



computable metric that has a number of distinctive advantages over classic measures such as the total number of articles, total number of citations, or number of citations per article (Hirsch, 2005). As a result, the  $h$  index has been promoted by many, including *Science* (Holden, 2005) and *Nature* (Ball, 2005), as a new measure of research performance that provides a robust evaluation of the scientific output of a researcher.

The  $h$  index also holds promise for assessing journal quality because the research excellence of an individual and a journal are both judged according to number of publications and citations (Braun, Glanzel & Schubert, 2005). Recently, Chapron and Husté (2006) suggested that a ranking of ecological journals according to the  $h$  index might avoid many of the commonly encountered problems associated with ranking systems such as the Impact Factor by measuring both significance and sustainability in scientific production. For example, any journal that continually published high-impact papers would be rewarded by a higher  $h$  index, whereas its Impact Factor is not affected by citations more than 2 y after an article's publication.

New bibliometric indices of journal (and researcher) quality are needed to assess scientific performance (Lehmann, Jackson & Lautrup, 2007). A Hirsch-based ranking of ecological journals would be an important resource in that it would provide an easy to compute ranking indicator that would serve a variety of purposes, such as choosing which journals should receive a scholarly submission, deciding academic faculty appointment and advancement, awarding research grants, and even assisting librarians in the preferential selection of periodical subscriptions. In this study, I used the  $h$  index to assess the present-day quality of 111 ecological journals according to their significance and sustainability in scientific production. Next, I compared journal rankings based on their Impact Factor *versus* their  $h$  index and tracked patterns in the  $h$  index over the past 25 y to assess changes in journal performance in relation to shifting research priorities in ecology.

## Methods

Using Thomson Scientific's Web of Science<sup>®</sup> (<http://isiknowledge.com>), an online citation service available through the Institution for Scientific Information, I compiled a list of 111 journals that are categorized as publishing ecological research (see Appendix I). In July 2006, I queried all articles published in each journal during a 5-y period (2001–2005) and ordered the list of publications in that journal according to the number of times they were cited. I then noted the highest ranked publication for which the number of times the publication was cited was equal to or greater than its rank. For example, suppose the journal's 10<sup>th</sup> most cited article was cited 10 or more times but its 11<sup>th</sup> most cited article was cited 10 or fewer times. This journal would have an  $h$  index of 10, because 10 is the number of articles that received at least as many citations as their ranked position. While the  $h$  index is not the definitive metric for ranking the scientific quality of journals (Kelly & Jennions, 2006), it does provide a powerful indicator for ranking journals that accounts for both the productiv-

ity and impact of high-quality scientific papers. I selected a citation period spanning the past 5 y to focus on the present-day quality of ecological journals. For a subset of top-tiered ecological journals ( $h \geq 25$ ), I also calculated the  $h$  index for articles published between  $x$  and 2001, where  $x$  equalled 1980 (or the journal's first year of publication), using increments of 1 y. The incrementally increasing time period reflects the fact that a journal's scientific quality is based on its cumulative publication record over time. Given that the  $h$  index of a journal depends on the amount of time since the articles were published (much as the scientific age of a researcher influences his/her  $h$  index), I followed Hirsch (2005) and calculated the  $m$  index for each journal by dividing  $h$  by the number of years prior to 2005 (see Kelly & Jennions, 2006 for a discussion of the robustness of  $m$ ). By selecting only those articles published prior to 2001, I eliminated the inflated  $m$  indices of recent years resulting from the over-influence of young scientific age (J. D. Olden, unpubl. data).

## Results and discussion

The 111 ecological journals examined in this study exhibited  $h$  indices ranging from 1 to 56 ( $h = 15.2$ ,  $SD = 10.4$ ; see Appendix I). The distribution of  $h$  indices was right-skewed in that the majority of journals exhibited values between 5 and 15 and few journals had  $h$  values that exceeded 25 (Figure 1). Among the top-20-ranked ecological journals, I found that *Trends in Ecology and Evolution* had the highest  $h$  index, followed by *Ecology*, *Molecular Ecology*, *Evolution*, and *American Naturalist* (Table I). Interestingly, the top-20 list was composed of journals that publish on a variety of ecological topics from basic to applied research, from small to large spatial scales, and from species to ecosystems. Moreover, it represented a mixture of journals with both long (e.g., *American Naturalist*, *Journal of Ecology*, *Oikos*) and short publication histories (e.g., *Ecology Letters*, *Ecosystems*), which published anywhere from 151 to 2596 articles between 2001 and 2005.

