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The authorship structure of "ecosystem services" as a transdisciplinary field of scholarship

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ABSTRACT

"Ecosystem Services" is now a well-defined and active enough field of scholarship to warrant its own academic journal (this paper is published in the inaugural issue). In this paper we describe the authorship structure of this rapidly emerging transdisciplinary field, which has so far generated over 2400 papers (as of January 2011) listed in ISI Web of Science journals, written by over 2000 authors since the 1990s. We describe the number of publications, the number and interconnection of co-authors, clusters of co-authors, and other variables for the top 172 authors who have authored or co-authored more than 5 papers each. These 172 authors together have written over half the total papers. This allows a coherent picture of current participants in the field and their collaborative interconnections. These methods can be applied to any topic area and represent one way to better understand and support emerging scholarship that goes beyond disciplinary boundaries.

1. Introduction

During the nineteenth century, a shift occurred within scholarship from a generalist and interdisciplinary perspective towards one of increasing specialization (Costanza et al., 1997). This shift in focus occurred for a variety of reasons including: (1) available funding geared towards products and patents (Kubiszewski et al., 2010); (2) a staggering increase in available information (Cummings, 1989); and (3) unprecedented demand for new innovations (Frost and Jean, 2003).

However, in the recent decades, problems that transcend disciplinary boundaries have become increasingly urgent. Disciplines, although creating a foundation for interdisciplinarity (Klein, 2000), on their own create artificial barriers to asking appropriately scaled questions and create perspectives, worldviews, and modes of thought unique to individual disciplines (Kincheloe, 2001). Real-world problems today require a broader outlook as a means of understanding the complexity of the whole-system and potential solutions (Bill et al., 2001). Increasingly, these solutions are more likely to result from interdisciplinary research and practice (Rafols and Meyer, 2010).

In the past few years, many new inter and transdisciplinary fields, and their associated scientific communities and journals, have been created. The study of "ecosystem services" is one such transdisciplinary community. Creation of new institutions has also occurred, with the specific goal of connecting scientists from different disciplines together with policy-makers and practioners to collaborate in developing creative on-the-ground ideas and solutions, outside a single discipline's or scientist's knowledge (Frost and Jean, 2003; Cech and Rubin, 2004). The Ecosystem Services Partnership (ESP) is one such institution that supports this new journal (www.es-partnership.org). Other movement in this direction include the creation of interdisciplinary courses (Eagan et al., 2002), establishment of new degrees, and the reallocation of funds and policies to encourage cross-disciplinary collaboration (Jacobs and Amos), creating a greater likelihood of breakthroughs (Carayol and Thi, 2005). As has been said: 'Real-world problems do not come in disciplinary-shaped boxes' (Jeffrey, 2003), and neither do the solutions associated with these problems.

With all the new activity surrounding inter and transdisciplinary scholarship, there is a growing need to better define and identify what it is and how it is structured (Aram, 2004). Different disciplines, institutions, and countries often use different typologies of interdisciplinary scholarship (Huutoniemi et al., 2010) and there is no single standard (Klein, 2006, 2008). Also, determining where disciplinary boundaries lie and what represents crossing them is a challenge. Often as a field creates new knowledge and evolves, its boundaries shift and change, creating new expectations and the need for new measurements (Carayol and Thi, 2005).

In this paper we develop a quantification, mapping, and visualization of the authorship structure of the transdisciplinary field of ecosystem services. We assess the number of co-authors and the size and structure of the networks around the publications in the field. Similar studies using co-authorship have been done looking at specific disciplines to determine whether overlap exists (Schummer, 2004) or finding the degree of interdisciplinarity of a journal or a specific discipline (Qiu, 1992), but our approach offers a more

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complex assessment of the authorship structure within a specific field.

2. Methods

Data used was collected on January 2, 2011 from the Institute for Scientific Information's (ISI) Web of Science for the analysis of the topic area of "ecosystem services". ISI provides data for a large subset of peer-reviewed journal articles. Different subscription levels are available. The one we used through Portland State University includes articles published from 1972. Unlike Google Scholar, it does not include books, book chapters, magazine articles, or other forms of publication. However, ISI does contain the majority, although not all, peer-reviewed journal articles within the topic area.

We utilized ISI's Web of Science to retrieve the names of all authors that have published at least five papers with the term 'ecosystem service' or 'ecosystem services' as a "topic" (the term appears in the title, abstract, or keywords of the paper)[1]. This search resulted in 172 authors, which we will call key authors[2]. For these key authors we retrieved the number of papers published on ecosystem services, the h-index[3] based on these papers, the total number of co-authors, total number of citations, average number of citations, the institution from which they published their latest paper, and the country of that institution (data can be found in Appendix A). We then plotted those results using a Google Docs gadget called "Motion Chart."

Using ISI, we were also able to retrieve, for each key author, the number of papers co-authored with all other key authors. This data was put into Omnigraffle software to create a visualization of the ecosystem services network.

3. Results

Since 1983, when the first paper using the term "ecosystem services" was published (Ehrlich and Mooney, 1983), 2386 papers on this topic have been published in journals included in the ISI database[4]. This trend has been, up until now, on an exponential trajectory (Figure Total published.png). Citations to these papers have been increasing on a similar trajectory (Figure Total citations.png) and have now reached over 30,000.

This study looked at the 172 most prolific authors in this topic area—those that published 5 or more papers (Appendix Table A1). These authors came from 109 institutions in 24 countries. They published a total of 1367 papers, or 57% of the total papers published on this topic. They had an average h-index of 5 and an average number of citations per paper of 32 (when considering only the papers they published on ecosystem services). They had an average number of co-authors per paper of 4.5.

Using the Google docs gadget "motion chart", we produced several graphs using the variables in Table A1: average number of coauthors, average citations, h-index, total number of citations, total number of coauthors, and total number of papers. We found a strong linear relationship ($R^2=0.78$) between the number of papers published and an author's h-index (Fig. 1). This is not surprising, since the more papers an author publishes the better their chances of getting cited and raising their h-index. We also found that the total number of papers was linearly related to the total number of coauthors ($R^2=0.33$) (Fig. 2). As the number of papers increased, the number of coauthors increased significantly so co-authoring allows an author to produce more papers and thus get more citations. No significant relationship existed between number of papers and the average citations or average co-authors, however.

We also found a significant relationship between the number of coauthors and the number of citations (Fig. 3) ($R^2=0.18$) and between the number of co-authors and the author's h-index as calculated using just these papers (Fig. 4) ($R^2=0.30$). This could be the result of more co-authors leading to higher quality, more citeable papers. However, it could also be that more co-authors allow greater opportunities for self-citation and discovery of the paper by associates of the co-authors, or some combination of these effects.

