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The science of ecological economics**A content analysis of *Ecological Economics*, 1989–2004**

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The *Ecological Economics* journal is a primary source for inquiry on ecological economics and sustainability. To explore the scholarly pursuit of ecological economics, we conducted a content analysis of 200 randomly sampled research, survey, and methodological articles published in *Ecological Economics* during the 15-year period of 1989–2004. Results of the analysis were used to investigate facets of transdisciplinarity within the journal. A robust qualitative approach was used to gather and examine data to identify themes representing substantive content found within the span of sampled journal papers. The extent to which each theme was represented was counted as well as additional data, such as author discipline, year published, etc. Four main categories were revealed: (1) foundations (self-reflexive themes stemming from direct discussions about ecological economics); (2) human systems, represented by the themes of values, social indicators of well-being, intergenerational distribution, and equity; (3) biophysical systems, including themes, such as carrying capacity and scarcity, energy, and resource use, relating directly to the biophysical aspects of systems; and (4) policy and management encompassing themes of development, growth, trade, accounting, and valuation, as well as institutional structures and management. The results provide empirical evidence for discussing the future direction of ecological economic efforts.

Keywords: ecological economics; content analysis; qualitative analysis; mixed-method research

Despite 20 years of development, the domain of ecological economics remains unsettled to many. In the first issue of *Ecological Economics*, the stated aim of the field was to explore “the relationships between ecosystems and economic systems”¹ and embrace transdisciplinarity as a key vehicle in this pursuit. While headway has been made in the past two decades, it is also true that much work remains. The quest for greater clarity about the content, practice, and transdisciplinarity of ecological economics prompted content analysis of randomly sampled articles from 1989 to 2004 in *Ecological Economics*. Our goal was to provide empirically based historical insights that will help in shaping future dialogue and strategies within the field.

During a doctoral-level course on the conceptual, theoretical, and philosophical foundations of ecological economics, the lack of clear disciplinary foci surfaced on numerous occasions, prompting students from a wide variety of backgrounds to pose questions about the practical elements of the field. These questions surfaced in spite of—and in many cases as a result of—their simultaneous exploration of theoretical literatures outlining the structure and function of ecological economics. References to the transdisciplinary nature of ecological economics^{1,2} further complicated the discussion, both in posing a challenge to understand transdisciplinarity itself, and in an attempt to identify its representation within the scholarly works of ecological economics.

Recent analyses of environmental and ecological economics citations³ and influential publications in ecological economics indicate the importance of *Ecological Economics* in communicating the results of sustainability science. We decided to investigate manuscript contributions to the journal as a means of pursuing the question: “What constitutes the scholarly pursuit of ecological economics?” We designed and implemented the study described herein to help answer this question.

Data source: the journal of *Ecological Economics*

The *Ecological Economics* journal published by Elsevier is a key resource for anyone interested in ecological economics and is a source of highly influential papers in the field.⁴ The International Society for Ecological Economics sponsors the journal, which has been published since 1989, following a 1987 meeting in Barcelona at which the organization was created.⁵ The name “Ecological Economics” was chosen because the founders felt it implied a “broad ecological, interdisciplinary, and holistic view of the problem of studying and managing our world.”¹ The aims and scope of the journal⁶ state:

Ecological Economics is concerned with extending and integrating the study and management of “nature’s household” (ecology) and “mankind’s household” (economics). This integration is necessary because conceptual and professional isolation have led to economic and environmental policies which are mutually destructive rather than reinforcing in the long term. The journal is transdisciplinary in spirit and methodologically open.

Specific research areas covered include: valuation of natural resources, sustainable agriculture and development, ecologically integrated technology, integrated ecologic-economic modeling at scales from local to regional to global, implications of thermodynamics for economics and ecology, renewable resource management and conservation, critical assessments of the basic assumptions underlying current economic and ecological paradigms and the implications of alternative assumptions, economic and ecological consequences of genetically engineered organisms, and gene pool inventory and management (p. 1).

