FORUM

Publish *and* Perish?

The Impact of Citation Indexing on the Development of New Fields of Environmental Research

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Keywords

academic publishing
bibliometry
environmental journals
interdisciplinary research
Science Citation Index (SCI)
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Summary

The publishing of research has implications for the evaluation of research careers, research departments, and funding for research projects. Researchers' academic evaluation relies heavily on the status of the journals in which they publish. The inclusion of one's work in the Science Citation Index (SCI) and the Social Science Citation Index (SSCI) is often used as an indicator of academic quality. This is unfortunate for many environmental researchers, as their journals are not represented in the SCI and SSCI. Two investigations were carried out to determine the reasons for this. The first investigation identified 352 existing environmental academic journals, classified into seven categories (and several subcategories). Of these, two categories were not represented in the SCI or SSCI: environmental systems analysis journals and corporate environmental management journals. The second survey investigated the publishing patterns of interdisciplinary research groups and the characteristics of the journals in which they publish. In spite of acceptable citation levels, interdisciplinary environmental journals are excluded from the SCI and SSCI. A major reason seems to be that citations of their articles are uncounted by the Institute for Scientific Information (ISI), the organization producing the SCI and SSCI, because citations mostly take place in a group of journals completely unrepresented in ISI's database.

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Introduction

"Publish or perish" is said to be a fact of academic life. This phrase signals the importance of publishing research results. Researchers widely understand that publishing should take place in peer-reviewed academic journals, preferably those included in the Science Citation Index (SCI) or the Social Science Citation Index (SSCI), two databases that index the leading and most influential academic journals. Satisfying these criteria is difficult for researchers in emerging fields, however, especially within certain fields of interdisciplinary environmental research, because their journals have not gained adequate recognition for inclusion in the SCI or SSCI. Researchers in industry and academia use the SCI and the SSCI and similar databases to find references to research publications of interest for many purposes, for example, to learn about the latest findings in a field, to make sure that one's recommendations offered to managers or policy makers are state of the art, and to avoid duplication of efforts when planning new projects. Although there are other databases, the SCI and the SSCI are considered particularly important in the academic world because they are internationally used in the evaluation of research proposals in funding agencies, of research departments, and of promotion and tenure for individual researchers. Fields without representation in the SCI and the SSCI run the risk of discrimination in academic competition, for example, because researchers and their projects are often evaluated by the number of their articles that are published in journals included in the SCI and the SSCI. As a consequence, knowledge production, the dissemination and application of research results, and the development of research communities in these fields can be inhibited.

Reading, Writing, and Information Seeking

Tenopir and King (2000) have studied the scholarly publishing system for 30 years. Their research confirms that the two main reasons for publishing are the application and advancement of science and career advancement. These two aspects are related, as are reading and writing, and a link between them is information seeking. All scientists (i.e., scholars, researchers, analysts) read extensively. The patterns for finding articles to read have changed during the past 10 to 15 years. Spiraling journal prices have led to an increase in library subscriptions at the expense of individual scientists'. Thus, articles are increasingly found via automated searches in databases of abstracting and indexing (A&I) services, such as the SCI and SSCI. Whereas university scientists mostly read to keep current and for research and teaching purposes, industrial scientists mostly read because they are often required to change research direction and must bring themselves up to date in new specialties (Tenopir and King 2000). In total, most reading is done outside of universities owing to the greater number of industry scientists (Tenopir and King 2000). Given that reading is important for scientists and time is a precious resource, the ability to quickly locate relevant articles is crucial (Tenopir and King 2000). This makes A&I services, such as the SCI and SSCI, important for the application and advancement of science. Without relevant A&I services, scientists would have to turn to other channels, such as hearsay, colleagues, conferences, the Internet and, to some extent, to other types of publications, such as technical reports and conference abstracts. The problem with these other types of publications (technical reports, etc.) is that they are not well organized or readily available; for this reason, they are known as the "gray" literature.

In contrast to reading patterns, the pattern is for university scientists to do most of the writing (75% of the articles in 1995, according to Tenopir and King [2000]). Scientists, especially university scientists, are often evaluated (for promotion and tenure, research funding, etc.) on the basis of the number of articles they have published in journals covered by the SCI and SSCI. In fact, one strong motivation to write seems to be career advancement (Tenopir and King 2000). The SCI and SSCI are particularly important because they represent a selection of the most important and influential journals. In addition, several studies have shown that the prestige of a journal and its topic/readership are the two top reasons for choosing which journal to publish in (Page et al. 1997; Tenopir and King

2000), reinforcing the importance of SCI and SSCI.

Indexing and Abstracting

The SCI and the SSCI are examples of databases that are built up on the principles of indexing and abstracting and are thus part of the larger universe of what are often called A&I services.

An index is typically an alphabetical list, usually at the end of a book, of names, subjects, and so on, with references to where these are mentioned. Basic indexing of a scientific paper includes information about where to find it, that is, title, author, journal, and year of publication. More extensive indexing may include information about the number of pages, keywords, or references cited in the paper. Indexing that includes the references cited in a paper can be used to identify the most influential journals and papers through citation statistics; this latter form of indexing is known as citation indexing. Identification of high-impact journals through citation statistics is the basis for the Institute for Scientific Information's (ISI's) selection of journals used to produce the SCI and SSCI.