We also used the data collected from ISI Web of Science to create a network diagram (Fig. 5). Within this network, each bubble represents an author, the size of the bubble represents the number of papers published by that author on ecosystem services, the color of the bubble indicates the country of the author, and the thickness of the lines between two authors indicate the number of papers they co-authored. Fig. 5 shows the key authors arranged into clusters that minimize the distance between authors (weighted by line thickness) and the number of line crossings. We identified eight relatively distinct clusters of coauthor groupings, all with slightly different characteristics. For example, two clusters had a composition of key authors from only one country: the cluster of 10 South African authors in the upper middle of the diagram, and the cluster of 7 British authors on the right of the diagram. These clusters showed high rates of co-authorship within the group, but only sparse co-authorship outside the groups. Other clusters exist in which the coauthors within the clusters primarily surround one author that has published a significant number of papers (i.e. those around Costanza and Folke on the left of the diagram). The cluster on the lower right is interesting in the number and degree of co-authorship of its members. It includes 21 authors from 10 countries, none of whom have published more than 13 papers, but who have an average 10 co-authors. This creates a large, dense cluster of highly interconnected authors. On the other extreme is the small cluster on the upper right of the diagram consisting of 7 authors with an average of 3.4 co-authors.

Several authors do not neatly fit into any of the clusters and were placed between the clusters as connectors (i.e. Robin Naidoo, Diana Wall, and Margaret Palmer). Twenty-one (12%) of the key authors have not coauthored a paper with another key author, and four pairs of coauthors were not connected to any other key authors. These were arranged at the top of the figure with no lines connecting them to other authors.

4. Discussion

What can we say about the structure of this topic area? We can first characterize it based on its overall statistics: number of papers, number of authors, number of citations, h-index of the topic area, average citations per paper, and average citations per author. Table 1 lists these statistics for ecosystem services and several other emerging transdisciplinary topic areas[5]. One can see

[1] Other databases could also be used for this purpose, including Scopus or Google Scholar.

[2] The cutoff at 5 papers was arbitrary, but we needed to limit the search and this cutoff point included a reasonably small number of authors and over half the papers.

[3] The h-index is the number of papers by an author that have been cited at least h times. For example, an author with an h-index of 5 would have 5 papers that have been cited at least 5 times.

[4] Actually, there was an earlier use of the related term "nature's services" in Westman (1977).

[5] We chose these fields somewhat arbitrarily simply to give some context and leave a more elaborate analysis for further research. One problem is that ISI treats searches for "topic" somewhat narrowly. For example, our search turned up only 623 papers with the topic "ecological economics" even though the journal *Ecological Economics* currently publishes around 300 papers/yr. We can surmise that ecological economics is already a fairly advanced field (with ecosystem services as just one topic

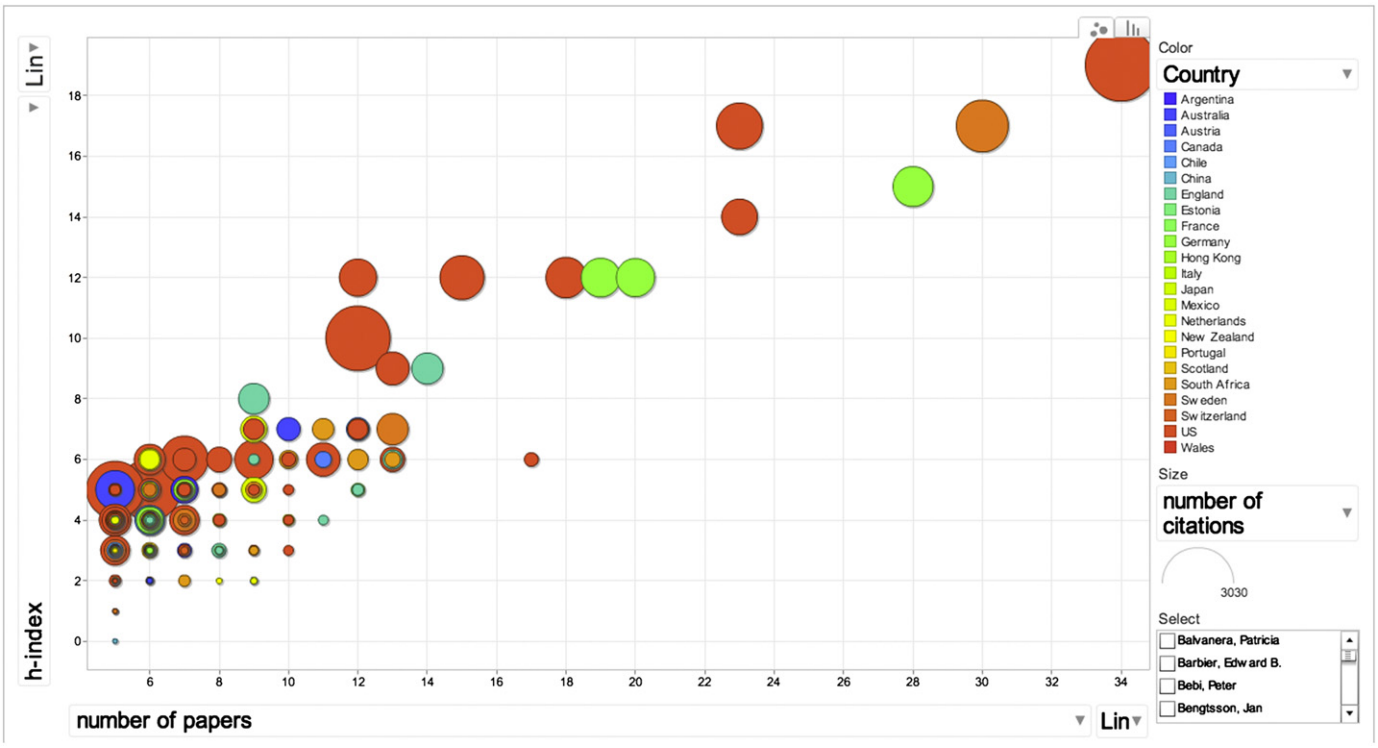

Fig. 1. Number of papers published vs. h-index for the 172 key authors (R^2=0.78). Size of the circles indicates total number of citations to the authors papers on ecosystem services. Color of the circles indicates the country of the author.