I found a positive relationship between  $h$  indices and 2005 ISI<sup>®</sup> Impact Factors ( $r = 0.73$ ,  $P < 0.0001$ ,  $n = 109$ ;

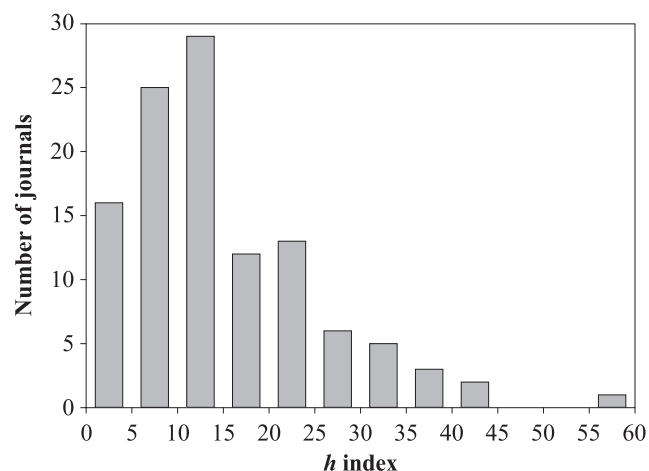


FIGURE 1. Histogram of  $h$  values for 111 journals in the ecological sciences.

Figure 2), although for any particular Impact Factor (IF) there was a large range in *h* values. Journals characterized by Impact Factors between 4 and 5 had *h* values between 5 and 44, and journals with Impact Factors of approximately 2 were characterized by *h* indices between 1 and 23. Journal rankings according to Impact Factor differed greatly from those according to *h* index in some instances. For example, *Oecologia* was the 24<sup>th</sup> ranked journal with respect to Impact Factor but was 6<sup>th</sup> ranked based on its *h* index. The opposite pattern was observed for *Ecological Monographs* (5<sup>th</sup> IF rank versus 16<sup>th</sup> *h* rank) and *Journal of Applied Ecology* (7<sup>th</sup> IF rank versus 13<sup>th</sup> *h* rank) (Table I, Appendix I). There is no expectation that the *h* index and

TABLE I. Top 20 ecological journals according to their *h* index. Publications in the past 5 y (2001–2005) were included in the calculation. ISI® Impact Factors are from Thomson Scientific’s Web of Science© 2005 Journal Citation Report (<http://isiknowledge.com>) and values in parentheses represent journal ranking according to Impact Factor.

Journal name	<i>h</i> index	Impact Factor	Number of publications
Trends in Ecology and Evolution	56	14.86 (1)	743
Ecology	44	4.51 (8)	1623
Molecular Ecology	43	4.30 (10)	1501
Evolution	38	4.16 (12)	1281
American Naturalist	37	4.46 (9)	185
Oecologia	36	3.03 (24)	1530
Ecological Applications	35	3.80 (15)	803
Ecology Letters	34	5.15 (4)	639
Conservation Biology	33	4.11 (13)	1126
Global Change Biology	32	4.08 (14)	675
Marine Ecology Progress Series	31	2.32 (34)	2596
Oikos	30	3.31 (21)	1292
Journal of Applied Ecology	28	4.59 (7)	515
Journal of Ecology	27	4.28 (11)	492
Biological Conservation	27	2.58 (30)	1303
Ecological Monographs	26	4.86 (5)	151
Journal of Animal Ecology	26	3.40 (18)	540
Ecosystems	25	3.46 (17)	332
Journal of Evolutionary Biology	25	3.33 (20)	686
Functional Ecology	25	3.15 (22)	559

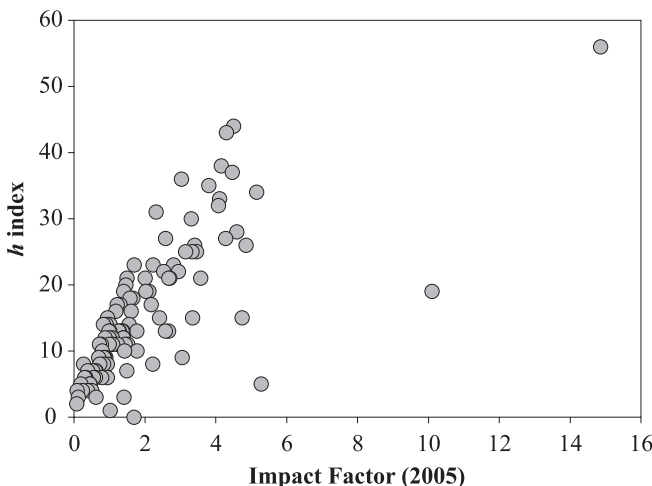


FIGURE 2. Impact Factor (2005) versus *h* values for journals in the ecological sciences.