A limited selection of journals for inclusion in citation indices is possible because it has been shown that a relatively small number of journals publish the bulk of significant scientific results. As few as 150 journals account for half of what is cited. Around 2,000 journals account for about 95% of cited articles and 85% of published articles (Garfield 1996). Based on the citation counts, ISI calculates the impact factors of the journals. Those with the highest impact factors make it into the SCI and the SSCI. ISI reviews nearly 2,000 new journal titles annually, of which only 10% to 12% are selected for the SCI and SSCI. The selected journals, together with some of the remaining ones, are searchable through ISI's other services, for example, SCIExpanded (ISI 1999).

Other ways of indexing on a selective basis are possible. The Emerald Management Reviews (formerly known as Anbar), established in 1994, uses a selection process quite different from ISI's. Whereas ISI's selection process is largely computerized and databased, that of the Emerald Management Reviews is based on an expert panel's choices (Anbar 1999; Emerald 2002).[1]

Abstracting services, as the name suggests, supply abstracts of articles. An abstracting service is mainly an information service using more basic indexing, and it does not produce a limited selection (and implicit ranking) of journals. Instead, its aim is to cover a particular field completely. Examples of abstracting services are Cambridge Scientific Abstracts, Chemical Abstracts, Compendex Engineering Index, and Environment Abstracts.

Does Our Research Field Face Discrimination?

Despite acceptable quality, journals in certain fields of environmental science are not represented in the SCI and SSCI. As an illustration, my own multidisciplinary department includes engineers (chemical, civil, mechanical, etc.), biologists, and business scholars. The department thus draws on research from the natural, engineering, and social sciences. Environmental management practices are studied, and tools are developed for environmental analysis and decision making (life-cycle assessment [LCA], materials flow analysis [MFA], environmental performance indicators, environmental impact assessment [EIA], and ecological risk assessment). None of "our" journals, for example, *International Journal of Life Cycle Assessment, Journal of Industrial Ecology (JIE),* or *Business Strategy and the Environment,* are indexed in the SCI or SSCI. Our situation is not unique. At the Greening of Industry Network Conference in November 1999, professors T. Gladwin, S. Hart, and N. Roome discussed the publishing situation and its implications on research careers in North American and European universities (Gladwin et al. 1999). Their outlook was not optimistic; it was more like "Publish *and* perish!" Without the possibility of publishing in the "right" journals, individual researchers in certain countries have difficulty acquiring tenure, and tenured researchers are important for the growth of research groups.

Publication can also affect existing research groups. Certain countries practice formal assessment of the quality and standing of research groups, such as the "research assessment exercise"

in the United Kingdom. The grade awarded to a research group is in part determined by the standing of the researchers' publications, that is, whether they publish in SCI- and SSCI-listed journals. Because the grade determines the level of core funding, it can determine the viability and even the survival of the group (Clift 2002). In addition, when existing journals are not accepted by well-established A&I services, the dissemination of results is inefficient (e.g., potentially leading to duplication of results).

To understand why none of "our" interdisciplinary environmental journals have achieved recognition outside the community of active researchers in the field, two investigations were undertaken (Baumann 2000). The first was an overview of available journals, the second an investigation of the current outlets for interdisciplinary environmental researchers, focusing on academic journals. The aim was to determine whether there was a market for a new journal, but the survey results sparked so much discussion among colleagues that we felt it necessary to disseminate the results more widely, hence this article.

The First Investigation: Existing Environmental Academic Journals

Survey Methodology

A survey of environmental journals was conducted in the autumn of 1999.[2] The term "environmental journal" was used for any journal with an *explicit* environmental scope, for example, environmental science, environmental technology, environmental economics, or environmental management. Some nonenvironmental journals publish environmental papers, but these were not included. The search for environmental journals relied on the following sources:

- More than 100 publishers' catalogues (e.g., Academic Press, Blackwell Science, Carfax, CRC Press, Elsevier, Gordon and Breach, Kluwer, Sage, Springer, Taylor and Francis, Wiley, various societies, and various university presses)
- Library databases (LIBRIS, the Swedish academic library system; ELIN, the library of the Swedish Environmental Protection Agency; British Library; U.S. Library of Congress)
- Journal lists of the ISI (the organization producing the SCI and SSCI)
- Colleagues' experience of publishing

Journals were sorted into subject categories (table 1). Some very broad journals were difficult to categorize and were thus given a category of their own, the "multifield" category. Because the search focused on environmental journals, categories bordering on the life sciences were only partially covered. As a consequence, the number of journals recorded for the categories "ecology," "toxicology," and "agriculture" is lower than what is actually published. Also, there are more "policy and law" journals than those listed here; those journals that only report on court cases in their respective country have not been included, whereas those with more extensive analyses of environmental regulation and policy have.