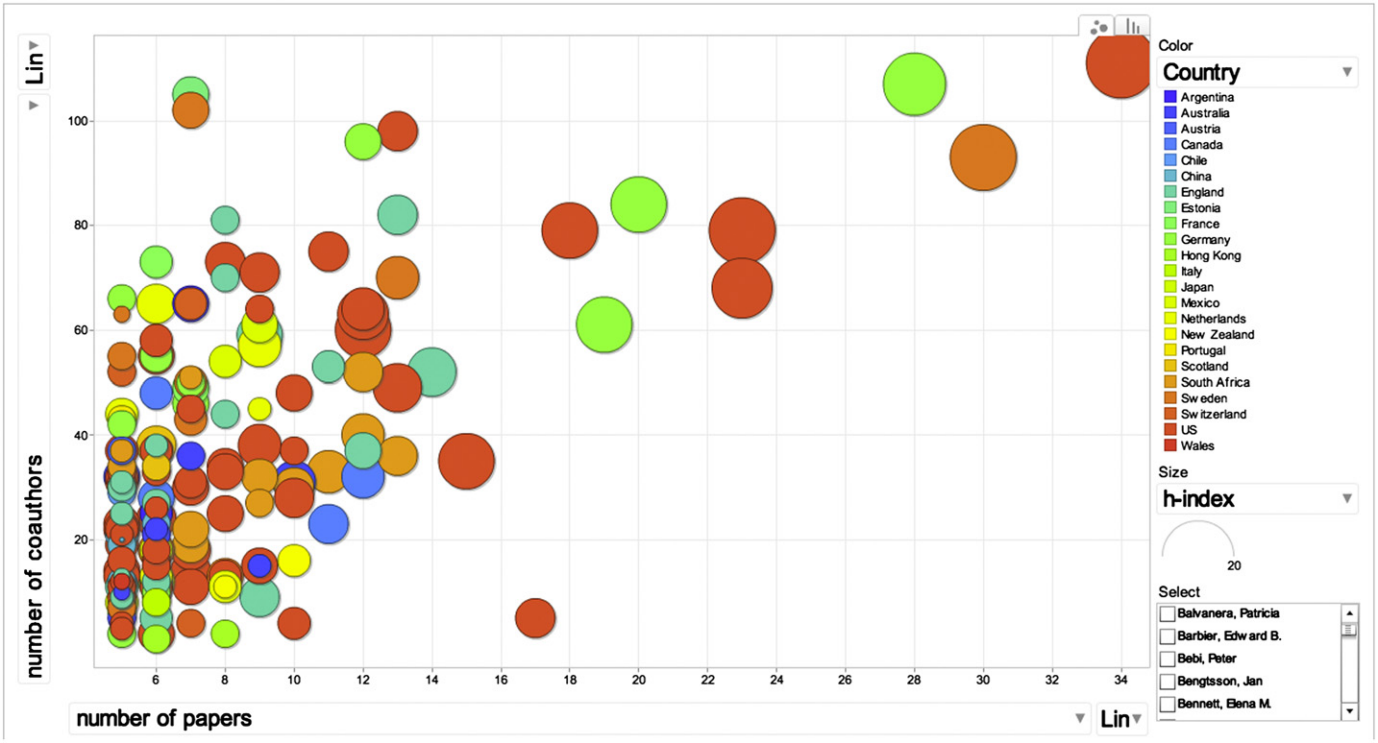

Fig. 2. Number of papers published vs. number of co-authors for the 172 key authors (R^2=0.33). Size of the circles indicates the author's h-index for papers on ecosystem services. Color of the circles indicates the country of the author.

(*footnote continued*)
area within it) and ISI is picking up only papers *about* ecological economics not all the papers within the domain of ecological economics.

from this, for example, the relative magnitude of activity in this topic area (i.e. 2462 papers published vs. 837 for environmental ethics) and the relative rate of co-authorship (i.e. 2.83 average number of co-authors vs. 1.0 for environmental ethics). Fig. 6

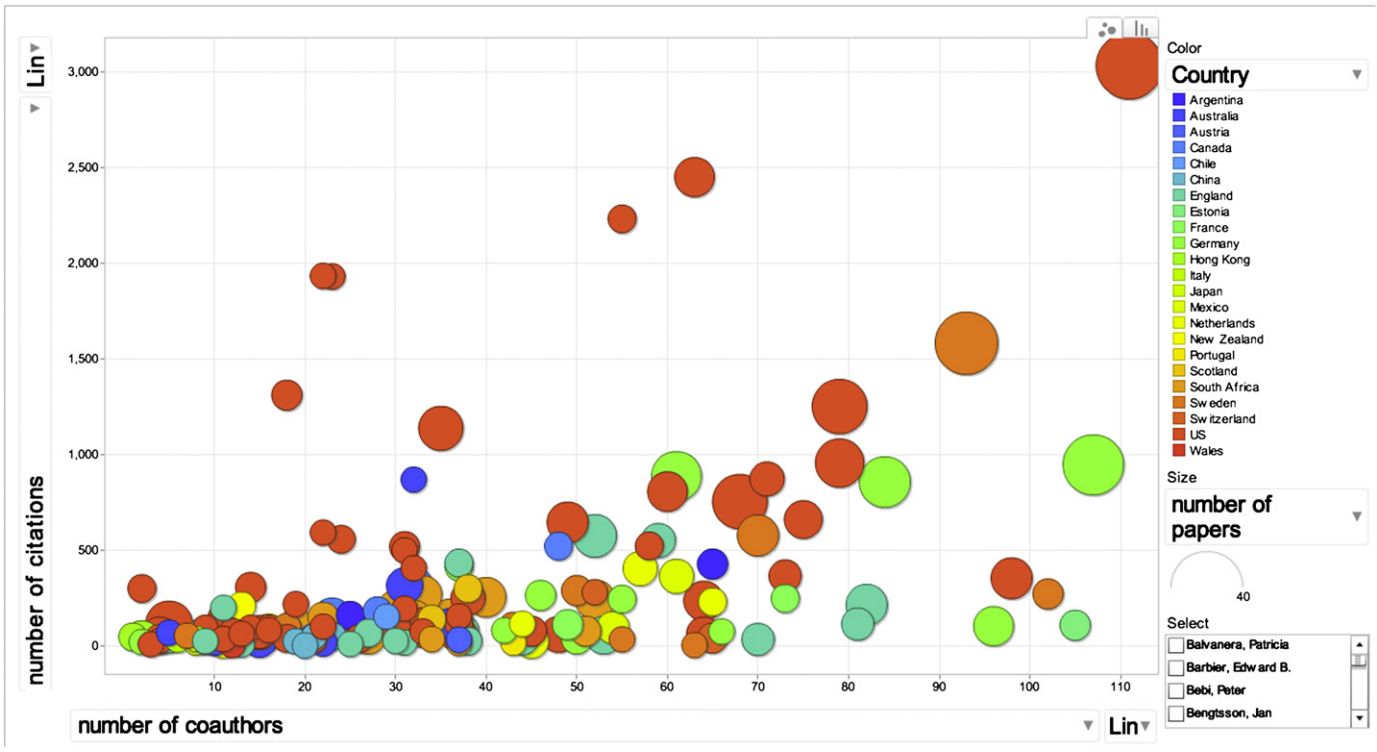

Fig. 3. Number of co-authors vs. number of citations for the 172 key authors ($R^2 = 0.18$). Size of the circles indicates total number of papers by each author on ecosystem services. Color of the circles indicates the country of the author.

