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ANALYSIS

Environmental and ecological economics: A citation analysis

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Abstract

This study looks at two distinct questions: 'What have been the most influential journal articles in environmental economics and ecological economics over the 10-year period 1994–2003?'; and 'How much overlap is there between the fields of environmental and ecological economics?' We examine the references in all articles published in *JEEM* and Ecological Economics (*EE*) over this period. For each of these two fields, a list of the top articles and top journals cited by articles published in *JEEM* and *EE* is presented. We also present some results based on our study of the ISI *Journal Citation Reports*. We find that there is a significant overlap between the two fields at the journal level — the two journals cite similar journals. There is a correlation of 0.34 between the number of citations received by the journals that are most cited and the correlation is even higher if journal self-citation is excluded. The main differences are that ecological economics tends to cite (but not be cited by) general natural science journals more often than environmental economics does, environmental economics cites more heavily from journals rather than other publications, and citations in environmental economics are more concentrated on particular journals and individual publications. However, there is much less similarity at the level of individual articles. Non-market valuation articles dominate the most cited articles in *JEEM* while green accounting, sustainability, and the environmental Kuznets curve are all prominent topics in *EE*.

Keywords: Citations; Bibliometrics; Environmental economics; Ecological economics

JEL classification: A14; B20; Q00

1. Introduction and literature review

Costanza et al. (2004) assess which publications have been most influential on the field of ecological economics and which ecological economics publications have had the widest influence. In this paper we expand that analysis to cover two additional principal questions: 'Which have been the journal articles that have been most influential on the related mainstream

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economic field of environmental and resource economics?'; and 'To what extent are environmental and resource economics and ecological economics distinct areas of scientific endeavor and in what ways do they differ?'

A special issue of *JEEM* in 2000 celebrated the first 25 years of that journal and included a number of surveys of the papers published in *JEEM* and their influence on the profession (e.g. Fisher and Ward, 2000; Smith, 2000; Kolstad, 2000). These studies allow an assessment of the influence of the journal on economics and science and scholarship in general. Although *JEEM* is the premier journal in environmental and resource economics, many important articles in the field will have been published in other journals.[2] Therefore, the type of analysis carried out by Fisher and Ward (2000) and Smith (2000) will not capture all the most important articles in environmental and resource economics. It also does not differentiate between citation inside the field and outside the field and so does not capture the set of articles that have been the most influential on the field itself. These comments are not criticisms as these papers did not set out to answer these questions.

Costanza et al. (2004) treat the journal Ecological Economics (*EE*) as a representative sample of work in the field of ecological economics and measure which publications were most influential on that work. This is captured by a list of the papers most cited in papers published in *EE*. In this paper we use the articles published in *JEEM* over the period of 1994–2003 as a sample of high quality research in environmental economics. If a paper appeared in *JEEM* one would assume that it must be an environmental economics article. However, *JEEM* also publishes work in resource economics (Fisher and Ward, 2000) — perhaps half the total articles. According to Fisher and Ward, the proportion of resource economics articles has in fact increased over time from less than half in the early years to more than half in recent years. *JEEM* has the highest citation impact score of any specialist environmental or resource economics journal.[3] Therefore, we take the articles published in *JEEM* as a representative sample of high quality research in mainstream environmental and resource economics.

We examine the references in all articles published in *JEEM* and *EE*. This can determine which individual publications as well as which journals have had the greatest influence on the two fields. The list of articles is not censored or truncated by only counting articles published in certain journals as in most citation analyses in economics (e.g. Kolstad, 2000) nor restricted to particular topics. We compare 10 years of data from *JEEM* and *EE*. What are the most influential articles in 1994–2003? How much overlap is there between the two fields? Are they distinctive? Or are they largely overlapping and "sociological" rather than "epistemological" communities?

Typically, citation analysis has been used in economics in order to rank departments of economics, economics journals, and individual economists rather than to trace the influence of particular papers (e.g. Burton and Phimister, 1995; Coupé, 2003; Dusansky and Vernon, 1998; Kalaitzidakis et al., 2003; Laband and Piette, 1994; Scott and Mitias, 1996; Palacios-Huerta and Volij, 2004). Using citation analysis to understand the nature of a field or to trace the influence of particular ideas and articles is rare in economics but common in other fields, including some closely related fields (e.g. Dombrow and Turnbull, 2004). In fact, the articles in *JEEM* by Smith (2000) and Kolstad (2000) as well as Fuchs (2000) seem to be the only ones in economics that we could find in the *ISI Citation Index* in the last few years that look at the citations to specific papers rather than citation counts of individuals, departments, etc. Cahlik (2000) uses some of the more sophisticated scientometric tools – co-citation analysis and co-word analysis – to look at research foci in economics. The co-word analysis only succeeds in dividing economics articles in the top 13 journals into micro- and macro-economic articles and the co-citation analysis is extremely preliminary. The rudimentary nature of this study highlights the lack of any other such research in economics.

Fisher and Ward (2000) looked at trends in the topics of articles published in *JEEM* from 1974 to 1997. Smith (2000) lists the 10 most cited articles published in *JEEM* on the topic of non-market

[2] Kolstad (2000) reviews some energy and resource articles published in other selected economics journals.

[3] *Ecological Economics* has a higher citation impact score than *JEEM* in some years including 2003, but on other measures *JEEM* scores higher.

valuation. Kolstad (2000) carries out a citation analysis of papers on energy and depletable resources. Kolstad searched the citation index for a set of key words in articles published in a selected list of economics journals. This list does not include *EE*. He lists the most cited papers in the two fields in each time period, the journals receiving the greatest number of citations for energy and depletable resource articles and the top articles in these fields published in *JEEM*. We discuss below which of Smith's and Kolstad's articles show up in our listings. Costanza et al. (2004) examine the field of ecological economics combining these approaches with the analysis described above. In addition to counting citations in *EE* to all papers, they also listed the papers published in *EE*, which received the greatest number of total citations, and the number of citations to a nominated list of foundational papers. They also examine citations to monographs and edited books. Some environmental economists were among the most cited individuals in *EE* and some of the most highly cited articles in the journal were famous articles in environmental and resource economics. Also many of the most cited articles published in the journal were on clearly mainstream environmental economics topics such as contingent valuation. None of this may be too surprising, but it inspired us to conduct the current study with the aim of comparing the two fields.