The Guide for Authors from the journal in 1995 and again in 2000 reveals generally the same list of research areas, with the addition in 1995 of “alternative principles for valuing natural wealth, integrating natural resources and environmental services into national income and wealth accounts, methods of implementing efficient environmental policies, case studies of economic-ecologic conflict or harmony, etc.”⁷

A review of the first 10 years of *Ecological Economics* looked primarily at the number and types of articles published by journal category (analysis, commentary, methods, survey, news and views) and authorship, with a brief accounting of papers by topic by title.⁸ More recent citation analyses of influential publications in ecological economics reveal the importance of the *Ecological Economics* journal as a venue for broader discourse about the relationships between ecology and economics.^{3,4}

Methods

This study constitutes a content analysis of the first 15 years of the *Ecological Economics* journal. The focus was limited to the 1077 research, survey, and methodological articles published in *Ecological Economics* during the 15-year period of 1989–2004. A random sample of 200 papers was taken to ensure a 90% confidence interval with a margin of error of $\pm 5\%$ that the selected articles would be representative of all articles published during that period.

Babbie⁹ describes content analysis as “the study of recorded human communications,” including those found in books, magazines, web pages, and peer-reviewed journals. Underpinning this content analysis is the question of describing what is included in *Ecological Economics*. Of critical importance in content analysis is the unit of analysis and the methods for choosing sub-samples within the unit.⁹ The primary unit of analysis for the qualitative, descriptive analysis of content in this study was the individual article. A secondary analysis used the full data set (representing the articles in the journal from 1989–2004) to reflect on the transdisciplinary nature of ecological economics.

The first phase of data collection followed a constructivist approach that required reading the abstract, introduction, and conclusion sections of each selected paper to identify essential words and

phrases that reflect the main content of each paragraph read within each article. This is a much more robust approach than a simple analysis of titles to reveal topics—a common approach for quick content analyses. Each critical phrase or word is considered a “code”—the raw data of the content analysis and will be noted as such throughout this manuscript. Codes are the embodiment of the substantive content of each paper.

Analysis of the codes is a systematic process of conceptualization that groups raw data within a standardized framework.⁹ Analysis of the 200 articles in our sample was completed by a team of four coders. Reliability of codes was achieved through training prior to data collection that required all team members to independently code the same articles. The codes were reviewed by the coordinator, an experienced qualitative researcher, and the full group met to discuss the codes, how they were determined, and resolve any differences. This training period continued using additional articles until agreement among coders was reached without any discussion. By the end of this training, a clear link was noted between the range of number of codes and the number of pages in the article. This baseline was used by the coordinator to monitor the average number of codes per page turned in by each coder as an additional check on coding reliability.

Each of the four team members coded 50 of the 200 articles in the sample. About 2500 codes were collected and subsequently analyzed into categories. This grouping process involved the team of four coders and the coordinator. Each code was typed along with identification of its source paper, and these small snippets carried the data for consideration by the group as a whole. In a 2-day-long process, the group jointly considered each code, proceeding through an iterative process, physically grouping and regrouping the typed codes until logical categories were agreed upon by the full team. Validity of the results was enhanced by requiring agreement among all coders and the coordinator. This effort resulted in 64 categories averaging roughly 39 codes each. These categories were then discussed to identify an emergent set of themes that comprehensively encompassed the codes and categories. The codes, categories, and themes were then identified with a more comprehensive list of 43 essential phrases and words that represented the topical substance of the articles for use in the second phase of

data collection to determine the proportional representation of each main idea in the full sample.

The second phase of data collection was conducted by a second team of four researchers, each searching 50 of the 200 articles in the sample for occurrence of the following items:

- Essential phrases and words as identified in phase one data collection
- Author’s country of origin (collected for first three authors, three or more authors noted)
- Author’s disciplinary base (as identified by departmental affiliation when possible; collected for first three authors)
- Type of article (empirical, conceptual, theoretical, epistemological)
- Primary methods used.

Each article was obtained from the online journal, through ScienceDirect, as a PDF. Searches for essential phrases and words were completed using a search function to detect their presence or absence within each document. The article was examined to determine if the essential phrase or word represented the same meaning as identified by the qualitative data team and was counted if it did. Other data were found in the front material and in the methods sections of the articles.