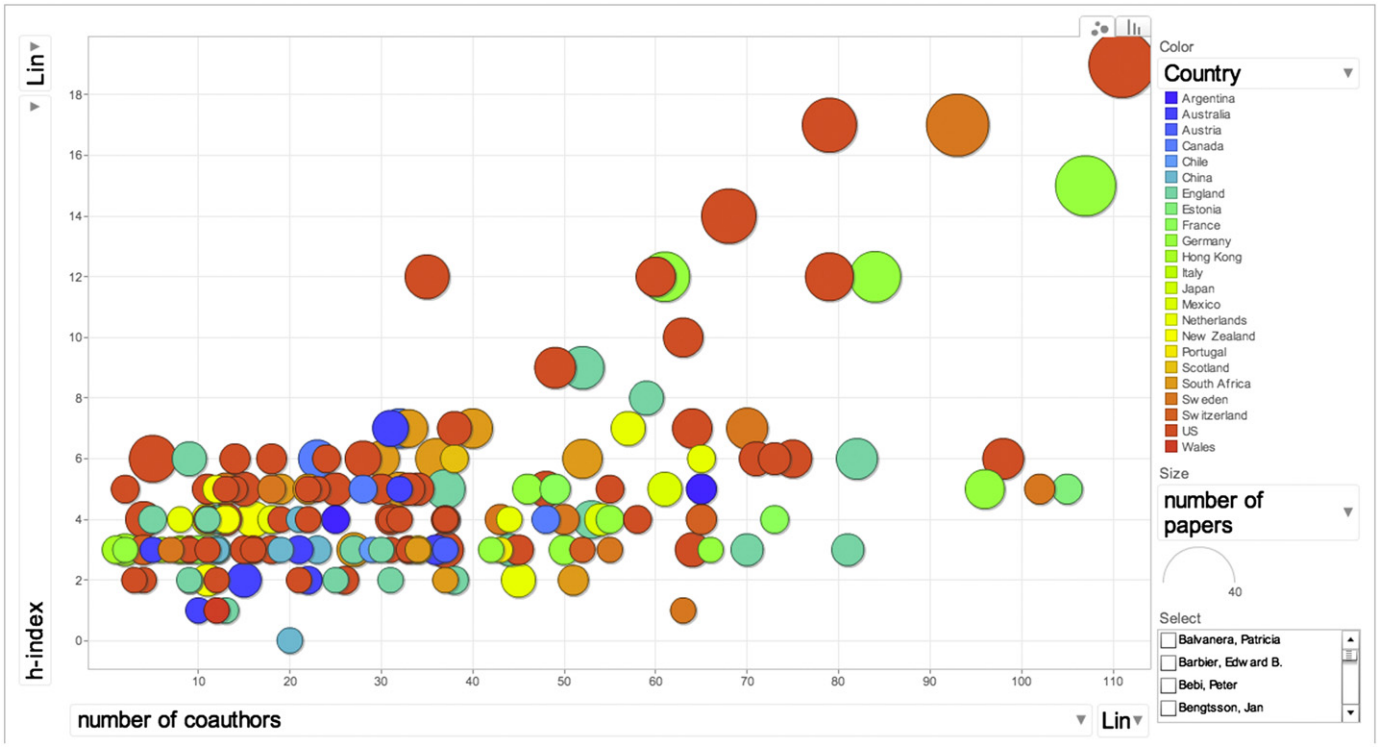

Fig. 4. Number of co-authors vs. h-index for the 172 key authors ($R^2 = 0.30$). Size of the circles indicates total number of papers by each author on ecosystem services. Color of the circles indicates the country of the author.

plots these characteristics for these five topic areas as a spider diagram. All characteristics have been scaled to 1 for the largest value in the group and the rest as fractions of that value. One can see from this that ecosystem services stands out from the others in all but the average citation/author category and number of subject areas. This makes sense since it has more than twice the number of co-authors as the next highest topic area and thus citations per author would be expected to be less. This is actually

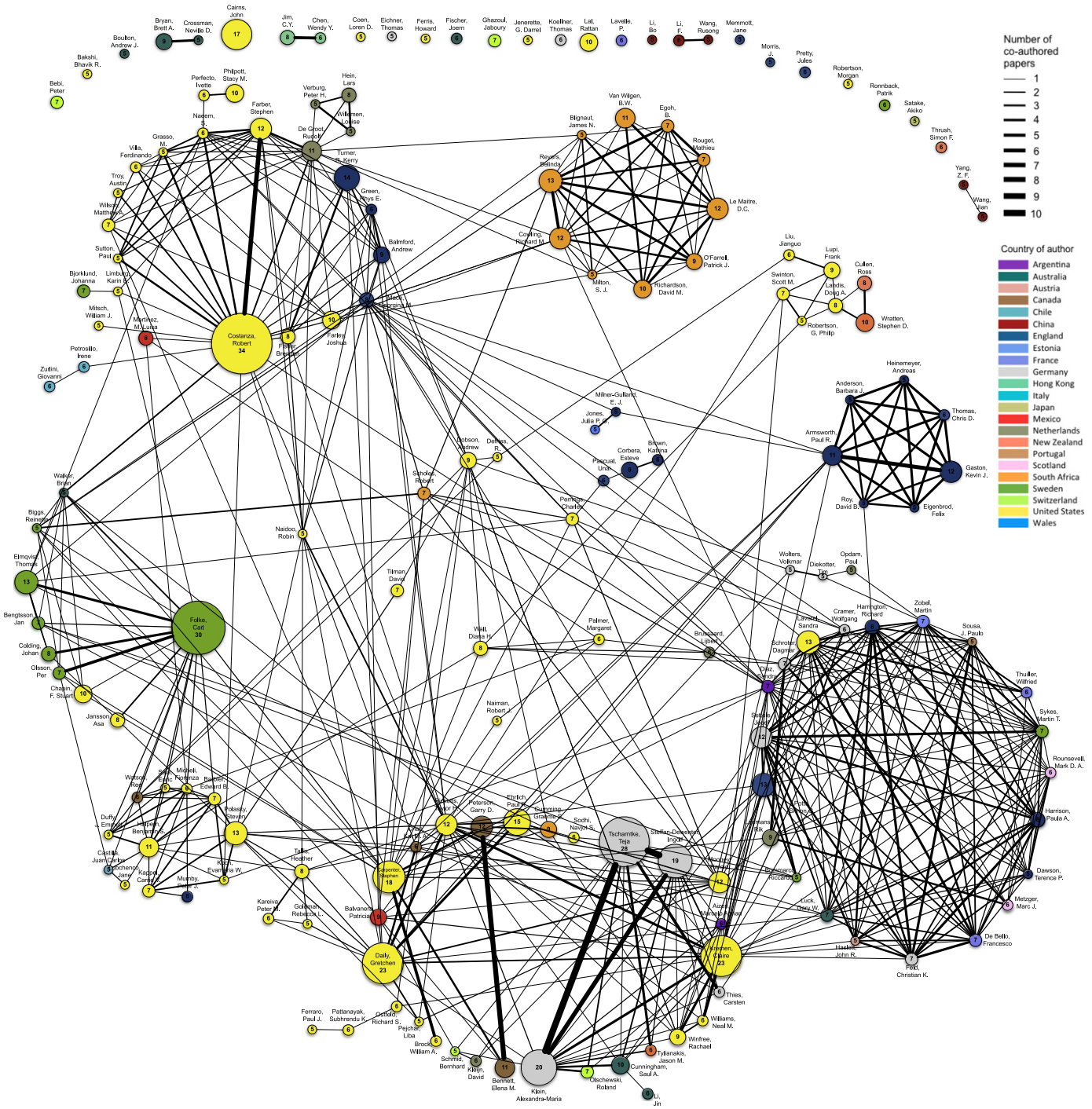

Fig. 5. Co-authorship network diagram for the 172 key authors. Size of the circles indicated total number of papers by each author on ecosystem services (number is also given inside the circle). Color of the circles indicates the country of the author. Width of the lines connecting authors indicates the number of co-authored papers.

a bit misleading, however, since in ISI all co-authors are credited with citations to a co-authored paper, but this does not show up in the aggregate statistics. For example, in aggregate, Ecosystem Services has 2.83 authors/paper (6958 authors divided by 2462 papers). But if one looks at the number of coauthors for each individual author (Appendix Table A1) and takes the average of those, one gets an average of 4.5 co-authors per author on the papers they have written. Suffice it to say that the topic area of ecosystem services is highly collaborative, prolific, and well cited.