The next section of the paper describes the data sources and methods with results and conclusions sections following.

2. Data and methods

Our analysis is split into three sub-analyses. First we compute and report some basic statistics and citation data for the two journals. Then we report an analysis of the journals that cite the two journals most and those that are cited most in the two journals. Finally, we produce lists of the individual articles that were cited most in the two journals.

For the first two analyses we use data for the full 10-year period from 1994 to 2003 and data for 2003 alone. The 2003 sample gives a snapshot at the end of the period of our primary analysis and it also allows us to present some statistics that we were unable to compute from the full 1994–2003 database. For the 2003 analysis the source is the 2003 Journal Citation Reports (JCR) published online by Institute for Scientific Information (ISI). For the first analysis we also present some data for other years derived from the *JCR* and the *Citation Index*. The third analysis is only done on the full 10 years as there are very few citations to most individual articles in a single year.

To obtain the 10-year sample, we downloaded from the online *Citation Index* the reference lists from all articles published in *EE* and *JEEM* in the 10-year period and cleaned and sorted the data.

Based on the *2003 Journal Citation Reports*, the following tables were compiled:

Table 1 Basic citation statistics 2003
Table 4 Top 20 journals citing *JEEM* and *EE* in 2003
Table 5 References to top 20 journals in *JEEM* and *EE* in 2003

Using a mixture of data from the *JCR* for the years 1997–2003 and for 1994–97 data directly downloaded from the *Citation Index* we produced the following table:

Table 3 Citations to articles in *JEEM* and *EE* 1994–2003

Using the 10-year database we produced the following tables:

Table 2 Basic citation statistics 1994–2003 (including some data from the *JCR* from various years)

Using 31 citations as the cutoff line, we have two journal ranking tables:

Table 6 Most cited journals in *JEEM* 1994–2003 (38 journals, with 31 or more citations)
Table 7 Most cited journals in *EE* (70 journals, with 31 or more citations)

Using 10 citations as the cutoff line, we have two article ranking tables:

Table 8 Most cited journal articles in *JEEM* (31 articles, with 10 or more citations)

Table 9 Most cited journal articles in *EE* (26 articles, with 10 or more citations)

3. Results

3.1. Basic citation statistics

First we present some general citation related statistics for the two journals. Table 1 presents the statistics for 2003 from the 2003 *Journal Citation Reports* and Table 2 presents some of the same statistics from our 1994–2003 database.

JEEM was founded in 1974 and *EE* in 1989, so *JEEM* is twice the age of *EE*. However, *EE* published twelve issues per year in recent years and *JEEM* six. In 2003 the number of articles per issue of *JEEM* was slightly higher than the number of articles per issue of *EE*. The two journals have a similar citation impact factor in 2003 — the average number of citations received in 2003 by articles published in the previous 2 years. They rank 29th and 26th on this measure among the 171 economics journals cataloged by ISI. These citation impact factors have been fairly stable over recent years. In some years *EE* has a higher impact factor and in some years *JEEM* has a higher impact factor. The immediacy index – the number of citations in 2003 to articles published in 2003 – is almost identical. This index is usually low for social science journals, which are typified by long publication delays. *EE* has a much shorter cited half-life than *JEEM*. For citations to *EE* articles, *EE* articles published in the last 4.6 years received 50% of total citations, while for *JEEM* the time span for 50% of total citations is 8.8 years. This could imply that *JEEM* articles maintain their importance longer but also reflects the growth in *EE* over recent years and its recent inception. Even *JEEM* only ranks 57th among economics journals on the half-life measure as it, too, is a relatively new journal. The median age of articles referred to by articles in *JEEM* is 9.7 years, which is somewhat greater than the *EE* median of 7.4 years. Both the citing and cited half-lives are increasing over time.

Table 1
Basic citation statistics 2003

	JEEM		*EE*	
	Value	Rank	Value	Rank
Total citations	1526	20	1254	25
Impact	1.157	29	1.23	26
Immediacy	0.121	61	0.122	60
Cited half-life	8.8	57	4.6	139
Citing half-life	9.7	n.a.	7.4	n.a.
# Articles	66	40	98	9
Cites/Articles	24.1	30	12.8	92
Cited articles	1940	n.a.	4066	n.a.
References per article	29.4	n.a.	41.5	n.a.
Percentage of citations received are citations from the same journal (%)	10.80	n.a.	19.90	n.a.
Percentage of references in articles are citations to the same journal (%)	8.50	n.a.	6.10	n.a.

Rank refers to rank among all 171 economics journals followed by ISI.
n.a.: not applicable.