Environmental Academic Journals: A Growing and Ill-Defined Group

The survey identified 352 academic environmental journals (Baumann 2000), probably more than what most environmental researchers would have guessed. Yet, comparatively speaking, it is a small number. *Ulrich's Periodical Directory* currently lists approximately 230,000 international periodicals, of which approximately 41,000 are academic or scholarly (Diven 2002). Other estimates point to between 70,000 and 80,000 academic journals in the world (Tenopir and King 2000). The ISI covers 8,000 journals annually to produce the SCI, SSCI, and other related information products. The SCI includes 3,700 journals; the SSCI, 1,700 (ISI 2001).

The first environmental journal was published in the beginning of the twentieth century. During the first decades of the century, only a handful of such journals existed. Early topics for journals were water treatment, ecology, and wildlife management. The 1960s saw the start of an increase in publishing that rapidly expanded in the

Table 1 Number of journals identified in the first survey, separated by subject category

130	**Environmental sciences**	**16**	**Environmental values**
29	Environmental science, general	1	Values, general
31	Toxicology and medicine	11	"Green" economics
8	Climate and atmosphere	4	Ethics
11	Water		
5	Soil	**29**	**Environmental social sciences**
25	Ecology	7	Social science, general
13	Wildlife management	6	Social geography
6	Monitoring (GIS, remote sensing, etc.)	1	Sociology and psychology
2	Impacts on artifacts	–	Perception and communication
		5	Education
96	**Environmental engineering**	3	Political sciences
22	Environmental engineering, general	7	Humanities (history, literature, art, etc.)
18	Water treatment and management		
2	Atmospheric pollution control	**12**	**Systems, tools, and approaches**
7	Waste management	–	Systems, tools, and approaches, general
3	Soil remediation	1	Life-cycle assessment
8	Energy	4	Risk analysis
1	Transport and environment	3	Environmental impact assessment
3	Environmental product design	1	Industrial ecology
3	Environmental process design	–	Substance/material flow analysis
8	Built environment	–	Cleaner production and technology
7	Agriculture and environment	3	Modelling
7	Resource management		
2	Environmental measurement techniques	**22**	**Multifield category**
	Environmental statistics		
3	Environmental informatics		
47	**Environmental management and policy**	**352**	**Total number of journals**
7	Managment and policy, general		
27	Policy and law		
7	Corporate environmental management		
6	Planning (land-use, etc.)		

Note: Author's categorization.

1990s. About half of all the new titles have appeared only in the last ten years (figure 1). This expansion in the environmental field is remarkable in light of the fact that the expansion of new journal titles of all types peaked in the 1970s. The overall number of new journals introduced in the 1990s was relatively low, and the number that survives even lower (Page et al. 1997).

Typical topics for environmental journals started in the 1970s were environmental science and resources. Environmental engineering journals were in vogue in the 1980s. New categories of journals in the 1990s were environmental social science, environmental management, and environmental tools. Some trends go across categories. Journals with, for example, "global" or "dynamic" perspectives on environmental issues are of relatively recent origin and are found in several categories.

Journals often change names, a trend especially during the 1990s. Names have changed either to transform a nonenvironmental journal into an environmental one (e.g., *Planning Outlook* changed to *Journal of Environmental Planning and Management* in 1991) or to "update" an existing environmental journal (*Journal of Clean Technology, Environmental Toxicology, and Occupational Medicine* changed to *Environmental Epi-*

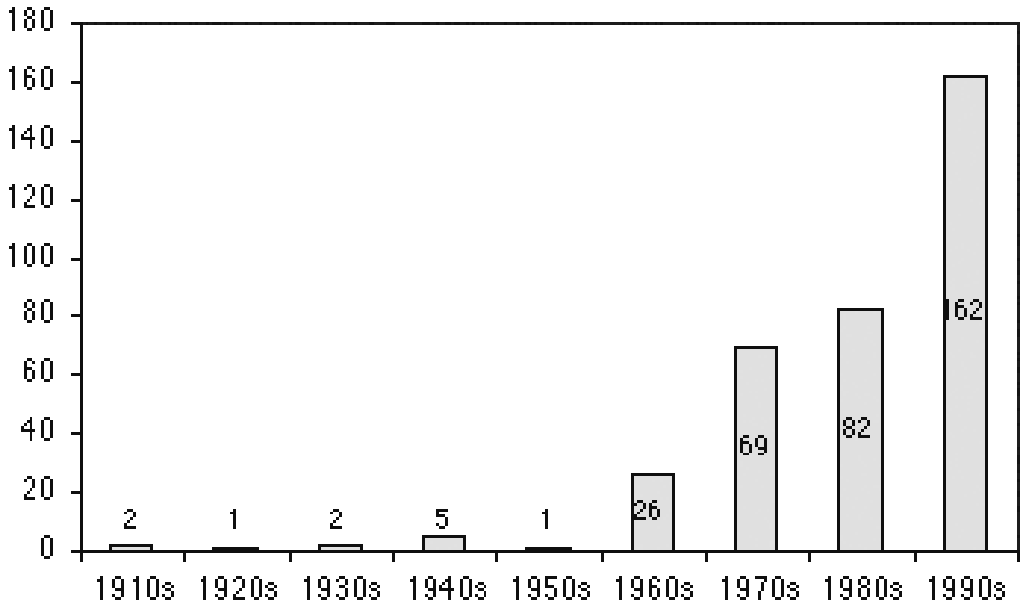

Figure 1 Number of new academic journal titles per decade.

demiology and Toxicology in 1998). Some journals have changed names more than once. In an extreme case, more than four name changes have been traced: *Water Environment Research* appeared originally as *Sewage Works Journal* (1928–1949); it changed to *Sewage and Industrial Wastes* (1950–1959), then to *Journal of the Water Pollution Control Federation* (1960–1989) and *Research Journal of the Water Pollution Control Federation* (1989–1991) before appearing under its present name in 1992.