But a more subtle and complex characterization concerns the pattern of co-authorship. This is one way to create the "social capital" of the topic area and distinguishes topic areas that are largely the domain of individual scientists from those that are largely group efforts[6] . The more detailed analysis by individual authors shows that only 12% of the key authors did not co-author any of their papers and were not connected to the network. Fig. 5 is a graphic representation of the complexity of this network structure. It shows several distinct clusters and a relatively small

[6] Co-authorship can also reflect the norms in different disciplines, of course. For example, it is not uncommon for high energy physics papers to include hundreds of co-authors, while history is most often done by single authors. While this certainly reflects the degree of cooperation on the publications, there may be other ways to collaborate that are not picked up using authorship structure.

Table 1
Comparison of basic statistics for several transdisciplinary topic areas.

Topic area	# of papers	# of coauthors	# of citations	Average coauthors/ paper	Average citations/ paper	Average citations/ author	h-index	Subject areas	Year of first mention
Ecosystem services	2462	6958	33,429	2.83	13.59	4.80	74	71	1983
Environmental history	1691	3083	13,117	1.82	7.76	4.25	49	81	1972 or earlier
Environmental ethics	837	835	3801	1.00	4.54	4.55	25	60	1972 or earlier
Positive psychology	701	1345	7142	1.92	10.19	5.31	34	55	1994
Ecological economics	623	926	5430	1.49	8.72	5.86	32	50	1974

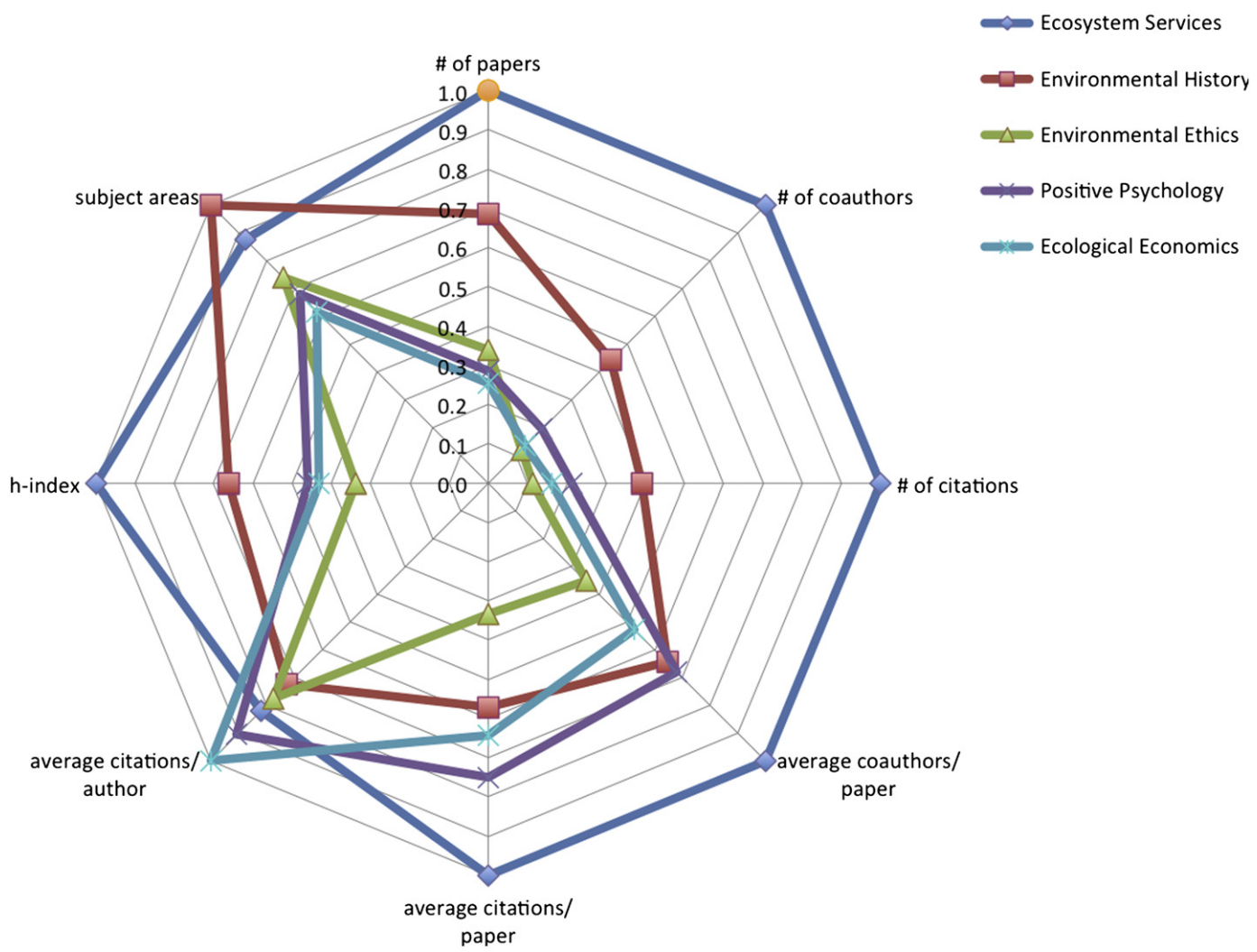

Fig. 6. Spider diagram of relative magnitudes of each of the variables in Table 1, scaled to the largest value in each category, comparing ecosystem services to other transdisciplinary fields.

number of unconnected authors. This is as one would expect for an active social network with high social capital. It also shows several distinct types of clusters as noted in the results section above. Some clusters form around central individual authors, some around groups within a county or institution, some among diverse authors who frequently publish with each other, etc. The groupings range from physical proximity to common interests to long-standing friendships. They probably relate to engagement on joint research projects and the various reasons for that association. One important way to encourage and perform transdisciplinary scholarship is to structure it around problems and projects that require multiple disciplinary perspectives to address. Ecosystem services certainly fits this description. Developing research and education models that further encourage transdisciplinary cooperation will most likely further enhance collaboration and co-authorship around ecosystem services.

This kind of network representation will be useful for characterizing and comparing topic areas and other kinds of social networks going forward.

