method, I ended up adding three additional columns: DIF (SIF-JIF), log (DIF) and log (∑#). The plot of log (DIF) x log (∑#) is shown in Figure 12. I also calculated the Pearson Correlation Coefficient (r) for this pair of data. I then created a new worksheet 'Journals4' containing the same subset of journals as in Journals3. Using this data, I plotted the SIF, JIF and ∑# values by descending SIF values, as shown in Figure 13.

Data Analysis – Geographic Analysis

Once the Author Address word frequency analysis was complete, I decided to take the analysis a step further and geolocate the most frequent geographic terms. The first step in this analysis involved geoparsing the same text input file I had analyzed previously using Voyant. For this purpose, I used another online tool, the Edinburgh Geoparser[19]. Within this tool, I uploaded the author address data, selected the geonames-local gazetteer, and geotagged the data. I then copied the geotagged output to a spreadsheet and populated the high-frequency geographic terms obtained previously with the corresponding latitude/longitude obtained from the Edinburgh Geoparser.

I then uploaded this spreadsheet data to the Google Maps Engine[20] to create a map of high-frequency geographic terms in the Author Address data. Using this initial map, I consolidated the data by conflating identical or similar reference data (e.g. usa, states). The final map identifies the most frequent geographic terms within the author address fields for the collected EC bibliography. One figure shows these locations on the globe (see Figure 18) while the other figure shows locations only within the continental United States (see Figure 19). Both of these figures were taken from the same Google Map and show the modified word frequency counts next to each location pin, which represent approximate locations only.

Data Analysis – Word Frequency

In preparation of the text analysis, I exported the article Titles, Abstracts and Author Address fields to three separate text files. I then removed enclosing double quotes "" and tab characters using a text editor. Next, I uploaded each text file to the Voyant website and performed the word frequency analysis on each file. I first selected the 'English (Taporware)' stop words list from the options menu. The stop words list contains common English words and numbers that are ignored during the word frequency analysis. For the Titles and Abstracts analysis, I added "environmental" and "communication" to this list since these two terms were ubiquitous in both cases, as could be expected. For the Author Address analysis, I added

[18] http://admin-apps.webofknowledge.com/JCR/JCR?RQ=HOME (requires account login).
[19] Available @ http://scargill.inf.ed.ac.uk/geoparser.html
Description @ http://www.ltg.ed.ac.uk/clusters/Edinburgh_Geoparser.
[20] Available @ https://mapsengine.google.com/map/

multiple high-frequency words to the stop list (e.g., college, department, university) to filter out non-geographic terms. These terms were identified using an iterative process whereby I reviewed the word cloud output (Voyant ~ Cirrus tab) for irrelevant terms and added them to the custom stop word list. This procedure continued until only geographic place names were visible within the word cloud. Once the text filter was in place, I saved the list of high-frequency words as a tab-delimited text file using the 'Export" button on the "Words in the Entire Corpus" tab. At the same time, I also saved the word clouds shown in the Cirrus tab as image files. Next, I added relevant header information to the Voyant text output files and removed all but the highest frequency words.

Appendix C : Bradford Distribution Derivation

The following procedures were adapted from chapter 4 of *Measuring Academic Research* (Andrés 2009, pp.34–37).

1. Copy journals and article counts from Journals2 worksheet to Journals5 worksheet.
2. Sort journal list by descending article counts (∑#) and add a cumulative count column.
3. Add pivot tables to Journals5 to show the cumulative number of journals in each journal rank (n) and the cumulative number of articles by journal rank (n).
4. Calculate Bradford's constant (k) using the equation:

$$k = (e^{\gamma} \times Y_m)^{\frac{1}{P}}$$

"where γ is Euler's number ($\gamma = 0.5772$), Y_m is the maximal productivity of the journal of rank one, and P is the number of zones or Bradford groups." (Egghe and Rousseau 1986, 1990 as cited in Andrés 2009).

5. Calculate the number of journals in the core zone (r_0) using this equation:

$$r_0 = \frac{T(k-1)}{k^P - 1}$$

"where T represents the total number of journals publishing articles in a given subject area, k is Bradford's constant and P is the number of Bradford groups." (Egghe and Rousseau 1986, 1990 as cited in Andrés 2009).

6. Calculate the number of journals in non-core zones ($r_1, r_2, r_3, \dots$) using this equation:

$$r_n = r_0 \times k^n$$

7. In both datasets, P was set to 3, as this number of zones produced a cumulative article total ($Sum_P = r_0 + \cdots + r_{P-1}$) closest to the total number of journals (T).
8. The number of journals in the non-core zones (r_1, r_2), as calculated in step 6, were also compared to the actual data under the assumption that the calculated number of journals in the core zone (r_0) was correct. The number of journals in each zone was then tabulated based on an equal number of journal articles in the non-core zones.
9. Calculate the ideal Bradford Distribution for each journal ranking using this equation:

$$R(r) = a \ln(1 + br)$$

"In this formula, $R(r)$ is the cumulative number of articles" (Andrés 2009, p.36) for the cumulative number of journals (r). The equation includes two constants: a and b.