Many journals, both older and newer ones, have recently increased the number of issues they publish per year, typically from four to six issues. Among the older ones are *Journal of Applied Ecology* (started in 1964), *Conservation Biology* (1968), and *Agriculture, Ecosystems, and Environment* (1974). Among the newer journals are several management, policy, and tool journals: *Environment and Planning, Part C: Government and Policy* (1983), *Business Strategy and the Environment* (1992), and *International Journal of Life Cycle Assessment* (1996). The greatest publishing increase was observed for *Journal of Aerosol Science* (from six to ten issues per year).

The increasing number of journals together with an increasing number of issues per year for many of them add up to a dramatic increase of publishing in the environmental field. Traditional science disciplines still dominate, however, and interdisciplinary journals are comparatively scarce. This is not in tune with what many researchers and organizations have been advocating for many years, namely, a multidisciplinary approach to environmental problems (e.g., Nordic Council of Ministers 1991; EU 1998).

Traditional environmental science also dominates ISI's database (compare figures 2 and 3). Certain interdisciplinary subject categories have no journals indexed in the SCI or SSCI, for example, "corporate environmental management" and "environmental product design" or tool categories such as "life-cycle assessment," "environmental impact assessment," and "industrial ecology."

Further, ISI treats same category journals in an inconsistent way. For example, "green" economy journals are indexed in the SSCI in all cases but one. The exception, *Ecological Economics*, is indexed only in the SCI. Similar inconsistencies exist for "general management and policy" journals. The only journal found to be indexed in both SCI and SSCI was one in the multifield category, *Ecosystem Health*.

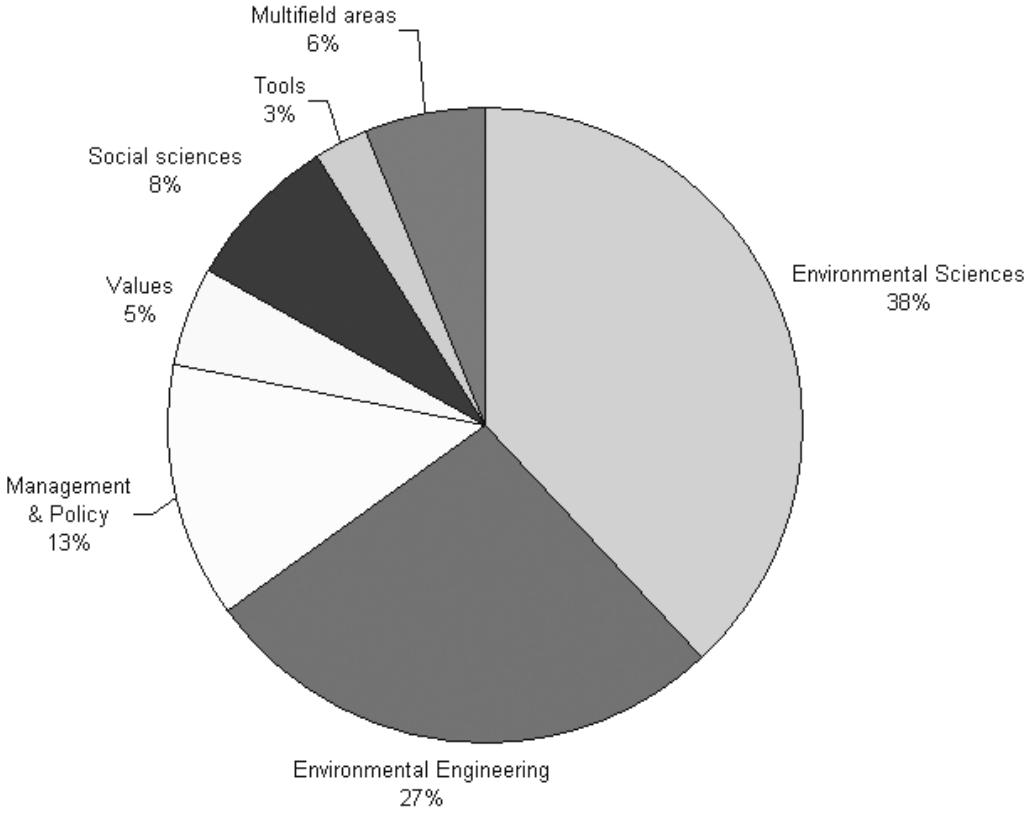

Figure 2 Distribution of all found environmental journals (a total of 352 journals).

