ANNALS OF FOREST RESEARCH
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An evaluation of forestry journals using bibliometric indices

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Malesios C., Arabatzis G., 2012. An evaluation of forestry journals using bibliometric indices. Ann. For. Res. 55(2): 147-164, 2012.

Abstract. The increasing number of scientific journals, especially over the last 20 years, created the need for methodologies based on simple metrics, to accurately capture the "quality" of those journals and their impact on the scientific community. Especially in the case of journals from the field of forestry, relatively little work has been conducted on providing valid journal classifications. In this paper we attempt to assess the impact of journals from this field in terms of bibliometric data. In addition to the already proposed metrics (complementary to the journal *h*-index), we also apply a new measure to rank journals, that provides a more balanced evaluation of the journal performance, by adjusting for various biases affecting the *h*-index. We examined the relationships between various bibliometric indicators proposed for assessing the journal impact and wo found high correlations between most indices, with only few exceptions. According to citation analysis, Canadian Journal of Forest Research, Journal of Vegetation Science, Forest Science, Tree Physiology, International Journal of Wildland Fire, Holzforschung, Trees-Structure and Function, Silva Fennica, Agricultural and Forest Meteorology and Wood and Fiber Science are the top forestry journals. These publish articles related to all the domains of forestry science. More specialized journals are also included, dealing with specific issues of scientific interest and also of major importance to the scientific community.
Keywords h-index, Impact Factor (IF), citation-based metrics, forestry.

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Manuscript received August 27, 2011; revised October 15, 2012; accepted October 19, 2012; online first October 15, 2012.

Introduction

General considerations

Especially for scientists, journal rankings are essential, since one of the basic ways for them to illustrate their achievements to their academic institution and funding agencies is through the assessment of the journals in which they publish their work.

The main qualitative method (and until a few decades ago the only method) is that of peer review, whereby a number of experts rank the quality of scientific journals in their field by their own subjective criteria; based on the average scores obtained by each journal a ranking list is created. Beyond this, however, the ranking of journals is generally conducted using the method of citation analysis and various bibliometric indicators.

In the field of forestry, a representative example of a recent qualitative evaluation is a peer-review ranking of journals, conducted by a group of five individuals, nominated by senior members of the Institute of Foresters of Australia and assigned by the Australian Academy of Technical Sciences and Engineering (ATSE 2007).

The process of journal evaluation using bibliometric indices goes back many years, and various tools for ranking and comparing journals have been proposed. For the last 30 years the well-known Impact Factor (*IF*) has been the standard measure of journal quality in the scientific community (Garfield 1955, 2006). The *IF* – developed by ISI Thomson Reuters (USA) – essentially expresses the average number of citations received within a specific year by articles published in a specific journal within a previous given period of time. Usually, the impact the factor of a journal is calculated based on information collected within a three-year period. However, several studies highlight the disadvantages and inefficiencies of the *IF* (Seglen 1997, Bloch & Walter 2001, Whitehouse 2002). Modifications of *IF* have been proposed to cover both longer (Vinkler 1999, Garfield 1998) and shorter (e.g. citation immediacy index) periods of time. The latter provides the number of citations obtained by an item in the year of publication itself.

Apart from the traditional *IF*, in the recent years a number of other bibliometric indicators have appeared designed to assess the impact and value of scientific journals and, accordingly, the evaluation of the scientific work of individual scientists.

Hirsch (2005) introduced another indicator, the *h*-index, originally proposed as a measure to quantify the scientific output of a researcher. However, the *h*-index can also be applied to any publication set, including for instance the publication of journals. In this context, Braun et al. (2005, 2006) proposed a Hirsch-type index for evaluating the scientific impact of journals, assigning to a journal an *h*-index equal to *h* if the specific journal had *h* published papers, each of them had received at least *h* citations. Braun et al. (2005, 2006) suggested that the use of *h*-type indices in journal ranking could be employed as a supplementary indicator to impact factors because of two important properties of the *h*-index: its robustness to accidental citations and the fact that it combines quantity (articles published) with impact (citations received).

Almost immediately, a number of publications concerning the application of the *h*-index to journal rankings, or proposing modifications of the *h*-index to account for differences in a journal's size (Vanclay 2006, Rousseau 2007) or differences in the lives of the journals (Sidiropoulos et al. 2007) appeared in the literature.