The structure of scholarship is changing rapidly. The increasing necessity to work across traditional disciplinary lines, combined with the increasing ability to do so, has resulted in significant blurring of traditional boundaries. There is a need to develop new ways of understanding the structure of multi, inter, and transdisciplinary scholarship, perhaps discarding "disciplinary" boundaries altogether. This will help to better acknowledge and reward

Table A1
Data for the 172 authors (key authors) who have published 5 or more papers on ecosystem services according to the ISI Web of Science as of Jan, 2011.

Authors	Number of papers	Number of co-authors	Average co-authors	h-index	Number of citations	Average citations	Institution	Country
All authors	2386	6765	2.84	73	32,228	13.51		
Key authors (5 or more papers)	1367	5956	4.52	5	46,488	32		
Aizen, Marcelo Adrian	6	25	4.2	4	159	26.50	Univ Nacl Comahue	Argentina
Anderson, Barbara J.	5	9	1.8	2	24	4.80	University of York	England
Armsworth, Paul R.	11	53	4.8	4	55	5.00	University of Sheffield	England
Bakshi, Bhavik R.	9	64	7.1	3	61	12.20	Ohio State University	US
Balmford, Andrew	9	59	6.6	8	550	61.11	University Cambridge	England
Balvanera, Patricia	9	61	6.8	5	363	40.33	Univ Nacl Autonoma	Mexico
Barbier, Edward B.	7	31	4.4	4	517	73.86	University of Wyoming	US
Bebi, Peter	7	65	9.3	4	40	5.71	WSL Inst Snow & Avalanche Res SLF	Switzerland
Bengtsson, Jan	7	50	7.1	4	288	41.14	Swedish University of Agricultural Science	Sweden
Bennett, Elena M.	11	23	2.1	6	151	13.73	McGill University	Canada
Biggs, Reinette	5	55	11.0	3	33	6.60	Stockholm University	Sweden
Bjorklund, Johanna	5	7	1.4	3	52	10.40	Swedish University of Agricultural Science	Sweden
Blignaut, J.N.	5	34	6.8	3	34	6.80	University of Pretoria	South Africa
Bommarco, Riccardo	5	63	12.6	1	3	0.60	Swedish University of Agricultural Science	Sweden
Boulton, Andrew J.	5	5	1.0	3	68	13.60	University of New England	Australia
Brock, William A.	6	2	0.3	5	299	49.83	University of Wisconsin	US
Brown, Katrina	6	5	0.8	4	33	5.50	University of East Anglia	England
Brussaard, Lijbert	9	45	5.0	2	24	4.00	Wageningen University	Netherlands
Bryan, Brett A.	9	15	1.7	2	28	3.11	CSIRO	Australia
Cairns, John	17	5	0.3	6	110	6.47	Virginia Polytech Institute & State University	US
Carpenter, Stephen R.	18	79	4.4	12	955	53.06	University Wisconsin	US
Castilla, Juan Carlos	5	29	5.8	3	152	30.40	Pontificia Univ Catolica Chile	Chile
Chan, Kai M.A.	6	28	4.7	5	183	30.50	University of British Columbia	Canada
Chapin, F. Stuart	10	48	4.8	5	59	5.90	University of Alaska, Fairbanks	US
Chen, Wendy Y.	6	1	0.2	3	46	7.67	University of Hong Kong	Hong Kong
Coen, Loren D.	5	12	2.4	2	76	15.20	Sanibel Captiva Conservat Fdn	US
Colding, Johan	8	13	1.6	5	91	11.38	Stockholm University	Sweden
Corbera, Esteve	9	9	1.0	6	65	7.22	University of East Anglia	England
Costanza, Robert	34	111	3.3	19	3030	89.12	Portland State University	US
Cowling, Richard M.	12	52	4.3	6	242	20.17	Nelson Mandela Metropolitan University	South Africa
Cramer, Wolfgang	6	55	9.2	4	243	40.50	Potsdam Inst Climate Impact Res	Germany
Crossman, Neville D.	5	10	2.0	1	15	3.00	CSIRO	Australia
Cullen, Ross	8	11	1.4	2	19	2.38	Lincoln University	New Zealand
Cumming, Graeme S.	9	32	3.6	5	149	16.56	University Cape Town	South Africa
Cunningham, Saul A.	10	31	3.1	7	313	31.30	CSIRO	Australia
Daily, Gretchen C.	23	68	3.0	14	753	32.74	Stanford University	US
Dawson, Terence P.	5	30	6.0	3	25	5.00	University of Southampton	England
De Bello, Francesco	7	49	7.0	5	110	15.71	University of Grenoble	France
De Groot, Rudolf	6	65	10.8	6	229	20.82	Wageningen University	Netherlands
Defries, R.	5	33	6.6	3	75	15.00	Columbia University	US
Diaz, Sandra	7	65	9.3	5	426	60.86	University of Nacl Cordoba	Argentina
Diekotter, Tim	5	66	13.2	3	74	14.80	University of Giessen	Germany
Dobson, Andrew	9	71	7.9	6	871	96.78	Princeton University	US
Duffy, J. Emmett	5	31	6.2	3	499	99.80	College of William & Mary	US
Egoh, B.	7	22	3.1	5	149	21.29	CSIR	South Africa
Ehrlich, Paul R.	15	35	2.3	12	1136	75.73	Stanford University	US
Eichner, Thomas	5	2	0.4	3	20	4.00	University of Bielefeld	Germany
Eigenbrod, Felix	5	9	1.8	2	24	4.80	Univiversity of Sheffield	England
Elmqvist, Thomas	13	70	5.4	7	576	44.31	Stockholm University	Sweden
Farber, Stephen	12	63	5.3	10	2448	204.00	University of Pittsburgh	US
Farley, Joshua	10	37	3.7	3	56	5.60	Portland State University	US
Feld, Christian K.	7	50	7.1	3	35	5.00	University of Duisburg Essen	Germany
Ferraro, Paul J.	5	9	1.8	3	93	18.60	Georgia State University	US
Ferris, Howard	5	21	4.2	2	27	5.40	University of California, Davis	US
Fischer, Joern	6	21	3.5	3	44	7.33	Australian National University	Australia
Fisher, Brendan	8	33	4.1	5	115	14.38	Princeton University	US
Folke, Carl	30	93	3.1	17	1580	52.67	Stockholm University	Sweden
Gaston, Kevin J.	12	37	3.1	5	73	6.08	University of Sheffield	England
Ghazoul, Jaboury	7	4	0.6	3	33	4.71	ETH, Inst Terr Ecosyst	Switzerland
Goldman, Rebecca L.	5	4	0.8	2	26	5.20	Nature Conservancy	US
Grasso, M.	5	22	4.4	5	1932	386.40	University of Maryland	US
Green, Rhys E.	6	37	6.2	4	432	72.00	University of Cambridge	England
Halpern, Benjamin S.	11	75	6.8	6	659	59.91	University of California, Santa Barbara	US

Table A1 (*continued*)