The number of new journals and new titles following topical changes illustrates in particular the fluid character of environmental academic publishing. Surveying a rapidly expanding field is not simple, not even for A&I professionals. The many title changes together with the creation of new journals through the redefinition of existing journals add to the difficulties. We can then perhaps understand why their journal categorization sometimes becomes inconsistent, especially for new and interdisciplinary research areas.

The Second Investigation: Where Do Interdisciplinary Environmental Researchers Publish?

Survey Methodology

The publication situation for interdisciplinary environmental researchers was studied by looking at how researchers in five interdisciplinary and related areas publish. For each area, prominent research centers were identified and their publication lists were analyzed to identify publishing patterns. This selection is intended as a useful approximation of the wider population of environmental systems researchers. A simple content analysis was conducted and reference statistics were determined. The five areas were LCA, substance flow analysis (SFA) or MFA, EIA, industrial ecology (IE), and environmental accounting (EA). Together they form what is here called environmental systems analysis (ESA). These areas have in common the use of quantitative models of matter and energy flows to describe environmental impacts of sociotechnical systems, such as product systems, regional industrial areas, and development sites. These researchers could therefore be expected to share an interest in environmental systems modeling and environmental valuation and decision

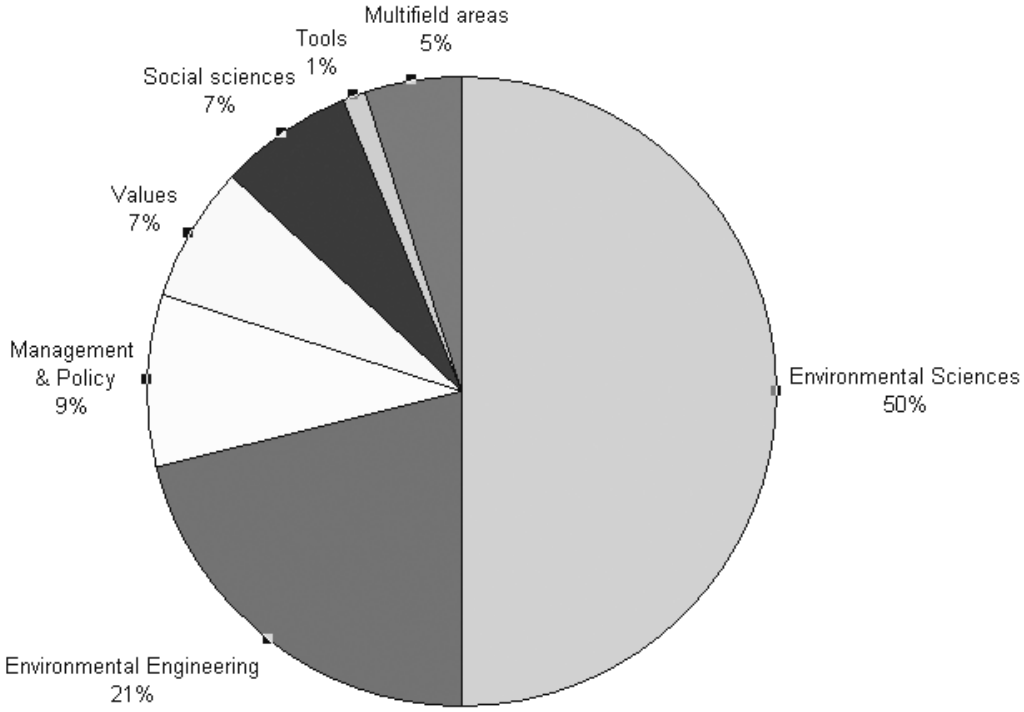

Figure 3 Distribution of environmental journals indexed in either the SCI or SSCI (a total of 122 journals).

making, as well as in publications in which these topics are discussed.

Publishing Patterns for Five Related Research Areas

Life-Cycle Assessment

Two prominent groups of LCA researchers are found in the Netherlands at the University of Leiden and in Sweden at Chalmers University of Technology. The Swedish LCA researchers list 15 LCA articles in their list of publications (TEP 1999). Most articles concerned methodology and appeared mainly in the *International Journal of Life Cycle Assessment* and *Journal of Cleaner Production*. Applied articles, reporting on LCA case studies, appeared in various sector-oriented journals, such as *Energy and Environment*, *Building and Environment*, and *Water Science and Technology*. The Dutch LCA researchers had 13 journal articles on LCA on their publication list (CML 1999). More than half of them had appeared in the *International Journal of Life Cycle Assessment*, the rest appearing in the *Journal of Cleaner Production* and *JIE*.

Material Flow Analysis/Substance Flow Analysis

Many MFA/SFA researchers in Europe are associated with ConAccount, a platform for material flow accounting research founded as a European Union Concerted Action (ConAccount 1999). On its Web site, ConAccount has listed 276 publications considered central to the field. Around 40 of these are references to journal articles; the rest are to books, reports, and conference papers. The 40 journal articles were published in as many as 24 different journals. Eight journals had published more than one of the listed MFA papers. Four of them had published more than two MFA papers (*Fresenius Environmental Bulletin*, *Ecological Economics*, *Environmental Science and Pollution Research*, and *Environmental Conservation)*.