The journal *h*-index, as proposed by Braun et al. (2005) presents some drawbacks highlighted in literature. Soon enough were suggestions to consider the publication frequency of the journal when calculating its *h*-index (e.g., Vanclay 2006). Besides the number of articles published in a journal, also the period over which that journal can collect citations influences the *h*-index. To overcome these issues several authors have proposed to modify the journal *h*-index. Rousseau (2007), Barendse (2007) and Molinari & Molinari (2008) tried to incorporate the number of articles published by journal into the calculation of *h*-index, while others (Bornmann et al. 2009, Olden 2007) attempted to alleviate the bias introduced by the different age of the journals, using the same time window.

Sidiropoulos et al. (2007) define the normalized yearly *h*-index, h_y^n for year *y*, by dividing the yearly *h*-index with the number of articles published by the journal in the year *y*:

$$h_y^n = \frac{h_y}{N_y} \quad (1)$$

where N_y are the articles published by journal in the year *y*.

Barendse (2007) notices the influence of the journal size on the calculation of *h*-index and proposed a "normalizing" factor, called strike rate index (*SRI*):

$$SRI = \frac{10 \cdot \log(h)}{\log(N)} \quad (2)$$

where *N* is the total number of articles published by the journal in a given time period. The analysis showed that values of *SRI* rarely correlate with *IF* values, a result attributed to the general behaviour of the two indices.

Previous evaluations of the forestry journals

There are only a few studies in the literature for assessing the scientific impact of forestry journals. Vanclay (2008a,b) collected data from 180 forestry journals and compared their rankings based on *IF*, the *h*-index and also an expert ranking. Expert ranking was related to the Australian government's Research Quality Framework (RQF)(Gale et al. 2005) and carried out by five senior members of the Institute of Foresters in Australia (IFA). The author being the fifth member of the IFA body, omitted his own opinions from his paper, and reported the views of the only four other experts. Vanclay (2008a) reported the ranking proposed by the IFA, subsequently revised by others, and available as final list at http://thomsonreuters.com/products_services/scientific/Web_of_Science).

Hirsch's *h*-indices were computed for several intervals, but the 8-year interval 2000-2007 seemed insightful for forestry journals. Although the *h*-index (2000-2007) is well correlated with the *IF*, it exhibited closer agreement with the expert assessment ($r = 0.62$) than with *IF* ($r = 0.56$), suggesting that the *h*-index may be useful for ranking journals objectively.

Other contributions were made also by Vanclay (2007), who is supportive for the use of *h*-indices instead of *IFs* in journal ratings, given the several "good" properties of the former: robustness against possible errors attributed to publications and citations in the tails of the associated distributions, "grey literature" or accidentally counted "highly cited" articles.

In another study, Kelsey & Diamond (2003) analyzed bibliometric data on the faculty members of selected southern US Universities that offered a doctoral program for the period 1990-2002. They tried to establish a current core list of the most highly cited forestry journals. Based on three faculty ranks, the authors concluded that assistant professors and associate professors are using more journals with ecological, environmental, and plant science subject emphases than full professors.

In Symonds et al. (2006), a regression-based approach was used to control the sex effects on the *h*-indices of scientists for the field of life sciences, utilizing the residuals of the linear regression between the *h*-index values (dependent variable) and the number of publications of the scientists (independent variable). It was attempted to use them as a measure of scientific impact.

Finally, it is well known that the citation rates vary significantly from one scientific field to another (e.g., Podlubny 2005). We also believe that another potential complication not considered hitherto in similar studies is the diversity and the different context of the journals included in the general category of "Forestry". Specifically, the ISI list is composed of journals that publish on a variety of topics, ranging from ecology to agronomy, in addition to journals that are purely of forestry context. It is reasonable thus to assume that these interdisciplinary journals are favoured to some extend on their citation rates when compared to specialized journals from the fields of forestry, since the former usually ensure broader coverage and, accordingly, more possibilities of being cited.

In this paper, to account for the above differences in a more unified manner, we apply a new measure to assess the scientific impact of forestry journals, attempting a thorough investigation of the assessment of research performance of journals from this field. Also, we tested the behaviour of journal indicators proposed in the literature in comparison with our measure.

Materials and methods

To evaluate the scientific journals from the field of forestry a total of 39 journals were selected from the database of the Institute of Scientific Information (ISI), respectively from Web of Science (WoS) list (http://thomsonreuters.com/products_services/scientific/Web_of_Science), which was accessed in May 2010. Although it has been reported to exist about 200 forestry journals worldwide (Vanclay 2008a), we chose the ISI list of forestry journals mainly for two reasons. Firstly, because WoS is a comprehensive database widely accepted by the scientific community for providing valid citation data and, secondly, because the calculation of bibliometric indices for non-ISI journals has been frequently reported to be imperfect (Jacso 2008). For example, Google Scholar (GS), which has a limited coverage of the pre-1990 publications, has been criticized for including gray literature in its citation counts. Nevertheless, the journals associated with the forestry research and practice, included in Thomson Scientific ISI, clearly constitute the bulk of most eminent and recognizable forestry journals, as shown in relative studies (Vanclay 2008a), despite few exceptions.