Table 2
Basic citation statistics 1994–2003

	JEEM	*EE*
Cited articles	11957	33838
Citations to articles in journal	10322	6258
References per article	26.1	37.5
Percentage of citations received are citations from the same journal (%)	11.9	31.9
Percentage of references in articles are citations to the same journal (%)	10.3	5.9

Table 3 shows how the number of citations to articles in *EE* and *JEEM* has increased over time. *JEEM* received more citations in total to its articles in 2003 than *EE*. Dividing this figure by the number of articles published in 2003, to get a rough adjustment for journal size, we find that *JEEM*'s score exceeds *EE*'s by a factor of two. Again this figure is affected by the age and expansion of journals over time. *JEEM* is ranked 30th among economics journals on this measure and is top ranked among all resource, environment, or energy journals. In 2003, there were 4066 references in the articles published in *EE* and 1940 in *JEEM* reflecting the larger number of papers published in *EE* and that the average *EE* article made 41.5 references while the average *JEEM* article made 29.4 (Table 1). This difference reflects that more survey type articles are published in *EE* and possibly that a more interdisciplinary stance results in more references. Table 2 shows that the number of refer-

Table 3
Citations to articles in *JEEM* and *EE* 1994–2003

Year	*JEEM*	*EE*
2003	1526	1254
2002	1254	966
2001	1221	946
2000	1268	856
1999	1016	737
1998	1152	499
1997	741	398
1996	860	251
1995	672	191
1994	612	160
Total	10322	6258

ences in each article has edged up over time, which is true of other economics journals too (Laband et al., 2002). Comparing Tables 1 and 2 also shows that *EE*'s citation import/export ratio has improved over time. In the full 10-year period there are around five articles cited for every citation the journal receives, while in 2003 the ratio is only three to one. *JEEM*'s ratio has been stable or worsening over the period.

A substantial proportion of the citations received by both journals are references in articles published in the same journal. This proportion was about twice as high for *EE* as *JEEM* in 2003 (Table 1). *EE* gets cited less and more of the citations are in-journal citations. However, the proportion of references in the articles published in 2003 to previous articles published in the journal is lower for *EE* than for *JEEM* – which is a function of the fact that both journals are net importers of citations – they reference more publications each year than the number of times they get cited each year. For *EE* this import/export ratio is higher but this also implies that references in *EE* articles are more eclectic as might be expected from a more interdisciplinary journal. Looking at Table 2, we see that in the period 1994–2003 around a third of the citations to *EE* articles were from articles published in *EE*. The self-citation rate of *JEEM* declined more moderately.

3.2. Citation relations between journals

Table 4 shows which journals (and books) made the most citations to our two journals of interest in 2003. The citations *EE* received from other journals are much less concentrated in specific publications than those received by *JEEM*. *EE* is the third greatest

Table 4
Top 20 journals citing *JEEM* and *EE* in 2003

Rank	*JEEM*			*EE*		
	Journal	Citations	Percent of total	Journal	Citations	Percent of total
1	**J. ENVIRON. ECON. MANAG.**	164	10.75	**ECOL. ECON.**	250	19.94
2	**ENVIRON. RESOUR. ECON.**	132	8.65	ADV. ECOL. SCI.	30	2.39
3	**ECOL. ECON.**	102	6.68	ORGAN. ENVIRON.	29	2.31
4	**LAND ECON.**	71	4.65	**ENVIRON. RESOUR. ECON.**	27	2.15
5	AM. J. AGRIC. ECON.	49	3.21	**ENVIRON. DEV. ECON.**	26	2.07
6	ECON. ENVIRON.	49	3.21	ECOL. MODEL.	25	1.99
7	J. REGUL. ECON.	43	2.82	**LAND ECON.**	21	1.67
8	NEW HORIZ. ENVIRON. ECON.	37	2.42	INT. J. SUSTAIN. DEV. WORLD	20	1.59
9	**ENVIRON. DEV. ECON.**	34	2.23	J. CLEAN. PROD.	20	1.59
10	HEALTH ECON.	24	1.57	AGRIC. ECOSYST. ENVIRON.	18	1.44
11	RESOUR. ENERGY ECON.	22	1.44	RESOUR. CONSERV. RECYCL	18	1.44
12	**J. ENVIRON. MANAGE.**	21	1.38	**J. ENVIRON. MANAG.**	17	1.36
13	J. PUBLIC ECON.	20	1.31	OCEAN COAST. MANAG.	17	1.36
14	J. REG. SCI.	17	1.11	INTEGRAT. ASS. STUDIES	16	1.28
15	OXF. REV. ECON. POLICY	17	1.11	WORLD DEV.	16	1.28
16	FOREST SCI.	16	1.05	GLOBAL ENVIRON. CHANGE	15	1.20
17	J. AGRIC. RESOUR. ECON.	16	1.05	**J. ENVIRON. ECON. MANAG.**	15	1.20
18	J. ECON. BEHAV. ORGAN.	16	1.05	ENVIRON. VALUE	14	1.12
19	CONTEMP. ECON. POLICY	13	0.85	ENVIRON. MANAGE	13	1.04
20	IND. ENG. CHEM. RES.	13	0.85	ENVIRON. MONIT. ASSESS.	13	1.04

Journals in boldface are those that *JEEM* and *EE* share in their top 20 lists.

Table 5
References to top 20 journals in *JEEM* and *EE* in 2003

Rank	*JEEM*			*EE*		
	Journal	References	Percent of total	Journal	References	Percent of total
1	**J. ENVIRON. ECON. MANAG.**	164	8.5	**ECOL. ECON.**	250	6.1
2	**AM. ECON. REV.**	89	4.6	**J. ENVIRON. ECON. MANAG.**	102	2.5
3	**J. POLIT. ECON.**	53	2.7	**AM. J. AGRIC. ECON.**	68	1.7
4	**LAND ECON.**	51	2.6	**LAND ECON.**	55	1.4
5	**AM. J. AGRIC. ECON.**	50	2.6	**ENVIRON. RESOUR. ECON.**	50	1.2
6	ECONOMETRICA	38	2.0	SCIENCE	49	1.2
7	J. PUBLIC ECON.	38	2.0	**AM. ECON. REV.**	40	1.0
8	REV. ECON. STAT.	36	1.9	AMBIO	27	0.7
9	REV. ECON. STUD.	30	1.5	ENERGY POLICY	25	0.6
10	J. URBAN ECON.	22	1.1	J. ENVIRON. MANAG.	23	0.6
11	J. ECON. THEORY	19	1.0	NATURE	22	0.5
12	**Q. J. ECON.**	19	1.0	CONSERV. BIOL.	21	0.5
13	J. LAW ECON.	16	0.8	**J. POLIT. ECON.**	21	0.5
14	**ECOL. ECON.**	15	0.8	ENVIRON. DEV. ECON.	19	0.5
15	**ENVIRON. RESOUR. ECON.**	15	0.8	**Q. J. ECON.**	18	0.4
16	CAN. J. ECON.	13	0.7	WATER RESOUR. RES.	17	0.4
17	INT. ECON. REV.	13	0.7	WORLD DEV.	16	0.4
18	ECON. J.	12	0.6	BIOSCIENCE	15	0.4
19	J. ECON. PERSPECT.	12	0.6	AGRIC. SYST.	14	0.3
20	J. ECON. LIT.	11	0.6	ENVIRON. VALUE	13	0.3