Environmental Impact Assessment

EIA researchers are organized through the International Association for Impact Assessment. Its Web site also lists key publications of the field (IAIA 1999); however, the list contains mostly book titles. The EIA Centre at the University of Manchester is one of the main EIA research centers. The 64 journal articles in their publication list appeared in 24 journals (EIA Manchester 1999). Around a third of the articles appeared in one of two specialized EIA journals (*Impact Assessment and Project Appraisal* and *EIA Review)*. The rest appeared mainly in various planning journals (e.g., *Town Planning Review* and *The Planner*).

Environmental Accounting

EA can be divided into two branches: societal EA and corporate EA. Societal EA includes regional environmental quality indicators and national environmental statistics and is related to "green GDP." This side of EA is covered in "green economics" journals and policy journals. Corporate EA includes, for example, methods for environmental performance evaluation of industrial organizations. The Centre for Social and Environmental Accounting Research at the University of Dundee conducts research concerning corporate EA. Of the 25 journal articles in their list of publications (CSEAR 1999), 6 articles were published in five different environmental management journals. The remaining 19 articles were published in 15 different, nonenvironmental accounting journals.

Industrial Ecology

IE is concerned with the impact of industry and technology on the biophysical environment (Erkman 1997). Because the study of flows of material and energy is the main form of analysis, IE is sometimes used as a collective term encompassing the above-mentioned research areas; however, it is not fully recognized as an overarching concept in all these fields. The *JIE* was started in 1997 and became the official journal of the International Society for Industrial Ecology, formed in 2001. A content analysis of *JIE* for the year 2000 showed that the most frequent topics were general articles on the concept of IE and LCA. Articles on MFA/SFA, design for environment (DfE), environmental management, and education were prevalent.

Observed Patterns

The typical pattern for both the LCA and EIA communities is that a majority of methodological articles are published in what can be identified as core journals (*International Journal of Life Cycle Assessment, Journal of Cleaner Production, Environmental Impact Assessment Review,* and *JIE*). The applied articles are found in a wider range of journals. The MFA/SFA and the EA communities, however, seem to lack core journals because publishing is much more dispersed in these areas. These related research areas seem to each have their own publishing domains. Journals such as *JIE* and a new tools journal planned by the Society for Environmental Toxicology and Chemistry (SETAC 2001) strive at being platforms for mutual exchange, and the future will show if they are successful.

Notably, none of the journals identified as central to ESA *(International Journal of Life Cycle Assessment, JIE, Journal of Cleaner Production, Environmental Impact Assessment Review,* and *Impact Assessment and Project Appraisal)* are listed in the SCI or SSCI (ISI 2001). The fact that there is no abstract database that covers all of these journals does not help accessibility. At least three abstract services have to be used: Chemical Abstract for *International Journal of Life Cycle Assessment* and *JIE*, Pollution Abstract for *JIE* and *Environmental Impact Assessment Review,* and Fluid Abstracts for *Journal of Cleaner Production*. No information is available for *Impact Assessment and Project Appraisal*. An important step toward more general recognition has been taken with the recent inclusion of the *International Journal of Life Cycle Assessment* in SCIExpanded (Heinrich 2001).[3] With its coverage of 5,900 journals, it is less selective than the SCI (ISI 2001).

Why Does ISI Exclude Certain Categories of Journals?

The issue raised in the introduction concerned the problematic publishing situation for interdisciplinary environmental researchers. The first survey showed that interdisciplinary journals bridging the natural, engineering, and social sci-

ences do exist, although there are relatively few of them. The second survey showed that it is difficult to identify central and recognized journals. In short, the existing interdisciplinary journals have low status. This problem is explored in the following sections.

Some Explanations

"The Older the Better"

The first investigation showed that the older the journal, the more likely it is to be indexed (figure 4). But this is insufficient to explain why ESA journals are not listed in the SCI and the SSCI. Examples of rapid introductions to SCI exist. For two journals (*Transportation Research, Part D: Transport and Environment* and *Environmental Toxicology and Pharmacology*, both started in 1996), it took less than three years from the launch of the journal to their being indexed by SCI. Most journals identified as core ESA journals, however, have a longer history of publication.

Irregular Publication

Many factors are taken into account when ISI evaluates journals, but timeliness of publication is pointed out as a basic criterion (ISI 1999). The ability to publish on time is seen as a sign of a "healthy" backlog of manuscripts, ensuring viability. ESA journals have occasionally had problems with publishing on time. Delayed publication, sometimes solved by the publisher with double issues, could in part explain why these journals are not included in the SCI and SSCI.