Authors	Number of papers	Number of co-authors	Average co-authors	h-index	Number of citations	Average citations	Institution	Country
Harrington, Richard	8	70	8.8	3	33	4.12	Rothamsted Research	England
Harrison, Paula A.	8	44	5.5	3	36	4.50	University of Oxford	England
Haslett, John R.	5	37	7.4	3	31	6.20	Salzburg University	Austria
Hein, Lars	8	11	1.4	4	90	11.25	Wageningen University	Netherlands
Heinemeyer, Andreas	5	9	1.8	2	24	4.80	University of York	England
Jansson, Asa	8	13	1.6	4	75	9.38	University of Minnesota	US
Jenerette, G. Darrel	5	14	2.8	5	93	18.60	Arizona State University	US
Jim, C.Y.	8	2	0.3	3	47	5.88	University of Hong Kong	Hong Kong
Jones, Julia P.G.	5	12	2.4	1	4	0.80	Bangor University	Wales
Kappel, Carrie V.	7	30	4.3	5	93	13.29	University of California, Santa Barbara	US
Kareiva, Peter M.	6	11	1.8	4	129	21.50	Nature Conservancy	US
Kleijn, David	6	18	3.0	4	94	15.67	Wageningen University	Netherlands
Klein, Alexandra-Maria	20	84	4.2	12	855	42.75	University of Jena	Germany
Koch, Evamaria W.	5	31	6.2	4	194	38.80	University of Maryland	US
Koellner, Thomas	6	10	1.7	3	26	4.33	University of Bayreuth	Germany
Kremen, Claire	23	79	3.4	17	1250	54.35	University of California, Berkeley	US
Lal, Rattan	10	4	0.4	4	56	5.60	Carbon Management & Sequestrat Ctr	US
Landis, Doug A.	8	25	3.1	5	97	12.12	Michigan State University	US
Lavelle, P.	6	18	3.0	4	72	12.00	University of Paris	France
Lavorel, Sandra	13	98	7.5	6	352	27.08	University of Maryland	US
Le Maitre, D.C.	12	40	3.3	7	253	21.08	CSIR	South Africa
Leemans, Rik	9	57	6.3	7	403	44.78	Wageningen University	Netherlands
Li, Bo	5	21	4.2	4	48	9.60	Fudan University	China
Li, F.	6	23	3.8	3	48	8.00	Chinese Academy of Science	China
Li, Jin	6	22	3.7	2	17	2.83	CSIRO	Australia
Limburg, Karin E.	5	11	2.2	3	93	18.60	SUNY Coll Environm Sci & Forestry	US
Liu, Jianguo	6	15	2.5	3	58	9.67	Michigan State University	US
Lubchenco, Jane	5	19	3.8	4	217	43.40	NOAA	US
Luck, Gary W.	7	36	5.1	3	115	16.43	Charles Sturt University	Australia
Lupi, Frank	9	15	1.7	5	69	7.67	Michigan State University	US
Mace, Georgina M.	8	81	10.1	3	113	14.12	University of London Imperial Coll Sci Technol & Med	England
Martinez M. Luisa	8	54	6.8	4	94	11.75	Red Ecol Func Inst Ecol	Mexico
Memmott, Jane	5	11	2.2	4	198	39.60	University of Bristol	England
Metzger, Marc J.	6	38	6.3	6	298	49.67	University of Edinburgh	Scotland
Micheli, Fiorenza	6	58	9.7	4	521	86.83	Stanford University	US
Milner-Gulland, E.J.	5	25	5.0	2	9	1.80	Imperial College of London	England
Milton, S.J.	5	37	7.4	2	14	2.80	Renu Karoo Veld Restorat	South Africa
Mitsch, William J.	5	11	2.2	3	35	7.00	Ohio State University	US
Mooney, Harold	12	64	5.3	7	234	19.50	Stanford University	US
Morris, J.	5	13	2.6	1	6	1.20	Cranfield University	England
Mumby, Peter J.	6	12	2.0	3	77	12.83	University of Exeter	England
Naeem, S.	6	55	9.2	5	2230	371.67	Columbia University	US
Naidoo, Robin	5	37	7.4	4	153	30.60	World Wildlife Fund	US
Naiman, Robert J.	5	32	6.4	4	405	81.00	University of Washington	US
O'Farrell, Patrick J.	9	27	3.0	3	45	5.00	CSIR	South Africa
Olschewski, Roland	6	9	1.5	3	28	4.67	Swiss Fed Res Inst WSL	Switzerland
Olsson, Per	7	43	6.1	4	96	13.71	Stockholm University	Sweden
Opdam, Paul	5	44	8.8	4	114	22.80	University of Wageningen	Netherlands
Ostfeld, Richard S.	6	37	6.2	4	113	18.83	Cary Inst Ecosyst Studies	US
Palmer, Margaret	6	33	5.5	3	63	10.50	University of Maryland	US
Pascual, Unai	6	12	2.0	4	66	11.00	University of Cambridge	England
Pattanayak, Subhrendu K.	6	18	3.0	3	38	6.33	Duke University	US
Pejchar, Liba	5	13	2.6	5	63	12.60	Colorado State University	US
Perfecto, Ivette	6	11	1.8	4	98	16.33	Univeversity Michigan	US
Perrings, Charles	7	45	6.4	3	76	10.86	Arizona State University	US
Peterson, Garry D.	12	32	2.7	7	307	25.58	McGill University	Canada
Petrosillo, Irene	6	8	1.3	3	32	5.33	University of Salento	Italy
Philpott, Stacy M.	10	28	2.8	6	114	11.40	University of Toledo	US
Polasky, Steven	13	49	3.8	9	644	49.54	University of Minnesota	US
Potts, Simon G.	13	82	6.3	6	213	16.38	University of Reading	England
Pretty, Jules	6	27	4.5	3	66	11.00	University Essex	England
Reyers, Belinda	13	36	2.8	6	136	10.46	CSIR	South Africa
Richardson, David M.	10	30	3.0	6	195	19.50	Univiversity of Stellenbosch	South Africa
Ricketts, Taylor H.	12	60	5.0	12	805	67.08	World Wildlife Fund	US
Robertson, G. Philip	5	22	4.4	4	100	20.00	Michigan State University	US
Robertson, Morgan	5	3	0.6	2	8	1.60	University of Kentucky	US
Ronnback, Patrik	6	18	3.0	5	96	16.00	Stockholm University	Sweden
Rouget, Mathieu	7	19	2.7	5	121	17.29	South African National Biodiversity Institute	South Africa
Rounsevell, Mark D.A.	6	34	5.7	3	139	23.17	University of Edinburgh	Scotland
Roy, David B.	5	31	6.2	2	17	3.40	Ctr Ecol & Hydrol Wallingford	England

Table A1 (*continued*)