Journals in boldface are those that *JEEM* and *EE* share in their top 20 lists.

citer of *JEEM* but *JEEM* cites *EE* much less. *EE* gave *JEEM* 6.7% of its citations while *JEEM* only gave *EE* 1.2% of its citations.

ERE is the highest citing journal for both *EE* and *JEEM* but *JEEM* received 8.7% of its citations from *ERE* and *EE* only 2.2%. Of the remaining journals in the top 20 citers *Land Economics*, *Environment and Development Economics*, and *Journal of Environmental Management* are the only three shared in common. The majority of the other journals citing *JEEM* are economics journals. The journals citing *EE* are much more varied with many middle or lower tier interdisciplinary environment journals represented.[4] This pattern indicates that ecological economics is more interdisciplinary than environmental economics.

There is, however, a significant correlation between the number of citations *EE* and *JEEM* received in each of the citing journals.[5] In 2003 the correlation is 0.43 but falls to 0.27 when self-citation is ignored. In 2002 the correlation between the number of citations received in each journal by *EE* and *JEEM* is 0.33. In this case, the correlation rises to 0.45 if we leave out self-citations. We do not have comparable data for the 10-year sample.

Table 5 lists the 20 journals most cited in *JEEM* and *EE* in 2003. Here we get a first look at the influence of the journal literature on the development of environmental and ecological economics. As expected the prestige of these journals is higher than those that most cite the two journals. Eight of the journals are shared: *JEEM*, *EE*, *AER*, *Land Econ.*, *AJAE*, *JPE*, *QJE*, and *ERE*. All are economics journals. All the journals in the *JEEM* list are economics journals. Several of the journals cited in *EE* but not in the top 20 of those cited by *JEEM* are general natural science or biology journals: *Science*, *Nature*, *Bioscience*, *Conservation Biology*, *Ambio*, and *Agricultural Systems*. The remainder consists of economics journals or interdisciplinary environmental journals. Journals from other social sciences such as psychology do not show up on this list and neither do heterodox economics journals

[4] In 2002 most of the journals citing *EE* were economics related. It is not clear if this represents a trend.

[5] This correlation was computed for all journals citing *EE* and *JEEM* more than once each. Publications, which cited either journal only once are not detailed individually in the *JCR* and are therefore set to zero in our computation of the correlation coefficient.

Table 6
Most cited journals in *JEEM* 1994–2003

Titles of journals	Citations	Percent of total citations	Percent of total journal citations
Journal of Environmental Economics and Management	1234	10.32	16.27
American Economic Review	494	4.13	6.51
Land Economics	339	2.84	4.47
American Journal of Agricultural Economics	308	2.58	4.06
Journal of Political Economy	301	2.52	3.97
Econometrica	256	2.14	3.38
Journal of Public Economics	214	1.79	2.82
The Review of Economics and Statistics	171	1.43	2.25
Quarterly Journal of Economics	159	1.33	2.10
The Review of Economic Studies	149	1.25	1.96
Sum of Top 10	**3625**	**30.32**	**47.79**
Journal of Economic Theory	119	1.00	1.57
The Journal of Economic Perspectives	103	0.86	1.36
Environmental and Resource Economics	87	0.73	1.15
The Economic Journal	85	0.71	1.12
Rand Journal of Economics	84	0.70	1.11
Water Resources Research	83	0.69	1.09
The Bell Journal of Economics	82	0.69	1.08
The Journal of Law and Economics	81	0.68	1.07
Journal of Economic Literature	76	0.64	1.00
International Economic Review	74	0.62	0.98
Canadian Journal of Economics	68	0.57	0.90
Journal of Urban Economics	65	0.54	0.86
Journal of Econometrics	62	0.52	0.82
Science	57	0.48	0.75
Marine Resource Economics	55	0.46	0.73
The Energy Journal	55	0.46	0.73
Ecological Economics	54	0.45	0.71
Journal of Risk and Uncertainty	43	0.36	0.57
Economic Inquiry	42	0.35	0.55
Journal of Policy Analysis and Management	41	0.34	0.54
Southern Economic Journal	41	0.34	0.54
European Economic Review	39	0.33	0.51
Oxford Economic Papers	38	0.32	0.50
Public Choice	38	0.32	0.50
Scandinavian Journal of Economics	35	0.29	0.46
Resource and Energy Economics	34	0.28	0.45
Journal of Economic Behavior and Organization	32	0.27	0.42
Economics Letters	31	0.26	0.41
Total (38)	**5329**	**44.57**	**70.26**

Total citations to journals are 7585, which is 63.44% of total citations of 11 957.

such as *Journal of Economic Issues*. This reflects that ecological economics does import citations from interdisciplinary sources and specifically, it is more interdisciplinary in the direction of natural science. However, many of the articles from *Nature*, *Science, Ambio, and Bioscience* that are highly cited in *EE* are by prominent ecological economists (Costanza et al., 2004; also see Table 9). Therefore, ecological economics may be less interdisciplinary in practice than it would seem from this list of journals cited. As is the case with the concentration of citing journals, articles cited by *EE* are less concentrated in particular journals than are those cited by *JEEM*, which is indicated by higher percentages for particular journals on *JEEM*'s list than on *EE*'s list in Table 5.