The secondary analysis to capture the transdisciplinary nature of ecological economics involved creating a list of expected elements from a wide reading of the ecological economics literature well beyond the journal (see Box 1 for further background). This list was sent to key ecological economics scholars for review and comment, generating a good deal of commentary, and ultimately a final list:

- Covers topics that interface ecological and human systems
- Includes issues of scale and distribution, not only allocation
- Covers a wide range of temporal and spatial scales
- Draws on a wide range of disciplinary bases for theories and methods
- Acknowledges biophysical constraints, especially the Laws of Thermodynamics
- Richly interprets to reflect complexity, systems approaches, and the concept of evolution rather reductionist or mechanistic.

Box 1. Measuring transdisciplinarity

The challenging nature of the concept of transdisciplinarity involved deliberations of how to measure this aspect of ecological economics using the data from our content analysis. These discussions led to an empirical and visceral understanding of “transdisciplinarity” that we felt was valuable to share here rather than simply presenting the final approach used. Based in part on conversations with key leaders in ecological economics who reviewed the list of key elements, the research team began with the notion that the papers published in the journal could be assigned a score for how many of the key ecological economics elements they reflected as a means of measuring transdisciplinarity at the paper level.

While the list of key elements was agreed to reflect the body of scholarly work identified as ecological economics, by attempting to find these elements in individual manuscripts it quickly became clear that any individual paper was not likely to have all of them or even, sometimes, many of them. Yet we were beginning to get a collective picture as we gathered the data and we could see the elements of a transdisciplinary ecological economics revealing themselves across the various papers. The lesson was in finding that the appropriate unit of analysis to determine the presence or absence of these elements was the collective rather than individual paper level. As a meta-level construct reaching beyond disciplinary boundaries for both theories and methods, integrating knowledge from expert and non-expert sources, transdisciplinarity is better reflected at the collective level.

Using the entire data set from the two phases of data collection as described above, we assessed transdisciplinarity as a reflection of key elements in ecological economics at the meta-scale by looking collectively at the topics, methods, and disciplines identified through the qualitative and quantitative methods as described.

Using the aggregated dataset from the two phases of data collection as described above, the research team determined the presence or absence of the elements, and when possible, the extent to which they were present within the representative sample of articles. The results presented are descriptive in nature, based on simple tabulation and summary.

Results

The wide range of topics in the pages of *Ecological Economics* from 1989–2004 are summarized below in two ways. First we present the topical summary from the qualitative data collection and analysis that includes a list of 25 themes that are organized into four main groups (one with two sub-groups) to describe the main content of the journal (see Table 1). The four main groups include foundation of ecological economics, human systems, biophysical systems, and policy and management and are described below.

The foundations of ecological economics group included self-reflexive themes stemming from direct discussions about ecological economics as an

Table 1. Qualitative data themes and groupings

Group	Theme
Foundation <i>Self-reflexive</i>	Communications
	Direct mention of ecological economics
	Interdisciplinarity
	Transdisciplinarity
<i>Theory</i>	Economic theory
	<i>Methods</i>
Humans Systems	Values
	Social indicators
	Intergenerational distribution
	Equity
Biophysical Systems	Resource use
	Technology
	Carrying capacity
	Scarcity
	Systems, thermodynamic
	Energy
	Space and time scales
Policy and Management	Economic development
	Economic growth
	Institutional structures, management, and development
	Trade
	Environmental degradation related to economics
	Environmental accounting
	Valuation
	General policy