IF should be highly correlated given a number of key differences between these metrics. Among these, the *h* index accounts for publications over longer time frames (based on all citations since publication, rather than the previous 2 y), and it de-emphasizes highly successful publications in favour of sustained productivity. Moreover, many of its shortcomings either apply equally to the Impact Factor (*i.e.*, positive effect of review papers) or have been addressed in recent revisions (*e.g.*, Batista *et al.*, 2006; Egghe, 2006).

A subset of ecological journals has shown markedly different patterns of change in performance over the past 25 y according to the *m* index (Figure 3). *Trends in Ecology and Evolution*, *Molecular Ecology*, *Global Change Biology*, and *Ecosystems* have shown the greatest rate of increase, whereas *Ecology*, *Ecological Applications*, and *Conservation Biology* have exhibited moderate growth, and *Ecological Monographs* has shown only a modest increase over time. Interestingly, the recent surge of new journals in the ecological sciences has resulted in a significant re-shuffling of journal rankings (Figure 3). In 1991, *Trends in Ecology and Evolution* replaced *Ecology* as the top-ranked journal, after which *Ecology* showed a steady increase until reaching a plateau in 1998. *Molecular Ecology* has shown a similar increase in journal performance, leaping ahead of 2 applied journals (*Conservation Biology* and *Ecological Applications*) in 1996 and equalling *Ecology* in 2001. Similarly, *Global Change Biology* showed a sharp increase in the late 1990s, moving past *Conservation Biology* and drawing even with *Ecological Applications*.

How does a journal obtain a high *h* index? Is there a recipe for journal success? While all journals strive to publish highly citable research, the present-day success of the leading ecological journals likely reflects some combination of popularity and prestige. The rapidly increasing performance of new journals (*e.g.*, *Molecular Ecology*, *Global Change Biology*, *Ecosystems*), for example, is a result of shifting research interests within ecology, including recent popularity for the application of molecular techniques and the study of ecological processes (*i.e.*, ecosystems) at large spatial and temporal scales (Fazey, Fischer & Lindenmayer, 2005). However, the initial period of novelty associated with new journals is typically short-lived, after which the long-term performance of a journal is associated with prestige and the continued popularity that comes with publication excellence. Examples of such journals include *Ecology*, *Evolution*, *American Naturalist*, *Journal of Ecology*, and *Oikos*. While the performance of some journals has slowly levelled off over time (*e.g.*, *Ecology*), others continue to enjoy growth and success. For example, the performance of *Trends in Ecology and Evolution* has continued to increase since its initial publication, a pattern that may reflect its record of publishing highly cited review articles and featuring shorter communications of high impact that interest a broad audience. This result also highlights the potential importance of a journal’s publication efficiency (for example, in terms of speed) and of the pre-screening of submissions by editorial boards for increasing the quality of publications (Neff & Olden, 2006).

It is not difficult to imagine that a publisher could take the future ranking of a journal into its own hands. For example, by turning out a greater number of articles per