Tables 6 and 7 shows the most cited journals in *JEEM* and *EE* in the full 10-year period. We again find that almost all the journals highly cited by *JEEM* (Table 6) are economics journals. *Science* and *Water Resources Research* are the only exceptions in the top 30. Apart from *Land Economics*, most of the top journals are general economics journals rather than environmental and resource economics journals. The 10-year and 2003 rankings are very similar. *EE* is ranked considerably higher on *JEEM*'s list of journals cited in 2003, which might

Table 7
Most cited journals in *EE* 1994–2003

Titles of journals	Citations by journals	Percent of total citations	Percent of total journal citations	Rank
Ecological Economics	2004	5.92	12.73	1
Journal of Environmental Economics and Management	773	2.28	4.91	2
Science	514	1.52	3.26	3
Land Economics	426	1.26	2.71	4
American Economic Review	381	1.13	2.42	5
American Journal of Agricultural Economics	358	1.06	2.27	6
Nature	238	0.70	1.51	7
Ambio	236	0.70	1.50	8
Environmental and Resource Economics	187	0.55	1.19	9
Quarterly Journal of Economics	185	0.55	1.17	10
Sum of Top 10	**5302**	**15.67**	**33.67**	
World Development	181	0.53	1.15	11
Energy Policy	168	0.50	1.07	12
Journal of Political Economy	161	0.48	1.02	13
Conservation Biology	137	0.40	0.87	14
The Economic Journal	119	0.35	0.76	15
The Journal of Economic Perspectives	119	0.35	0.76	16
Econometrica	106	0.31	0.67	17
The Review of Economic Studies	104	0.31	0.66	18
Water Resources Research	100	0.30	0.64	19
Ecological Applications	99	0.29	0.63	20
Environmental Values	92	0.27	0.58	21
Ecology	89	0.26	0.57	22
Environment and Development Economics	85	0.25	0.54	23
The Energy Journal	84	0.25	0.53	24
The Review of Economics and Statistics	81	0.24	0.51	25
Journal of Public Economics	77	0.23	0.49	26
Journal of Economic Literature	76	0.22	0.48	27
Environmental Management	73	0.22	0.46	28
Scientific American	69	0.20	0.44	29
Environment	68	0.20	0.43	30
Ecological Modelling	61	0.18	0.39	31
Agriculture, Ecosystems and Environment	54	0.16	0.34	32
Environmental Conservation	52	0.15	0.33	33
Environment and Planning A	50	0.15	0.32	34
Journal of Agricultural Economics	50	0.15	0.32	35
Climatic Change	49	0.14	0.31	36
Forest Ecology and Management	49	0.14	0.31	37
Futures	48	0.14	0.30	38
Subtotal top 38	**7803**	**23.06**	**49.19**	
The Journal of Law and Economics	47	0.14	0.30	39
Natural Resources Journal	47	0.14	0.30	40
Resource and Energy Economics	46	0.14	0.29	41
Energy Economics	44	0.13	0.28	42
Marine Resource Economics	44	0.13	0.28	43
Forest Science	43	0.13	0.27	44
Journal of Risk and Uncertainty	43	0.13	0.27	45
Resources Policy	43	0.13	0.27	46
Biological Conservation	42	0.12	0.27	47
Journal of Theoretical Biology	42	0.12	0.27	48
Oxford Economic Papers	42	0.12	0.27	49
Annual Review of Ecology and Systematics	40	0.12	0.25	50

Table 7 (*continued*)

Titles of journals	Citations by journals	Percent of total citations	Percent of total journal citations	Rank
Agricultural Systems	39	0.12	0.25	51
Population and Environment	39	0.12	0.25	52
Scandinavian Journal of Economics	39	0.12	0.25	53
Journal of Development Economics	38	0.11	0.24	54
Journal of Economic Issues	38	0.11	0.24	55
Ecological Monographs	37	0.11	0.23	56
International Journal of Sustainable Development and World Ecology	37	0.11	0.23	57
Human Ecology	36	0.11	0.23	58
Energy	35	0.10	0.22	59
Journal of Economic Theory	34	0.10	0.22	60
Journal of Forestry	34	0.10	0.22	61
Annual Review of Energy and the Environment	33	0.10	0.21	62
Oikos	33	0.10	0.21	63
Trends in Ecology and Evolution	32	0.09	0.20	64
Biodiversity and Conservation	32	0.09	0.20	65
Ecologist	32	0.09	0.20	66
Economic Development and Cultural Change	32	0.09	0.20	67
Kyklos	32	0.09	0.20	68
Agricultural Economics	31	0.09	0.20	69
The Rand Journal of Economics	31	0.09	0.20	70
Total 70	**9020**	26.66	56.86	

Total citations to journals are 15 864, which is 46.88% of total citations of 33 838.

indicate that ecological economics is gaining more attention from mainstream environmental economics. More than a quarter of its citations occur in this last year.

EE's 10-year list of most cited journals is also similar to its 2003 list (Table 7). *Environmental and Resource Economics* gains in rank over the period. The next 50 journals are similar in nature to the first 20 — a mixture of mainstream economics, natural science, and general environmental policy journals. Again this shows that *EE* tends to cite (but not be cited by) top level general natural science and environmental journals more often than environmental economics does. Among the top 10 cited journals, *JEEM* and *EE* share five titles: *JEEM*, *AER*, *Land Economics*, *American Journal of Agricultural Economics*, and Quarterly Journal of Economics. The remainder of the top 10 for *JEEM* are all economic journals, while for *EE*, two are economics journals and three are natural science journals: *Science*, *Nature* and *Ambio*. If we examine the top 20, *JEEM* and *EE* share 12 journals. Again, for *JEEM* the remainder consists mostly of economics journals and those for *EE* are more diversified, including not only journals in economics, but also those in natural science. The only heterodox economics journal in the top 70 is *Journal of Economic Issues* at #55 and no non-policy-specific social science journals appear.