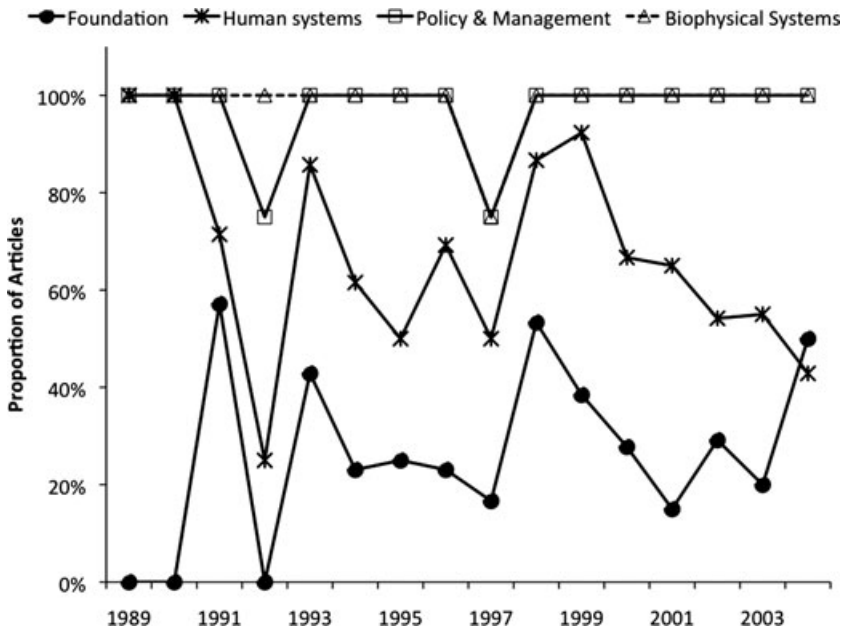


Figure 1. Proportion of articles in each category, 1989–2004.

area of research and communication among and between scientists, practitioners, and stakeholders from varied backgrounds. The foundations group also includes theory and methods associated with ecological economics.

The second main grouping, human systems, is represented by the themes of values (i.e., held values, beliefs, norms, morals, and ethics), social indicators of well-being, intergenerational distribution, and equity. The biophysical systems group of topics includes themes, such as carrying capacity and scarcity, energy, and resource use, relating directly to the biophysical aspects of systems. The policy and management group encompasses themes of development, growth, trade, accounting, and valuation, as well as institutional structures and management, essentially representing a problem-solving approach of moving toward sustainability. The full list of themes and groups is presented in Table 1.

The second presentation of topical content of the journal as identified in our study is the proportional analyses of articles representing each main group (Figs. 1 and 2). Figure 1 shows general trends over time for presence of the main groups as presented in Table 1. Policy and management and biophysical systems were almost always present in the sampled articles, revealing at least a multidisciplinary effort,

if not interdisciplinary. Interestingly, the number of papers primarily addressing human systems has gone down over time. Figure 2 shows the proportions of occurrence of the wide range of topics represented in the pages of *Ecological Economics*. In agreement with the general topic trends, we see that natural systems are a primary base for studies in *Ecological Economics*. Policy topics were present in nearly two-thirds of the articles, with technology occurring in 45%. Biophysical systems and natural resources of all sorts, including water, land, pollution, forests, and energy, were among the 10 most commonly represented critical words (Fig. 2). Economic growth was a topic in about one-third of the articles.

The articles in the journal were also described by type: empirical, conceptual or theoretical, and epistemological. Figure 3 shows that slightly more than half of the articles were empirical in nature, followed by a large proportion (42%) of conceptual and theoretical articles. A scant 3% were epistemological in nature, in keeping with the general trends shown above.

A wide variety of methodological approaches were employed by authors of *Ecological Economics* articles. Using the same basic categories, methods were grouped by primary approach. Modeling was