Following a similar approach to Symonds et al. (2006), and using citation data from this list of 39 journals, we calculated - complementary to the journal *h*-index - a new measure, called residual *h*-index (Panaretos & Malesios 2009), based on the residuals of a fitted general linear regression model (GLM), where the response variable was the *h*-index, while the explanatory variables were some of the best known factors that cause significant bias when obtaining a raw *h*-index, as well as factors of our own. Specifically, the overall number of articles published by the journal was included in the regression equation, since it is natural to expect a journal with a much higher number of publications to have a higher *h*-index when compared to a journal with fewer articles. Additionally, we believe that the year of entry of a journal into ISI database should also be considered, for deriving a fair ranking between the journals that presents varying citation-counting periods. Thus, we also included a variable expressing the number of years from the entry of the journal until the final year of the data collection period (2008). Another aspect, to our best knowledge not included on existing studies, is the frequency of publication of a journal (e.g. one journal publish every three months - quarterly, while another twice on a year - semi-annual). It would be of interest to examine if this difference of frequency has also a significant effect on the *h*-index of a journal. Hence, we decided to include a third explanatory variable in the regression model, the frequency of the yearly publication of a journal, taking values from 24 (semi-monthly publication) to 2 (semi-annual publication).

To conduct the analysis, four models were assumed using the *h*-index variable as the dependent variable, starting with only one explanatory variable (Model 1), and adding for each consecutive model another explanatory variable, until the 4th model including all four regressors.

The significance (or lack of) of the corresponding regression coefficients, or the sign of the coefficient reveals any possible associations and the direction of this association. The most comprehensive model (Model 4) has the following form:

$$(h-index)_i = \beta_1 \cdot (N_p)_i + \beta_2 \cdot (Year)_i + \beta_3 \cdot (Frequency)_i + \beta_4 \cdot (Category)_i + \varepsilon_i \quad (3)$$

$i = 1, 2, ... 39.$

In order to proceed with the calculation of the residual *h* measure we will use the residuals of the last fitted model (Model 4) as an adjusting measure for all four explanatory variables in the model.

Because the derived residuals can take both positive and negative values, to derive the measure for each one of the journals included in our analysis we transformed (Visweswaran 1996) all residual values to positive values, using the following transformation:

$$(residual \quad h)_i = \frac{e_i - e_{\min}}{e_{\max} - e_{\min}} \times 100 \quad (4)$$

The transformed values will now range from zero to 100.

It must be noted here that the derived values are data-dependent, and the ranks assigned to each journal can change depending on the specific dataset used for the analysis. However, we believe that the benefit from the use of the residual *h* measure due to the improvements in capturing more accurately important aspects of the journal's performance compensates for any possible discrepancies occurring by using different datasets.

In addition to the calculation of the proposed metric and also for comparison purposes, the following bibliometric indices were recorded from the WoS: the total number of papers, the total number of citations, the journal *h*-indices and the *h*-type indices proposed in the literature, the *IF*s of the journals, based on the year 2008, as well as some of the alternatives to the ISI *IF*, provided by the new version of the science citation index (*SCI*), namely the 5-year *IF* (for 2008), the immediacy index, and the eigenfactor score. The journal *h*-index values and the selected *h*-type indices were calculated using as time window the period starting from the inclusion of each journal in the ISI listings up to the year 2008. Besides the aforementioned indices, two additional bibliometric measures have been also included for comparison purposes: the total number of papers and the total number of citations of the journals. Finally, we gathered information concerning the date of inclusion of each journal in the ISI database and the frequency of each yearly journal appeareance.

To further examine the presence or absence of correspondence of the citation analysis rankings - as offered by the various journal bibliometric indices presented in the current study - and the qualitative methodologies, we used information from the peer-review of the Australian Academy of Technological Sciences and Engineering (Vanclay 2008a). The expert rankings classified the journals into four categories (A1 - top 5%, A - next 15%, B - next 30%, and C - lower 50%). We have isolated journals from the ISI list included in the ATSE rankings (only two out of the 39 journals in ISI were not evaluated by the peer review, and all ISI journals fall in the three first categories, A1, A and B).

The list of the 39 forestry journals was considered to be fully representative, covering the most prolific and distinguished journals in the field.