We also found that in the full period, as in 2003, references in *JEEM* are more concentrated on particular journals and individual publications. Table 6 shows that citations to the top 10 cited journals are 3625 in total, which accounts for 30.32% of total citations to all publications and 47.79% of total citations to journals. In Table 7, these figures are only 15.67% and 33.67%.

Another major difference between the two fields is that *JEEM* tends to cite more to journals rather than other publications, while *EE* cites more evenly to journals and other publications. There are 11 957 total references over the 10 years in *JEEM* and 7585 of these are citations to journals, which is 63.44%. For *EE*, only 15 864 citations, about 46.88%, out of a total of 33 838 are to journals. In other words, more than half of the

Table 8
Journal articles most cited in *JEEM* 1994–2003

Rank	Total *JEEM* cites	Author(s)	Year	Title	Journal	Volume: pages
1	25	Hanemann W. M.	1984	Welfare evaluations in contingent valuation experiments with discrete responses	American Journal of Agricultural Economics	66: 332–341
2	19	Kahneman, D. and J. Knetsch	1992	Valuing public goods: the purchase of moral satisfaction	Journal of Environmental Economics and Management	22(1): 57–70
3	19	Montgomery, W. D.	1972	Markets in licenses and efficient pollution control programs	Journal of Economic Theory	5(3): 395–418
4	18	Bishop, R. C. and T. A. Heberlin	1979	Measuring Values of extramarket goods: are indirect measures biased?	American Journal of Agricultural Economics	61: 926–930
5	17	Hotelling, H.	1931	The economics of exhaustible resources	Journal of Political Economy	39(2): 137–175
6	17	Cameron, T. A.	1988	A new paradigm for valuing non-market goods using referendum data: maximum likelihood estimation by censored logistic regression	Journal of Environmental Economics and Management	15: 355–379
7	16	Hanemann, M., J. Loomis, and B. Kanninen	1991	Statistical efficiency of double-bounded dichotomous choice contingent valuation	American Journal of Agricultural Economics	73: 1255–1263
8	14	Gordon, H. S.	1954	The economic theory of a common property resource: the fishery	Journal of Political Economy	62: 124–142
9	13	Rosen, S.	1974	Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition	Journal of Political Economy	82: 34–55
10	13	Adamowicz, W., Louviere, J. and Williams, M.	1994	Combining revealed and stated preference methods for valuing environmental amenities	Journal of Environmental Economics and Management	26: 271–292
11	12	Cameron, T. A. and M. D. James	1987	Efficient estimation methods for 'closed-ended' contingent valuation surveys	The Review of Economics and Statistics	69: 269–276
12	12	Cropper, M. L. and W. E. Oates	1992	Environmental economics: a survey	Journal of Economic Literature	30: 675–704
13	12	Krinsky, Itzhak and Robb, A. Leslie	1986	On approximating the statistical properties of elasticities	The Review of Economics and Statistics	68(4): 715–719
14	12	Grossman G. M. and A. B. Krueger	1995	Economic-growth and the environment	Quarterly Journal of Economics	110: 353–377

15	11	Harrington, W.	1988	Enforcement leverage when penalties are restricted	Journal of Public Economics	37: 29–53
16	11	Jorgenson, D. W. and P. J. Wilcoxen	1990	Environmental regulation and U.S. economic growth	Rand Journal of Economics	21(2): 314–340
17	11	Segerson, K.	1988	Uncertainty and incentives for nonpoint pollution control	Journal of Environmental Economics and Management	15: 87–98
18	11	Selden, T. M. and D. Q. Song	1994	Environmental-quality and development — is there a Kuznets curve for air-pollution emissions	Journal of Environmental Economics and Management	27: 147–162
19	11	Weitzman, M. L.	1974	Prices versus quantities	Review of Economic Studies	41: 477–491
20	10	Solow, R. M.	1974	Intergenerational equity and exhaustible resources	Review of Economic Studies	41: 29–45
21	10	Coase, R. H.	1960	The problem of social cost	Journal of Law and Economics	3: 1–44
22	10	Bovenberg, A. L. and L. Goulder	1996	Optimal environmental taxation in the presence of other taxes: general-equilibrium analysis	American Economic Review	86: 985–1000
23	10	Cummings, R. G., G. W. Harrison, and E. E. Rutström	1995	Homegrown values and hypothetical surveys: is the dichotomous choice approach incentive-compatible?	American Economic Review	85: 260–266
24	10	Hanemann, W. M.	1991	Willingness to pay and willingness to accept: how much can they differ?	American Economic Review	81: 635–647
25	10	Hoehn, J. P. and A. Randall	1987	A satisfactory benefit cost indicator from contingent valuation	Journal of Environmental Economics and Management	14: 226–247
26	10	Magat, W. A. and W. K. Viscusi	1990	Effectiveness of the EPA's regulatory enforcement: the case of industrial effluent standards	The Journal of Law and Economics	33: 331–360
27	10	Milliman, S. R. and R. Prince	1989	Firm incentives to promote technological change in pollution control	Journal of Environmental Economics and Management	17: 247–265
28	10	Morey. E. R., R. Rowe and M. Watson	1993	A repeated nested-logit model of Atlantic salmon fishing with comparisons to six other travel-cost models	American Journal of Agricultural Economics	75: 578–592
29	10	Oates, W. E., and R. M. Schwab	1988	Economic competition among jurisdictions: efficiency enhancing or distortion inducing?	Journal of Public Economics	35: 333–354
30	10	Stigler, G. J.	1971	The theory of economic regulation	Bell Journal of Economics	2: 3–21