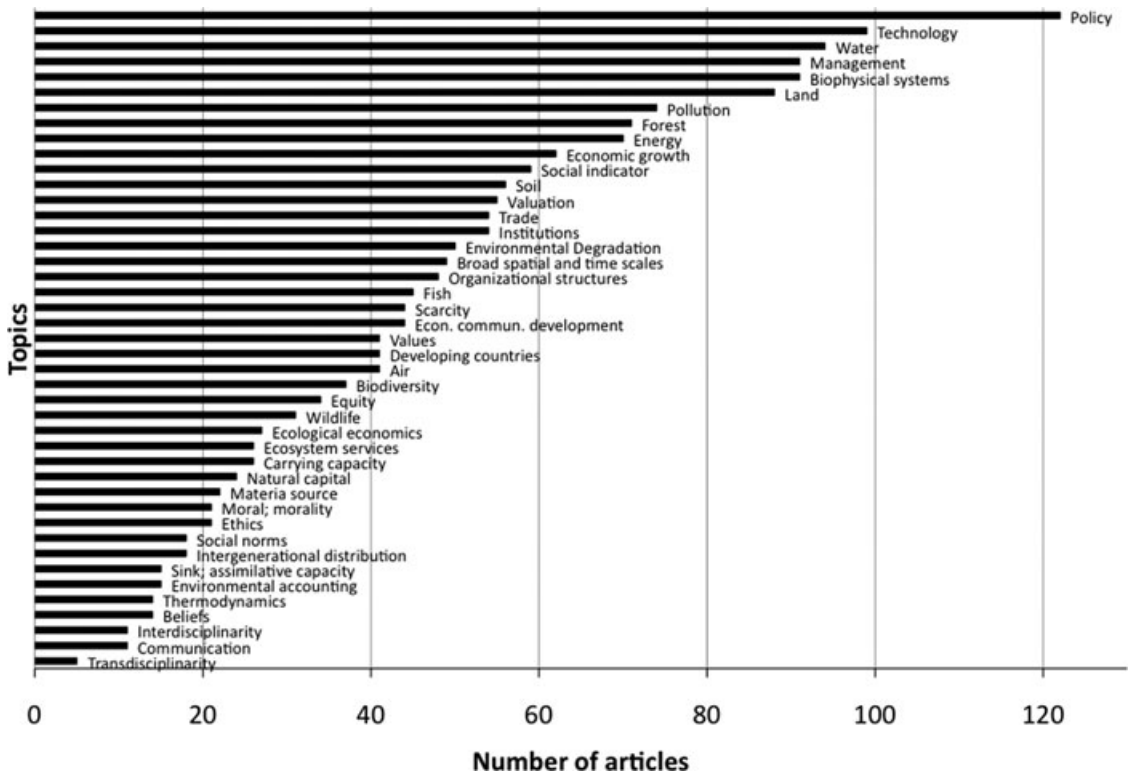


Figure 2. Topics as represented by critical words, with proportion of articles representing each.

the most frequent method, contained in 27.8% of all articles (Fig. 4). Modeling included a wide variety of applications, including economic, biophysical, and integrated social-biophysical models. Social methods, including surveys, case studies, historical analysis, risk analysis, and general comparative analyses, collectively were represented in 23.5% of articles. Valuation was the next most common methodology, showing up in 20.9% of the articles. Other economic methods, including environmental accounting, net present value, price and market analyses, input-output matrices, and economic production functions, among others, were found in 20% of the articles. Biophysical methods, including environmental footprint, physical geography, and energy and material flow analyses, were found in 7.8% of the articles. More than one distinct method or methodology was used in 17.4% of the articles reviewed.

As with methods, a broad range of theories provided the foundation of articles in the journal. The single largest group was classified as economic in nature (56%) (Fig. 5). Theories that specifically

link biophysical and economic concepts were separately identified and were found in 6% of the articles. Other theories represented included biophysical (16%), policy and management (10%), social (8%), and foundation theories, such as philosophy of science, in 4% of the articles.

Given the multidisciplinary approaches and the transdisciplinary hopes of ecological economics, the number of authors and the number of disciplines as

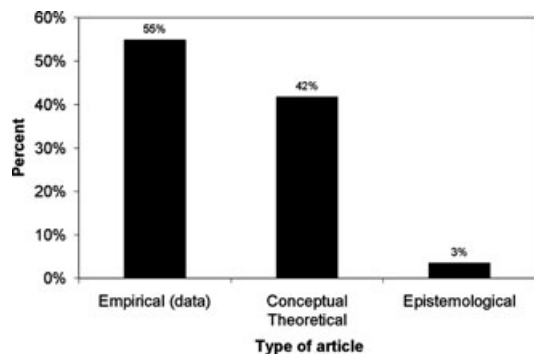


Figure 3. Types of articles published.

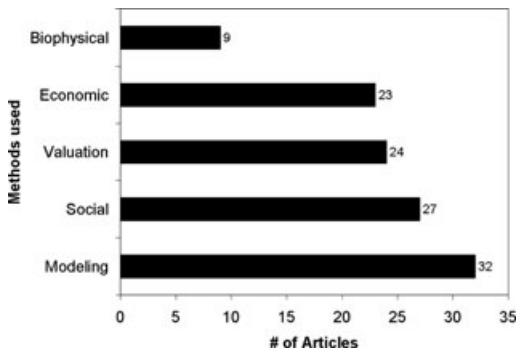


Figure 4. Variety of methods used in articles.

represented by departmental affiliations of authors over the first 15 years of publication of the journal were evaluated. Nearly two-thirds (64%) of the articles represented a single discipline, and 27% have two disciplines, leaving 8% with three or more disciplines. Of the full sample of papers, 45% had single authors. More than half of the articles (55%) had two or more authors, including 29% having three or more authors. However, papers with two or more authors did not necessarily involve two or more disciplines (see Fig. 6).