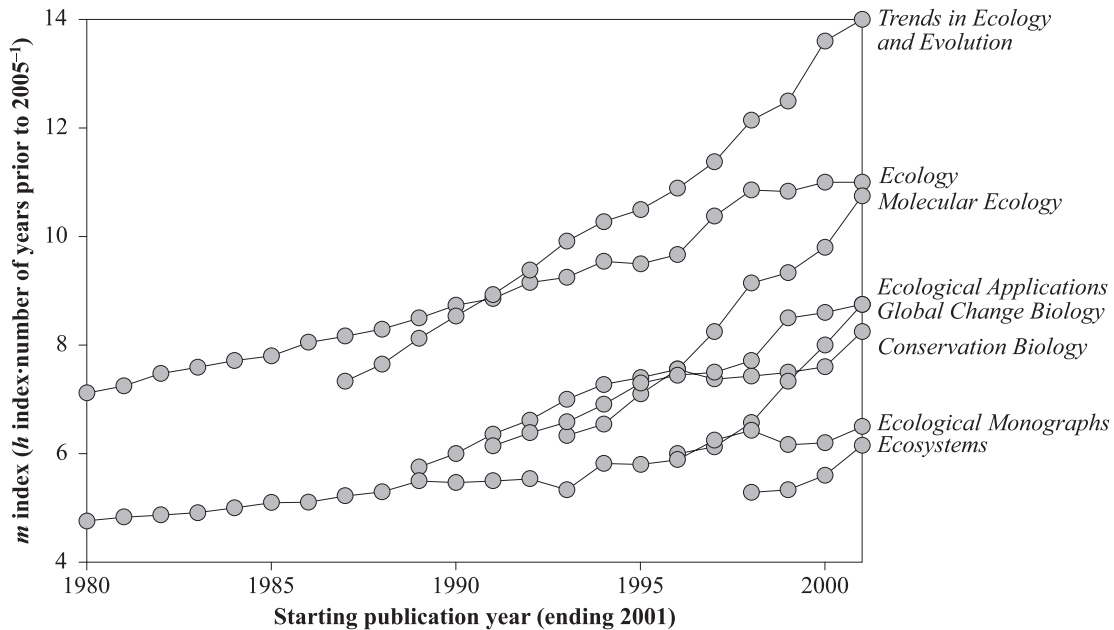


FIGURE 3.  $m$  values ( $h$  index divided by the number of years prior to 2005) over time for a selection of top 20 journals (see Table I).

year would it be possible for highly productive journals to generate more citable articles and, thus, increase their  $h$  value? If so, this would be the result of a lottery effect whereby the likelihood of a journal publishing a highly-cited article to elevate its  $h$  index simply increases the more articles it publishes. Kelly and Jennions (2006) envisioned a similar effect where a scientist could increase his/her  $h$  value by publishing more. However, while publishing more articles is advantageous for a scientist (independent of its effects on  $h$  index), it is actually disadvantageous for a journal in terms of production costs and increasing the likelihood of compromising the journal's prestige by publishing below-par research. Regardless, an examination of the top 20 ecological journals in Table I suggests that there may be some use of this tactic, though it is far from universal (see *Ecological Monographs*, *American Naturalist*). Moreover, journals could purposely manipulate their  $h$  index by requesting authors to preferentially cite papers within their own journal(s), a policy that is already promoted by many publishers. In the same vein, authors could influence their  $h$  index by citing papers of theirs whose citation counts were on the cusp of exceeding their rank (Purvis, 2006). The only difference is that editors are not in the position (at least not yet) of suggesting specific papers for authors to cite from their journal.

In conclusion, this study has illustrated the utility of the  $h$  index (Hirsch, 2005) for quantifying the scientific quality of journals in the ecological sciences and highlighted temporal trends in journal performance over recent decades. While the  $h$  index is not the definitive metric for ranking the scientific quality of researchers or journals (Bornmann & Daniel, 2005; Kelly & Jennions, 2006), it does provide a powerful indicator for ranking journals that accounts for both the productivity and impact of high-quality scientific papers. The ranking presented here provides an important resource for ecologists and an objective and transparent

methodology for assessing and tracking the scientific performance of ecological journals.

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APPENDIX I. Ranking of 111 ecological journals according to their  $h$  index. Publications in the past 5 y (2001–2005) were included in the calculation. Impact Factors (IF) are from Thomson Scientific's Web of Science© 2005 Citation Report (<http://isiknowledge.com>). Because  $h$  is bounded by the total number of publications, journals that have been in production for less than 5 y (e.g., *Frontiers in Ecology and the Environment*) are at an inherent disadvantage in this ranking.