Table 9
Journal articles most cited in *EE* 1994–2003

Rank	Total *EE* cites	Author(s)	Year	Title	Journal	Volume: pages
1	68	Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R. V. O'Neill, R. Raskin, P. Sutton, and M. van den Belt.	1997	The value of the world's ecosystem services and natural capital	Nature	387: 253–260
2	53	Arrow, K., B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C. S. Holling, B.-O. Jansson, S. Levin, K.-G. Mäler, C. Perrings, and D. Pimentel	1995	Economic growth, carrying capacity, and the environment	Science	268: 520–521
3	34	Ayres, R. U. and A. V. Kneese	1969	Production, consumption and externalities	American Economic Review	59: 282–297
4	31	Selden, T. M. and D. Q. Song	1994	Environmental-quality and development — is there a Kuznets curve for air-pollution emissions	Journal of Environmental Economics and Management	27: 147–162
5	30	Hardin, G.	1968	The tragedy of the commons	Science	162: 1243–1248
6	30	Pearce, D. W. and G. D. Atkinson	1993	Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability	Ecological Economics	8: 103–108
7	29	Cleveland, C. J., R. Costanza, C. A. S. Hall, and R. Kaufmann	1984	Energy and the United States economy: a biophysical perspective	Science	225: 890–897
8	29	Grossman G. M. and A. B. Krueger	1995	Economic-growth and the environment	Quarterly Journal of Economics	110: 353–377
9	28	Vitousek, P. M., P. R. Ehrlich, A. H. Ehrlich, and P. A. Matson	1986	Human appropriation of the products of photosynthesis	Bioscience	34: 368–373
10	27	Costanza, R. and H. E. Daly.	1992	Natural capital and sustainable development	Conservation Biology	6: 37–46
11	26	Coase, R. H.	1960	The problem of social cost	Journal of Law and Economics	3: 1–44
12	25	Daly, H. E.	1992	Allocation, distribution, and scale: towards an economics that is efficient, just and sustainable	Ecological Economics	6: 185–193

13	25	Vatn, A. and D. W. Bromley	1994	Choices without prices without apologies	Journal of Environmental Economics and Management	26: 129–148
14	24	Bishop, R. C.	1978	Endangered species and uncertainty: the economics of a safe minimum standard	American Journal of Agricultural Economics	60: 10–18
15	24	Ludwig, D., R. Hilborn, and C. Walters	1993	Uncertainty, resource exploitation, and conservation — lessons from history	Science	260: 17–36
16	24	Victor, P.	1991	Indicators of sustainable development: some lessons for capital theory	Ecological Economics	4: 191–213
17	23	Krutilla, J. V.	1967	Conservation reconsidered	American Economic Review	57: 777–784
18	22	Costanza, R.	1980	Embodied energy and economic valuation	Science	210: 1219–1224
19	22	Norgaard, R. B.	1989	The case for methodological pluralism	Ecological Economics	1: 37–57
20	22	Stern, D. I., M. S. Common, and E. B. Barbier	1996	Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development	World Development	24: 1151–1160
21	21	Beckerman, W.	1992	Economic-growth and the environment—whose growth—whose environment	World Development	20: 481–496
22	21	Holling, C. S.	1973	Resilience and stability of ecological systems	Annual Review of Ecological Systems	4: 1–24
23	21	Wackernagel, M., L. Onisto, P. Bello, A. C. Linares, I. S. L. Falfan, J. M. Garcia, A. I. S. Guerrero, and C. S. Guerrero	1999	National natural capital accounting with the ecological footprint concept	Ecological Economics	29: 375–390
24	20	Daly, H. E.	1990	Toward some operational principles of sustainable development	Ecological Economics	2: 1–6.
25	20	Hotelling, H.	1931	The economics of exhaustible resources	Journal of Political Economy	36: 137–175
26	20	Porter, M. E., C. van der Linde	1995	A new conception of the environment–competitiveness relationship	Journal of Economic Perspectives	9: 97–118

EE citations are from publications (books, reports, government documents, etc.) other than academic journals.

The correlation between the number of times each publication was cited in the two journals in 2003 is 0.47 rising to 0.58 when self-citations of the journals are excluded. In 2002 the correlation was 0.33 rising to 0.55 when self-citations are excluded. Correlations for the 10-year period are similar — 0.34 rising to 0.54 when self-citation is excluded. However, the computation behind this correlation excludes more of the low cited sources than were excluded for the single years based on the *JCR*. We took the top 38 most cited journals for both journals and found that the union gives a set of 59 unique journals. We find that there is a strong overlap between the two fields — the journals cite similar journals though *JEEM* tends to cite the economics journals more heavily. Of this list of 59 core journals, six are not cited by *JEEM*, but the other 53 are cited by both journals. Also the literature that these two journals refer to seems to be more overlapping than the literature that cites these two journals.

3.3. Most cited journal articles in JEEM and EE

Tables 8 and 9 list the most cited journal articles in *JEEM* and *EE* respectively. The cut-off point was chosen to include at least 25 articles on each list. This results in a much higher minimum level of citations for *EE* due to the larger number of references produced by *EE*.