Figure 7 shows the proportion and change over time of the main discipline of the first author of each article. First authors from economics show a slight downward trend over time, and social science authors appear to be rising in number over time. No other clear authorship patterns emerge from this analysis.

The secondary analysis found that all six major concepts of ecological economics identified prior to data collection were present in the content of the journal. These include: (1) topics that interface ecological and human systems; (2) issues of scale and distribution; (3) attention to broad temporal and spatial scales; (4) draws on a wide range of disciplinary bases for theories and methods; (5) acknowledges biophysical constraints, especially the Laws of Thermodynamics; and (6) richly interprets results to reflect complexity, systems approaches, and the concept of evolution.

Discussion

These data provide an empirical foundation from which to reflect on the scholarly pursuit of ecological economics. We clearly see expression of the ecological economics worldview as described both

in the Aims and Scope of the journal, and outlined in the broader debate on the topic of ecological economics.^{2,10–13} In particular, we see the foundational ideas of systems thinking and evolutionary concepts reflected in the journal's content (Table 1). Notions, such as the relationship between the Laws of Thermodynamics and economic systems, and human and biophysical systems as complex coevolving systems are implicit in most of the published manuscripts. Many of the themes identified by the qualitative research were stated in the original and subsequent Aims and Scope,^{6,7} reflecting successful editorial management of manuscript selection to meet the goals. It may also suggest a more general level of agreement that these broad topics are fruitful areas of and/or approaches to research. The variation of foundational, self-reflexive papers over time, as shown in Figure 1, reflects the ebb and flow of debate regarding what constitutes ecological economics, both practically and theoretically. Debate of this sort is integral to the direction of further intellectual development in ecological economics.

The predominance of policy, management, and economic themes was not surprising given the focus of ecological economics on sustainability. We note that while the word policy occurs with greatest frequency, few articles (~10%) use a policy theory base. This indicates the applied nature of *Ecological Economics* articles as they relate to policy. They inform policy but rarely analyze it in a theoretical sense. The clear inclusion of policy, management, and economic considerations linked with biophysical systems in nearly all studies also supports the secondary analysis results that the main concepts of ecological economics are found within the

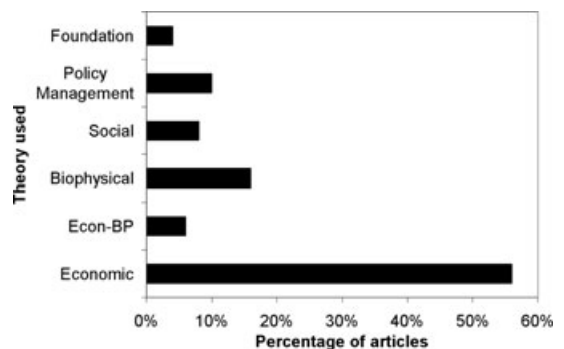


Figure 5. Proportion of articles using various theories.