Journal name	$h$ index	Impact Factor	IF ranking
Trends in Ecology & Evolution	56	14.86	1
Ecology	44	4.51	8
Molecular Ecology	43	4.30	10
Evolution	38	4.16	12
American Naturalist	37	4.46	9
Oecologia	36	3.03	24
Ecological Applications	35	3.80	15
Ecology Letters	34	5.15	4
Conservation Biology	33	4.11	13
Global Change Biology	32	4.08	14
Marine Ecology - Progress Series	31	2.32	34
Oikos	30	3.31	21
Journal of Applied Ecology	28	4.59	7
Journal of Ecology	27	4.28	11
Biological Conservation	27	2.58	30
Ecological Monographs	26	4.86	5
Journal of Animal Ecology	26	3.40	18
Ecosystems	25	3.46	17
Journal of Evolutionary Biology	25	3.33	20
Functional Ecology	25	3.15	22
Journal of Biogeography	23	2.80	26
Behavioral Ecology and Sociobiology	23	2.23	35
Ecological Modelling	23	1.70	43
Behavioral Ecology	22	2.94	25
Aquatic Microbial Ecology	22	2.53	32
Global Ecology and Biogeography	21	3.58	16
Ecography	21	2.70	27
Microbial Ecology	21	2.67	28
Theoretical Population Biology	21	2.01	40
Agriculture Ecosystems & Environment	21	1.50	50
Journal of Wildlife Management	20	1.46	52
Annual Review of Ecology Evolution and Systematics	19	10.10	2
Journal of Vegetation Science	19	2.11	38
Journal of Chemical Ecology	19	2.03	39
Biodiversity and Conservation	19	1.40	56
Journal of Experimental Marine Biology and Ecology	18	1.66	45
Journal of the North American Benthological Society	18	1.58	47
Landscape Ecology	17	2.17	37
Polar Biology	17	1.30	61
Molecular Ecology Notes	17	1.22	65
Evolutionary Ecology Research	16	1.61	46
Ecological Economics	16	1.18	66
Frontiers in Ecology and the Environment	15	4.75	6
Diversity and Distributions	15	3.35	19
Basic and Applied Ecology	15	2.41	33
Wildlife Society Bulletin	15	0.94	75
Ecotoxicology	14	1.55	48
Journal of tropical Ecology	14	1.01	70
Environmental Biology of Fishes	14	0.91	78
Biochemical Systematics and Ecology	14	0.83	84
Conservation Ecology	13	2.67	29
Paleobiology	13	2.58	31
Austral Ecology	13	1.77	42
restoration Ecology	13	1.38	59
Landscape and Urban Planning	13	1.36	60
Wetlands	13	1.27	62
Ecoscience	13	1.26	63
Plant Ecology	13	1.01	71
Ecological Engineering	13	0.98	74
Oryx	12	1.39	57
Animal Conservation	12	1.39	58
Acta Oecologica - International Journal of Ecology	12	1.08	68
Ecological Research	12	0.99	72
Journal of Arid Environments	12	0.88	80
Applied Vegetation Science	11	1.52	49

APPENDIX I. Continued.

Journal name	<i>h</i> index	Impact Factor	IF ranking
Chemoecology	11	1.44	53
Journal of Soil and Water Conservation	11	1.23	64
Biotropica	11	1.09	67
Annales Zoologici Fennici	11	0.99	73
American Midland Naturalist	11	0.77	87
Journal of Range Management	11	0.72	89
Evolutionary Ecology	10	1.78	41
Population Ecology	10	1.42	54
Wildlife Research	10	0.80	85
Perspectives in Plant Ecology Evolution and Systematics	9	3.05	23
Natural areas Journal	9	0.90	79
Pedobiologia	9	0.86	81
Compost Science & Utilization	9	0.84	82
Journal of Natural History	9	0.69	90
Advances in Ecological Research	8	2.22	36
European Journal of Soil Biology	8	0.94	77
New Zealand Journal of Ecology	8	0.83	83
Wildlife Biology	8	0.72	88
Western North American Naturalist	8	0.27	105
Northeastern Naturalist	7	1.49	51
Rangeland Journal	7	0.62	92
Revista Chilena de Historia Natural	7	0.60	94
Northwest Science	7	0.52	96
African Journal of Ecology	7	0.39	100
Insect Systematics & Evolution	6	0.94	76
Aquatic Ecology	6	0.78	86
Journal of Freshwater Ecology	6	0.60	93
Sarsia	6	0.54	95
Southeastern Naturalist	6	0.33	102
Polish Journal of Ecology	6	0.31	103
Southwestern Naturalist	6	0.30	104
Wildlife Monographs	5	5.29	3
Revue d'Écologie-La Terre et la Vie	5	0.45	98
Vie et Milieu-Life and Environment	5	0.44	99
Canadian Field-Naturalist	5	0.19	107
Proceedings of the Academy of Natural Sciences of Philadelphia	4	0.50	97
South African Journal of Wildlife Research	4	0.38	101
Amazoniana-Limnologia et Oecologia	4	0.24	106
Ekologia-Bratislava	4	0.09	109
Ecological Complexity	3	1.41	55
Proceedings of the Linnean Society of New South Wales	3	0.62	91
Russian Journal of Ecology	3	0.12	108
Natural History	2	0.08	110
Marine Biology Research	2	-	-
Rangeland Ecology & Management	2	-	-
Bulletin of the American Museum of Natural History	1	1.02	69