Authors	Number of papers	Number of co-authors	Average co-authors	h-index	Number of citations	Average citations	Institution	Country
Sala, Enric	5	22	4.4	4	591	118.20	Univ Calif San Diego	US
Satake, Akiko	5	8	1.6	3	17	3.40	Hokkaido University	Japan
Schmid, Bernhard	5	52	10.4	3	279	55.80	University of Zurich	Switzerland
Scholes, Robert	7	51	7.3	2	76	10.86	CSIR	South Africa
Schroter, Dagmar	7	46	6.6	5	263	37.57	Potsdam Inst Climate Impact Res	Germany
Settele, Josef	12	96	8.0	5	102	8.50	UFZ Helmholtz Ctr Environm Res	Germany
Sodhi, Navjot S.	6	26	4.3	2	36	6.00	Harvard University	US
Sousa, J. Paulo	5	43	8.6	3	15	3.00	University Coimbra	Portugal
Steffan-Dewenter, Ingolf	19	61	3.2	12	885	46.58	University of Bayreuth	Germany
Sutton, Paul	5	23	4.6	5	1929	385.80	University of Denver	US
Swinton, Scott M.	7	11	1.6	5	149	21.29	Michigan State University	US
Sykes, Martin T.	7	102	14.6	5	270	38.57	Lund University	Sweden
Tallis, Heather	8	34	4.3	5	100	12.50	Stanford University	US
Thies, Carsten	6	37	6.2	4	413	68.83	University of Gottingen	Germany
Thomas, Chris D.	6	38	6.3	2	24	4.00	University of York	England
Thrush, Simon F.	6	13	2.2	4	208	34.67	Nat Inst Water & Atmospher Res	New Zealand
Thuiller, Wilfried	6	73	12.2	4	247	41.17	University of Grenoble	France
Tilman, David	7	18	2.6	6	1309	187.00	University of Minnesota	US
Troy, Austin	5	16	3.2	3	81	16.20	University of Vermont	US
Tscharntke, Teja	28	107	3.8	15	945	33.75	University of Gottingen	Germany
Turner, R. Kerry	14	52	3.7	9	574	41.00	Univ E Anglia	England
Tylianakis, Jason M.	6	12	2.0	5	145	24.17	University of Canterbury	New Zealand
Van Wilgen, B.W.	11	33	3.0	7	267	24.27	CSIR	South Africa
Verburg, Peter H.	5	12	2.4	3	29	5.80	Vrije University of Amsterdam	Netherlands
Villa, Ferdinando	6	16	2.7	3	88	14.67	University of Vermont	US
Walker, Brian	5	32	6.4	5	868	173.60	CSIRO	Australia
Wall, Diana H.	8	73	9.1	6	364	45.50	Colorado State University	US
Wang, Jian	5	20	4.0	0	0	0.00	Chinese Academy of Science	China
Wang, Rusong	5	12	2.4	3	34	6.80	Chinese Academy of Science	China
Watson, Reg	6	48	8.0	4	520	86.67	University of British Columbia	Canada
Willeman, Louise	5	8	1.6	4	35	7.00	Wageningen University	Netherlands
Williams, Neal M.	6	24	4.0	6	556	92.67	Bryn Mawr College	US
Wilson, Matthew A.	7	14	2.0	6	305	43.57	University of Vermont	US
Winfree, Rachael	9	38	4.2	7	248	27.56	Rutgers State University	US
Wolters, Volkmar	5	42	8.4	3	80	16.00	University of Giessen	Germany
Wratten, Stephen D.	10	16	1.6	4	72	7.20	Lincoln University	New Zealand
Yang, Z.F.	5	19	3.8	3	23	4.60	Beijing Normal University	China
Zobel, Martin	7	105	15.0	5	107	15.29	University of Tartu	Estonia
Zurlini, Giovanni	5	6	1.2	3	32	6.40	University of Salento	Italy

transdisciplinary scholars, like those studying ecosystem services, and allow academia to better address the wickedly complex problems we now face.

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Appendix Table A1. Data for the 172 authors (key authors) who have published 5 or more papers on ecosystem services according to the ISI Web of Science as of Jan, 2011.

See Appendix Table A1.

References

Aram, J.D., 2004. Concepts of interdisciplinarity: configurations of knowledge and action. Human Relations 57 (4), 379–412.
Bill, A., Oetliker, S., et al., 2001. Why a Globalized World Needs Transdiciplinarity. Transdisciplinarity: Joint Problem Solving Among Science, Technology, and Society. in: Klein, J.T., Grossenbacher-Mansuy, W., Haberli, R., et al., Basel, Birkhauser Verlag. pp. 25–34.
Carayol, N., Thi, T.U.N., 2005. Why do academic scientists engage in interdisciplinary research? Research Evaluation 14 (1), 70–79.
Cech, T.R., Rubin, G.M., 2004. Nurturing interdisciplinary research. Nature Structural & Molecular Biology 11 (12), 1166–1169.
Costanza, R., Cumberland, J.C., et al., 1997. An Introduction to Ecological Economics. St. Lucie Press, Boca Raton, Florida.
Cummings, R.J., 1989. The Interdisciplinary Challenge: Connection and Balance.
Eagan, P., Cook, T., et al., 2002. Teaching the importance of culture and interdisciplinary education for sustainable development. International Journal of Sustainability in Higher Education 3 (1), 48–66.
Ehrlich, P.R., Mooney, H.A., 1983. Extinction, substitution, and ecosystem services. Bioscience 33 (4), 248–254.
Frost, S.H., Jean, P.M., 2003. Bridging the disciplines: interdisciplinary discourse and faculty scholarship. The Journal of Higher Education 74 (2), 119–149.
Huutoniemi, K., Klein, J.T., et al., 2010. Analyzing interdisciplinarity: typology and indicators. Research Policy 39 (1), 79–88.
Jacobs, N., Amos, M., Removing Barriers to Interdisciplinary Research. 〈http://www.elsevier.com/xml/linking-roles/preprint〉, arXiv:1012.4170.
Jeffrey, P., 2003. Smoothing the waters. Social Studies of Science 33 (4), 539.
Kincheloe, J.L., 2001. Describing the bricolage: conceptualizing a new rigor in qualitative research. Qualitative Inquiry 7 (6), 679–692.
Klein, J.T., 2000. A Cenceptual Vocabulary of Interdisciplinary Science. Practising interdisciplinarity. In: Weingart, P., Stehr, N. (Eds.), University of Toronto Press, Toronto.
Klein, J.T., 2006. Afterword: the emergent literature on interdisciplinary and transdisciplinary research evaluation. Research Evaluation 15 (1), 75–80.
Klein, J.T., 2008. Evaluation of interdisciplinary and transdisciplinary research. American Journal of Preventive Medicine 35 (2), 116.

Kubiszewski, I., Farley, J., et al., 2010. The production and allocation of information as a good that is enhanced with increased use. Ecological Economics 69, 1344–1354.
Qiu, L., 1992. A study of interdisciplinary research collaboration. Research Evaluation 2 (3), 169–175.
Rafols, I., Meyer, M., 2010. Diversity and network coherence as indicators of interdisciplinarity: case studies in bionanoscience. Scientometrics 82 (2), 263–287.
Schummer, J., 2004. Multidisciplinarity, interdisciplinarity, and patterns of research collaboration in nanoscience and nanotechnology. Scientometrics 59 (3), 425–465.
Westman, W., 1977. How much are "nature's services" worth? Science 197, 960–964.