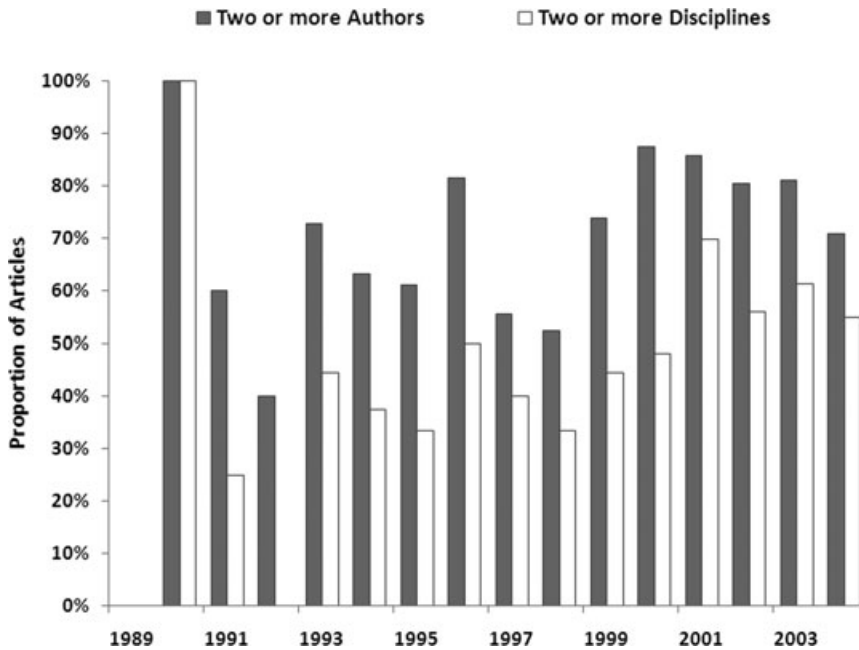


Figure 6. Proportion of articles with two or more authors and two or more disciplines.

content of the journal. Whether insights from multiple disciplines, integrated or synthesized interdisciplinary efforts, or the joint efforts of experts and non-experts often associated with transdisciplinary work,¹⁴ a primary conclusion is that the scholarly pursuit of ecological economics involves crossing disciplinary boundaries. These results support the findings of the 10-year review of the journal in which environmental policy and management was the most prevalent topic.⁸

The emphasis on transdisciplinarity in ecological economics demonstrates a breadth of concern and need for more integrative knowledge,¹² difference in focus from disciplinary level to a higher level question or problem,¹⁵ and joint pursuit of scientists and practitioners in problem solving.¹⁴ Transdisciplinarity requires a consciousness of one's own conceptual framework, and acknowledgement and tolerance of other frameworks¹¹ and may be represented by a collection of knowledge within an area of research. Given this range of interpretation, transdisciplinarity could also be considered an emergent property—possibly within a single journal article, but more likely a growing foundation of ecological economics more broadly.

Interest in transdisciplinary research has grown substantially. This is reflected in Requests for Pro-

posals from influential funding sources, such as the National Science Foundation (e.g., Biocomplexity, Coupled Human and Natural Systems, and the recent “Dear Colleague” letter suggesting proposals linking environment, society, and the economy). We also see a growing body of scholarly work clarifying multi-, inter-, and transdisciplinary research contributing to the broader discussion.^{14–17} All agree that understanding beyond that which is achieved by single or multidisciplinary approaches emerge as a result of these approaches.¹⁸

Using these interpretations, our data, taken collectively, suggest a level of transdisciplinarity present within the pages of *Ecological Economics*. At first glance the data reveal the tendency of *Ecological Economics* in its first 15 years to serve as an outlet for economists more so than ecologists and other biophysical scientists. That a majority of first authors were affiliated with economics departments and organizations, 41% of the articles employed economic methods, and 56% used some sort of economic theory supports this finding. However, in a comparison with the *Journal of Environmental Economics and Management*, Ma and Stern³ found that *Ecological Economics* brought in more science and diverse citation sources. This suggests the potential for more papers from social and biophysical

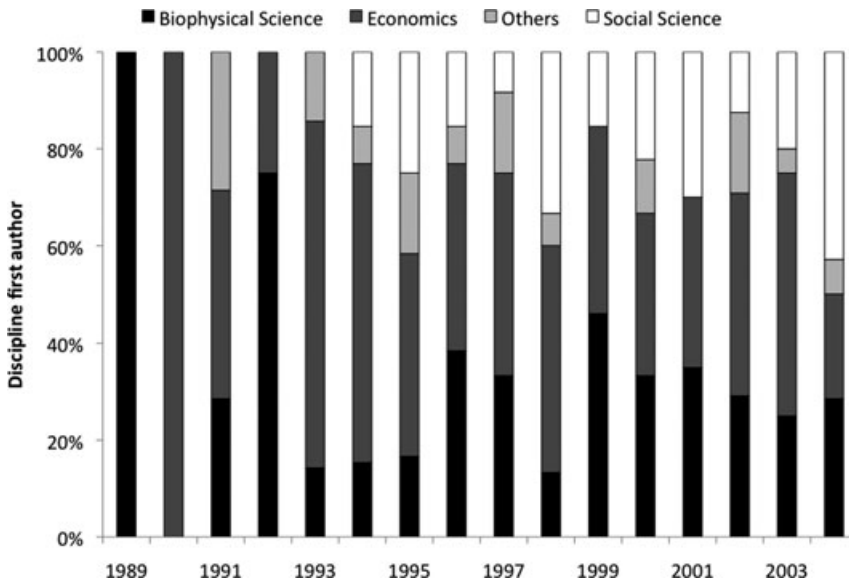


Figure 7. Change over time in proportion of first authors from each discipline area.