The constant a is calculated as follows:

$$a = y_0 / \ln k$$

Where y_0 is the number of articles in each zone calculated by dividing the total number of articles (A) by the number of Bradford zones (P), as follows:

$$y_0 = A/P$$

The constant b is calculated as follows:

$$b = (k-1)/r_0$$

10. The Pearson Correlation Coefficients and Chi-squared values for the Bradford Distribution data (observed vs. ideal) were also calculated.
11. The observed Bradford distributions (as tabulated in step 3) were then charted against the ideal Bradford distributions (as calculated in step 9) for both datasets. Logarithmic axes were applied on both the x-axis (Cumulative # Papers) and y-axis (Journal Rank).

Appendix D : Research Ethics Checklist

This form is designed to help students and staff completes an ethical scrutiny of their proposed research. It also enables the University and Faculty to keep a record of research conducted that has been subjected to ethical scrutiny.

Name of student or principal investigator	Robert Powers
Name of supervisor (if applicable)	David Farbey
Title of research proposal	What changes were there in the field of Environmental Communication as reflected in publication trends between 2001 and 2012 (and what was the impact of the launch of new peer-reviewed journals on this field) ?
Outline of methodology[21]	I will use basic bibliometric methods (i.e. simple statistics) on bibliometric data collected from three major citation indexes (Scopus, WoK, Google Scholar). I will also conduct some limited topic modeling using text mining tools.
What are the anticipated outcomes, impacts and benefits of the research? What are the plans for dissemination, and feedback to participants in the research/project?	Gain an overview of Environmental Communication (EC) peer-reviewed research. Examine the impact of a new journal on an emerging field. No participants, but I may disseminate my findings among the EC community.

	Question	Yes/No
1.	Does the research involve human participants?	No

If NO please go to question No. 6.
If YES, then please answer the following questions No. 2 - 5:

2.	Will any of the participants be vulnerable? (E.g. Young people under 18, people with learning disabilities, people who may be limited by age or sickness or disability from understanding the research, people who are limited by knowledge of language, and people whose livelihood may be in jeopardy as a result of the research etc.)	
3.	Is there any reasonable and foreseeable risk of physical or emotional harm to any of the participants? (E.g. Distressing interview questions, experiments involving participants, asking participants to consume samples etc.)	
4.	Will anyone be taking part without giving their informed consent? (E.g. Research involving covert study, coercion of subjects, where subjects have not properly understood the research etc.)	
5.	Will the research output allow identification of any individual who has not given express consent to be identified?	

If the answer to any of the questions 2 - 5 is YES then the research proposal should be submitted to the FREC for approval *unless* it falls into a category/programme of research that has already received **category approval. (See Section Three)**

[21] If the research has a number of distinctive phases where the full methodology or research subjects are not clear at the outset, a separate ethical approval may needed for each phase. In this case, the outline of methodology should make clear if approval is only being sought for an initial phase of work. Normally this requirement would only relate to Doctoral Students at the RF1 and RF2 stages of their research.

6.	Does the research require approval from any external ethics committee, e.g. the NHS? For NHS research, this includes any work using NHS Patients (including tissues, organs, or data), NHS staff, volunteers, carers, NHS premises or facilities.	No

If the answer to question 6 is YES then the research proposal should be submitted to the relevant external body. For NHS Research Ethics Committees please refer to http://www.corec.org.uk

What are the possible benefits of this research to participants in it?

If the research proposal does not require submission to either the FREC or an NHS or other external REC then **standard approval** applies.

If the research proposal requires submission to the FREC please refer to the Faculty Research Ethics Policy, or contact a member of the committee for more information. **Approval awaited** applies until the proposal has been considered by the FREC.

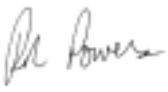
ETHICAL APPROVAL (please tick):

■ (*Standard approval)* This project does not require specific ethical approval.

□ *(Category approval)* In my opinion this work falls within the category Of..... projects which has been previously approved by the FREC and it does not therefore need individual approval (See Section 3)

□ *(Approval awaited)* This project should be referred to the FREC for individual consideration – the work should not proceed unless and until the FREC gives approval.

I can confirm that I have read the Sheffield Hallam University Research Ethics Policy and Procedures document and agree to abide by its principles (please tick). ■

Signed  Name. Robert Powers Date....11/11/2013.....
Student / Researcher/Principal Investigator (as applicable)

Signed..... Name..... Date.....
Supervisor or other person giving ethical sign-off (as defined by O&M Research Ethics Procedures)

Note: University Research Ethics policy available from the following web link:
http://www.shu.ac.uk/research/ethics.html

Students - If standard approval applies, please return this form at the same time you submit your research project proposal form to your supervisor.