Results

Models of the *h*-index

The fitting of the regression models showed the significance of the three from the four explanatory variables (Table 1). Specifically, model 1 included only the total number of articles as the predictor of a journal *h*-index, the total number of articles being a significant predictor for the *h*-index (beta coefficient = 0.014, $p < 0.001$)($R^2 = 0.69$). Adding the [years of inclusion in the ISI] term and the [frequency of publication] term into the regression equation, increases R^2 to 0.881, indicating an improvement of the model. Additional improvement was obtained after the incorporation of the [Category] factor, which increased further also the fit of the model ($R^2 = 0.903$, SSE = 6,562.5). However, when added to the final model other terms (frequency of publication, year of inclusion in the ISI, Categories), the [Number of articles] variable is no more significant.

The coefficients for [years of entry in the ISI] and for [frequency of publication within a year](0.855 and 1.929 respectively) were both significant at the 5% and 1% level, respectively. The sign of the coefficient of the frequency of publication (1.929) indicates that the journals that publish more frequently within a year tend to have higher *h*-indices, when compared with journals publishing less frequently.

The relationship between the journals' *h*-index with the journals' topics categories show that the interdisciplinary journals from fields of forestry, ecology and plant sciences tend to present different (higher) *h*-index values, in comparison with the *h*-index of the journals publishing only papers from the forestry field or other interdisciplinary areas. This can be attributed to the fact that multidisciplinary journals - especially from the field of ecology - have a larger citation frequency, since ecology can be considered as a more densely cited field compared to the field of forestry.

Summary statistics of the indices

In total, the 39 journals included in the study have published 63,003 papers, which received - from the date of their inclusion in the ISI database up to the end of 2008 - a total number of 637,386 citations. Summary statistics of the

Table 1 Regression models for the ISI *h*-index of forestry journals

Predictor	Model 1	Model 2	Model 3	Model 4
Total Articles (WoS)	0.014***	0.005*	0.002 n.s.	0.002 n.s.
Years of Inclusion in the ISI		1.243***	0.819***	0.855**
Frequency of publication within a Year			2.340***	1.929**
Category: Forestry				- 0.392 n.s.
Category: Forestry/Agronomy				12.439 n.s.
Category: Forestry/Ecology/Plant Sciences				17.492*
Category: Forestry/Materials/Wood				- 4.526 n.s.
Category: Forestry/Genetics & Heredity				- 2.418 n.s.
SSE	20,973.400	12,772.370	8,025.390	6,562.500
F	83.955	78.996	88.647	35.871
R^2	0.688	0.810	0.881	0.903
adj. R^2	0.680	0.800	0.871	0.877

Note. The significance symbols: * - $p < 0.05$, ** - $p < 0.01$, ***$p < 0.001$, n.s.: non-significant.

various bibliometric indicators for the journals included in our data set are presented in Table 2. The residual *h* measure is also included, for comparison purposes.

The common characteristic, met in other fields of research, of the concentration of most citations in only a few journals is also here present (Davis 2008, Seglen 1992). Indeed, the journal with the most citations (Canadian Journal of Forest Research) accounts for 18.93% of all citations, while the top three journals with respect to the total citations (Canadian Journal of Forest Research, Forest Ecology and Management and Agricultural and Forest Meteorology) account for almost half of the all 39 journals citations (43.5%).

The average number of articles per journal is 1,615.46, while the median number is 873. This difference indicates that only few journals have published a very high number of articles, while the majority shares significantly lower numbers in their publications. Also, as we observe from Table 2, the average journal *h*-index is 33.21, ranging between 1 and 94. The great differences between the *h*-indices values of the journals are easily observable in Table 1 from Appendix. When we comme to the *h*-type modifications proposed in the literature (i.e., the relative *h*-index, the impact index and the strike rate index), we see that the majority of the relative *h*-index values are near zero, but, however, the specific metric still has a high discriminatory power for ranking the forestry journals. The residual *h* measure proposed in the current study has an average value of 53.8, and - of course - due to the transformation of the original residual values, ranges between 0 and 100.

The statistics concerning the time passed from the inclusion of the articles in the ISI database and the frequency of publishing during this period tell us that the average number of years of the forestry journals in the WoS is 17.64, while the oldest papers being included since 1970. Regarding the frequency of publication of the journals, on average, the journals publish about six to seven times within a year. However, the high value of the standard deviation reveals that there are significant differences in the frequency cycle among the 39 journals.