scientists using social and biophysical theories and methods, including policy studies. Nonetheless, our data on the number of authors and varying disciplines of first authors, taken together with the general topic trends, methods, and theories, begin to outline a conceptual and methodological pluralism—referred to in the early influential literature of ecological economics¹⁹—as a step toward transdisciplinarity. Indeed, Costanza and King⁸ used these items as indicators of transdisciplinarity in their 10-year review of *Ecological Economics*. Interestingly, the original definition of ecological economics as the relationship between ecosystems and economic systems¹ does not articulate the emergent quality of transdisciplinarity.

Our study also shows that collectively the *Ecological Economics* journal effectively achieves its aim to focus on the broader question of sustainability. But the question remains as to whether such a compilation of articles on its own constitutes transdisciplinarity. In their 10-year review of *Ecological Economics*, Costanza and King⁸ suggested the need for additional articles synthesizing the body of work represented in the journal. “Interdisciplinarity” and “transdisciplinarity” both specifically emerged from our qualitative analysis of the journal’s content, but “synthesis” did not. “Synthesis” does appear in three of the 200 titles in our sample. Moreover, when inter- and transdisciplinarity were mentioned, it was

in an epistemological or methodological context, hence our grouping of those as foundational topics. The term “survey” also emerged, but as a method (e.g., questionnaire, or biophysical data collection approach) as opposed to a survey of literature which might result in synthesis. From this we conclude that there is room for growth through more specifically identified synthesis and survey papers.

In the first 15 years, *Ecological Economics* published eight special issues focusing on specific topics. These issues provided opportunities for synthesis and, while specifically evaluating their effectiveness was outside the scope of this study, it would be worthwhile for future research. In fact, since 2004, the journal has published 11 special issues and five special sections within issues as well, providing ripe prospects for synthesis. In future efforts to measure transdisciplinarity, we recommend qualitatively assessing article content for emerging insights and analyzing discourse via the language used for communicating such knowledge. This could be followed by a positivist approach to look for those specific critical words or phrases to get a better understanding of the amount of transdisciplinarity among the variety of descriptions shared above.

Ecological economics, as represented by the content of the first 15 years of the *Ecological Economics* journal, can be characterized as a scholarly pursuit to inform the ways in which we might live

sustainably, with a primary assumption that we live in complex adaptive systems circumscribed by biophysical limits. Ecologic-economic studies contribute new knowledge about the biophysical systems that support life, especially related to the economic aspects of social organization. Articles are framed to add to the debate over the ways in which we might appropriately organize and manage ourselves under the conditions of uncertainty inherent in complex, evolving systems.

Conclusion

This paper used randomly sampled manuscripts from the journal of *Ecological Economics* over a period of 15 years to summarize the historical and contemporary shape and nature of ecological economics as a transdisciplinary scholarly and practical endeavor. Aggregated contributions represent the daily workings of a field of study seeking to stake out its territory on the intellectual landscape. We clearly saw expression of an ecological economics worldview as described both in the Aims and Scope of the journal, and outlined in the broader debate on the topic of ecological economics. However, economics remains the most prevalent discipline represented in the pages of the journal. The addition of more submissions from social and biophysical scientists using social and biophysical theories and methods, including policy studies, would add fruitful breadth to *Ecological Economics*. We also conclude that growth in the number of synthesis and survey papers would add to the transdisciplinarity of ecological economics.

Our investigation was conducted not with forwarding a final answer in mind. Rather, we sought to provide an empirical foundation for a timely and needed reflection about the scholarly pursuit of ecological economics. In keeping with this intention, we extend our study as basis for further discussion with the hope that situated alongside normative perspectives on the scholarly pursuit of ecological economics it will contribute to its future development.

Conflicts of interest

The authors declare no conflicts of interest.

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