"Falling between the Chairs"

The first investigation showed that the environmental research field is difficult to delineate. Not surprisingly, certain subject categories were treated inconsistently by ISI. Should ESA journals be regarded as SCI or SSCI journals? The answer is not obvious. When ISI considers the inclusion of a journal, citation patterns are compared with those of similar journals. Smaller fields such as botany do not generate as many articles or citations as do larger fields such as biotechnology. Likewise, in areas within the social sciences, it may take a relatively long time, even several years, for an article to attract a meaningful number of citations. The ESA field makes use of natural and engineering sciences in the modeling of matter and energy flows, but it does so for a social context. The field therefore builds heavily on the social sciences for issues such as environmental valuation and ethics, policy making, decision making, and management in industry and society. Time-consuming case studies of large industrial systems, characteristic of the field, might lead to a lower article publication frequency than in most science and engineering fields. As citation levels and frequencies vary greatly among disciplines, it is important to know with what group of journals a new journal should

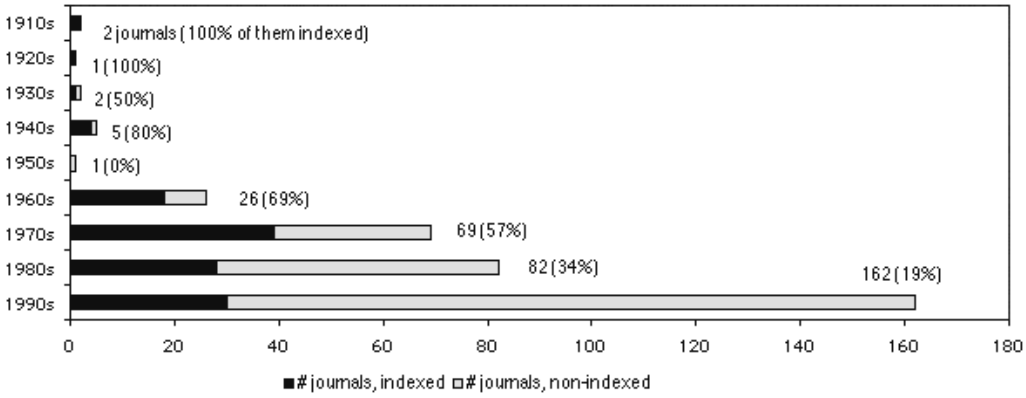

Figure 4 Number of new journal titles per decade and percentage of titles indexed in either the SCI or SSCI.

be compared. ESA journals seem to "fall between the chairs."

Not Enough Citations?

As mentioned, ISI selects journals for the SCI and SSCI through the identification of high-impact journals.[4] The articles in journals with a high impact factor are cited more frequently than those in a journal with a low impact factor. The "journal impact factor," published annually in *Journal Citation Reports* (e.g., JCR 2000), is related to the number of articles and the number of times these are cited under a given time period (ISI 1999).[5] Thus, for a journal to be counted as influential, its articles must be cited. In turn, this means that authors must be well read, formally acknowledge their "intellectual debt," and cite enough articles (and not just technical reports, books, etc.). According to ISI's statistics, a journal article has 15 references on average (ISI 2001). In comparison, the *International Journal for Life Cycle Assessment* (vol. 4) and *JIE* (vol. 3) are fairly average (16 and 18 references per article, respectively).

The question for the ESA journals is whether their authors make enough citations, and if so, whether ISI is able to count the citations. To check the citation level, I calculated the journal impact factor for one of the ESA journals according to ISI's formula (table 2). First, I counted the number of articles in the *International Journal for Life Cycle Assessment* published during two years (1998 and 1999). In addition to regular scientific articles, letters to the editor, debate articles, and book reviews should also be counted, according to ISI, because much of the scientific debate takes place there and they are thereby markers of influence. Then I counted the number of citations made during 2000 to the articles published in 1998 and 1999. I looked for citations in all the ESA journals available in our departmental library and in ISI's database. The resulting impact factor was 0.785. With an impact factor of 0.785, the *International Journal of Life Cycle Assessment* would have ranked as 67th among ISI's 143 environmental journals in the SCI (includes SCI categories "environmental science" and "environmental engineering") in 2000 (JCR 2000). This must be considered an acceptable citation level. Most citations, however, are uncounted by ISI because they take place in a group of journals not included in ISI's database.

Toward Recognition

A tool in itself cannot constitute a scientific field; however, if tools are dealt with in a systematic way (their principles of description, application, and validation), this could start to resemble a scientific field (called ESA in this article) whose journals ought to be recognized by ISI. A major reason for the exclusion of these journals seems to be the fact that citation of their articles takes place in a group of journals unrepresented in ISI's database. ESA journals are not the only ones excluded from ISI's database (cf. corporate environmental management journals). Insofar as automated searches are becoming increasingly important, it is crucial for ESA journals to be recognized by established A&I services and included in their databases so that information retrieval can be efficient for industry and university

Table 2 Journal impact factor calculation for the *International Journal of Life Cycle Assessment*

No. of articles in International Journal of Life-Cycle Assessment *during 1998 and 1999 (incl. letter to the editor, book reviews, etc.)*		*No. of citations in the year 2000 to 1998 and 1999 articles in* International Journal of Life-Cycle Assessment	
1998:	60	In *International Journal of Life-Cycle Assessment*:	73
1999:	75	In *Journal of Cleaner Production*:	7
	= 135 articles	In *Journal of Industrial Ecology*:	13
		In ISI listed journals via the SCI Expanded:	13
			= 106 citations