Of the top 31 most influential articles cited by *JEEM*, 13 are on the subject of non-market valuation, and of the top 10, seven are on this topic, indicating its overwhelming importance in environmental economics. Of the 13 non-market valuation articles, 4 were published in *JEEM*, and another three were published in *American Journal of Agricultural Economics* (*AJAE*). This reflects the fact that *JEEM* and *AJAE* have had a major influence on the development of non-market valuation. The second most represented topic is theory of environmental policy and policy instruments with 10 papers but only 1 in the top 10. The third is papers on the theme of economic growth and the environment and resources, including two papers on the environmental Kuznets curve. Several of the top papers are by Michael Hanemann, who appears to be the most cited environmental economist on this basis.[6]

Smith (2000) compiled a list of the top 10 *JEEM* articles on non-market valuation based on citations. Two of these articles show up in our list. Kahneman and Knetsch's (1992) "Valuing public goods: the purchase of moral satisfaction", ranks high in both our list and Smith's and Cameron's (1988) "A new paradigm for valuing non-market goods using referendum data" ranks sixth or seventh in both Smith's list and ours. Kolstad (2000) did a study on energy and depletable resources and came up with a list of *JEEM*'s 10 greatest hits in this field. Only one of the articles on his list shows up in our list (Solow, 1974). It is easy to understand the lack of overlap between Kolstad's list and our own. He only lists the top three articles in every 5-year period, measures citations using all ISI citations, and the dominance of valuation and environmental policy on our top 20 list leaves little room for energy and resources papers. The lack of overlap with Smith's list is due to Smith only looking at articles published in *JEEM*.

Table 9 presents the papers that were cited most in *EE*.[7] Only three papers are on valuation and none of these are on the theory of non-market valuation.[8] Green accounting, sustainability, and the environmental Kuznets curve are all prominent topics. An interesting inclusion is the classic paper by Krutilla (1967) that does not appear in the *JEEM* list.[9] Robert Costanza plays the role of Michael Hanemann on this list.

[6] Hanemann is the thirteenth most cited first author in *EE*. We compiled lists of the top 100 first authors in both journals. Reference lists in the ISI database only record first authors. As most economics papers follow the convention that authors are listed in alphabetical order a list of most cited first authors may not be representative of the most cited authors overall. Therefore, we chose not to include these lists in this paper.

[7] This list will differ slightly from that in Costanza et al. (2004) as they also include citations from 1989 to 1993.

[8] However, several of the papers published in *EE* that have received the most citations in other journals are on non-market valuation (Costanza et al., 2004).

[9] Another anomaly is that David Pearce, who identifies as an environmental economist (Pearce, 2002) is the third most cited first author in *EE* but does not appear on the top 100 list for *JEEM*. The first and second most cited first authors in *EE* are Costanza and Daly, respectively.

Comparing the 30 most cited journal articles in *JEEM* (Table 8) and the 26 in *EE* (Table 9), there is less overlap at this micro level. Only four articles are on both lists: Selden and Song (1994), Grossman and Krueger (1995), Hotelling (1931), and Coase (1960).

4. Conclusions

Our citation analysis differs from previous studies of the economics literature (except Costanza et al., 2004), which primarily are journal, department, and individual economist ranking exercises. The few previous studies of individual papers in environmental economics attempt to find the most important articles published in *JEEM* on various topics or search a small set of journals for potentially influential articles. The latter sample restriction could miss some important articles. We look at which articles and journals are the most influential for the development of environmental economics and ecological economics based on the number of citations that they received in *JEEM* and *EE*. Our study is based on all academic journals followed by the *ISI Citation Index*. We have also examined the differences and similarities between the two fields as indicated in citation patterns.

Specific findings on the articles that have been most influential on environmental and resource economics are contained in the body of this paper, and so here we focus on the comparison between the two fields. Among our findings are that *EE* does more self-citation (to the journal not self citation by author) than *JEEM*, but as a percentage of the total references in articles in *JEEM* and *EE*, *JEEM* does more self-citation. Thus, *JEEM* finds it easier to be cited elsewhere –in a concentrated set of publications – but *EE* is more open to references from other sources. A greater proportion of *JEEM* references than *EE* references are to academic journals. Citations in *JEEM* are more concentrated on particular journals and individual publications. References in *JEEM* to the top 10 cited journals account for a much higher percentage of citations to all publications or all journals than those in *EE* do. *JEEM* is a much more focused journal and environmental economics would seem a more self-contained field than ecological economics.

JEEM cites mostly from other economics journals, while *EE* does import citations from interdisciplinary sources and, in particular, general natural science and environmental science journals but not much from non-policy social sciences or heterodox economics. The majority of the top journals cited in *EE* are still mainstream economics journals and many of the articles from *Nature* and *Science* that are highly cited in *EE* are by prominent ecological economists. The latter would suggest that *EE* is less genuinely interdisciplinary than it would appear from the crude journal level data. Moreover, we find that there is a significant overlap between the journals cited by *JEEM* and *EE*. At this macro level, ecological economics is more interdisciplinary than environmental economics but only in particular ways. Also, due to the large number of citations to mainstream economics journals, neoclassical economics is clearly an important component of ecological economics. However, at the level of the specific topics covered by the two journals, there is a greater difference between the two fields than at the macro level of disciplines or journals cited.

The most cited topic in environmental economics is non-market valuation. *JEEM* and *AJAE* are the two journals that are most influential in this field. Less important topics are the theory of environmental policy, policy instruments, economic growth, environment and resources. For ecological economics, non-market valuation does not play such an overwhelmingly important role as in environmental economics, and green accounting, sustainability, and the environmental Kuznets curve are all prominent topics. These other topics do feature in *JEEM*, but to a lesser degree, with only three such papers (Solow, 1974; Grossman and Krueger, 1995; Selden and Song, 1994) appearing in the top 30 cited articles. At the level of the most cited individual articles there is the least overlap between the two fields. Only four articles appear on the most cited lists of both journals.

We conclude that ecological economics is somewhat more interdisciplinary than environmental economics but that there is a broad overlap at the disciplinary level between the two fields. However, the emphasis given to different topics is very different in the two fields and there is even more difference at the level of the specific papers and authors who are most cited.

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