Journal impact factor (year 2000): $\text{citations}_{2000}/\text{articles}_{1998-1999} = 106/135 = 0.785$

scientists alike. No alternative to the SCI and the SSCI has emerged. At least three different abstract services had to be searched to cover the five ESA journals. The emerging ESA field seems to be difficult to delineate and recognize for any A&I service, not only ISI. When a field of research is "invisible," a comprehensive article search becomes very difficult to accomplish. Important findings have difficulty in finding their industrial audience, and the cumulative mechanism for research in universities is impaired. Consequently, there is the risk for interdisciplinary environmental researchers that their work is inefficient and, perhaps worse, duplicated. When, on top of this, academic evaluation relies heavily on the status of the journal one publishes in, interdisciplinary research becomes disadvantaged both in the research funding process and in the evaluation of tenure for individual researchers. Career advancement, being so important for publishing, can lead to unfortunate consequences. For most fields, the two most important factors for an author's choice of journal, readership and prestige, are linked. Without ISI's recognition of the ESA journals, the two are not coupled, and ESA researchers are then faced with the choice of publishing for the right readership or for "brownie points." And, if article writing is not viewed as a worthwhile pursuit, either because of the low academic merit of the ESA journals or of the difficulties of getting published in journals that "count," then there is even a danger that the ESA researchers publish mostly in the gray literature. This is a vicious cycle that inhibits the advancement of science and leads to a scattered, poorly networked research community in which many smaller research groups suffer intellectual isolation resulting from poor availability of information.

To get away from the "publish *and* perish" situation, lessons must be learned on all sides. Researchers should rely more on articles than technical reports for the wider dissemination of their work, carry out extensive literature searches, as well as give just acknowledgement to other authors. Funding agencies and universities need to consider whether their evaluative criteria discriminate against interdisciplinary research or not. For journal publishers, timeliness of publication and the peer-review process are critical. Indexing organizations such as ISI need to consider the recognition of new, interdisciplinary environmental subject categories and to characterize their publishing patterns.

The inclusion of ESA journals in the SCI and the SSCI is not only important and possible, it is also a simple solution to the problems of research evaluation in this field. The number of citations in the SCI and the SSCI being a common criterion in the evaluation of research have led some to argue for changed evaluation procedures in order to give interdisciplinary research, usually poorly covered by ISI, an equal chance with disciplinary research, usually well covered by ISI. It would be easier to have ESA journals included in the SCI and the SSCI than to reform evaluation procedures in universities and funding agencies around the world, however.

The recent inclusion of the *International Journal of Life Cycle Assessment* in the SCIExp is a hopeful sign for the future. This can be viewed as the journal being placed under observation by ISI. When a full cycle of three years (the necessary number of published years to calculate the journal impact factor) has been covered, it is possible that the *International Journal of Life Cycle Assessment* will be included in the SCI and the SSCI. Because all references are recorded in the journals covered by ISI, references to other ESA journals in the *International Journal of Life Cycle Assessment* will also be noted. This ought to encourage editors of ESA journals to propose their journals to the SCI and the SSCI as well as help ISI to identify the other ESA journals.

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Notes

1. The Emerald Management Review does include what I call "corporate environmental management" journals, another category of journals neglected by ISI. Because an expert panel decides on which journals should be included and no quantitative rating is published, Emerald includes certain management journals that are not included in the SSCI.
2. The following information was gathered for each journal and collected in a database, reported in its entirety in Baumann (2000):
   - Title and, when available, earlier titles
   - Publisher and, when available, the name of the editor
   - Bibliographic information: ISSN, number of issues per year, and starting year
   - Type of review process
   - Where it is indexed and abstracted
   - Additional information where available, for example, number of subscribers, impact factor (measure of the relative importance of a journal as calculated by ISI), or the journal's association with a scientific society
3. Articles in journals indexed in SCIExpanded are included in ISI's well-known database, Web of Science. ISI documentation does not make clear whether citations to articles in journals in SCIExpanded are counted in the calculations of impact factors for journals in the SCI and SSCI, nor is it clear whether ISI calculates impact factors for the journals in SCIExpanded.
4. ISI covers around 8,000 journals annually to produce the SCI and SSCI; this is the universe ISI scans regularly. SCI contains approximately 3,700 journals, SCIExp contains 5,900 journals, and SSCI contains 1,700 journals. In addition, ISI scans about 2,000 new journal titles annually, of which 10% to 12% end up in the SCI or SSCI. Because ISI registers all citations in an article, ISI finds citations to articles in journals not included in their database. ISI is able to identify influential journals as long as there are many references to them. Because researchers in a field tend to "cluster" in certain journals, however, it is difficult (not to say impossible) for ISI to identify "new" journals from the reference lists of other journals. This is the case for ESA journals.
5. In addition to regular scientific articles, ISI also counts the number of letters to the editor, debate pieces, book reviews, and so on and citations to these. They are counted because much of the scientific debate takes place there and they are markers of influence. This means that the number of articles is counted for two years (e.g., 1998 and 1999) and the number of citations to those articles (in ISI's database, for the case of conventional ISI calculations; in various ESA journals in the authors' departmental library plus those in the ISI database, for the example presented in table 2) are counted the third year (e.g., 2000).

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