Relationships between indices

The type and strength of the correlation between the various metrics were determined using Spearman's rank correlation (Spearman 1904). Table 3 presents the rank order correla-

Table 2 Summary statistics of the journal impact indicators

	Mean	Median	Standard Deviation	Minimum	Maximum	*N*
h-index (WoS)	33.21	28	25.293	1	94	39
Relative h-index	0.037	0.035	0.024	0.006	0.135	39
Impact index	1.859	1.821	0.84	0.184	3.935	39
SRI index	4.668	4.878	0.98	0	5.775	39
Residual h	53.839	51.461	20.3	0	100	39
Number of articles (WoS)	1,615.46	873	2,002.16	52	7,287	39
Total cites (WoS)	16,343.23	6,422	26,808.6	14	120,655	39
Impact Factor (2008)	1.16	0.918	0.701	0.103	3.668	39
5-year Impact Factor (2008)	1.48	1.336	0.826	0.317	4.486	35
Immediacy Index	0.222	0.15	0.252	0	1.086	39
Eigenfactor score (2008)	0.005	0.002	0.008	0	0.042	39
Years of first publish	17.64	15	12.648	1	38	39
Frequency of publication	6.79	6	5.074	1	24	39

tion coefficients between the various metrics included in our analysis. First of all, we see that the journal *h*-index rankings are highly correlated with the rankings provided by the total number of articles and the total number of citations (ρ = 0.906 and ρ = 0.985, respectively).

By examining rank order correlations of the three *h*-type modifications (i.e., the relative *h*-index, the impact index and the strike rate index) we observe that the only index not positively correlated with the ranks corresponding to the total number of articles and citations received is the relative *h*-index (ρ = -0.704, ρ = -0.503, respectively). The impact index and the strike rate index both exceed significant positive correlations with the two standard bibliometric measures. The relationships between the three metrics show very strong rank correlations between the *h*-index, the impact index and the *SRI*, while the relative *h*-index seems to differentiate as ranking compared with the both other *h*-type indices and the *h*-index (for example, Spearman's rank correlation between the *h*-index and the relative *h*-index is ρ = -0.427, while the correlation coefficient between the *h*-index and the impact index is ρ = 0.825).

When analyze the proposed measure, its ranking is moderately correlated with the ranks given by the total number of citations (ρ = 0.280), while no associations are observed between our measure and the total number of articles (ρ = 0.071, p > 0.1). Like the relative *h*-index, the new measure is poorly associated with the journal *h*-index (ρ = 0.34).

Recently, an extensive examination of correlations between the various *h*-type indices has been conducted. After an empirical comparison of the *h*-index and some of its most important variants, Bornmann et al. (2008a,b) concluded that the examined *h*-type indices can be categorized into two general types, one describing the most productive core of the output of a scientist, while the other depicting the impact of the papers. Under this perspective, the residual *h*-measure - which allows for normalizations with respect to various factors not depicted by *h*-index and other *h*-type modifications - clearly differentiates from other indices, making it a useful alternative for comparison of journals. In addition, could be considered as a complementary index, combining various characteristics of other *h*-type modifications, and for instance normalizing for *N* (Barendse 2007) or for the years of publication (Sidiropoulos et al. 2007).

By examining the rank correlations of the *h*-index and the four *h*-type indices with the *IF*, we observed the strongest positive correlations between the relative *h*-index and the *IF* (ρ = 0.999, p < 0.001), followed by the impact index (ρ = 0.754, p < 0.001) and the *SRI* (ρ = 0.707, p < 0.001). A somewhat lower correlation coefficient was found between the journal *h*-index and the *IF* (ρ = 0.678, p < 0.001).

The strongest rank correlation coefficient of the new developed measure is observed with the impact index (ρ = 0.598, p < 0.001), while all other rank correlations of the measure range between 0.071 and 0.571.

For testing the validity of the ranking given by the *h*-index, we have calculated - in addition to the WoS journal's *h*-indices – the *h*-indices from GS, using the publish or perish (PoP) freely available software, and checked how the two variable rankings correlate. The results showed a Spearman's correlation coefficient of p = 0.868 (p < 0.001), indicating that both GS and WoS ranks are in accordance.

Journal rankings according to the residual *h*-measure

In Table 1 from Appendix, is presented the resulting ranking according to the residual *h* measure. We included also the rankings of the journal *h*-index and the other three *h*-type metrics (in the parentheses are the ranks according to each one of the four measures), as well as the rankings given by the (three-year) *IF*, the 5-year *IF*, the immediacy index and the eigen-

Table 3 Correlation matrix of the different indices

	Impact Factor (2008)	5-year Impact Factor (2008)	Immediacy Index	Eigenfactor score (2008)	*h*-index (WoS)	Relative *h*-index (WoS) - 1990-2008	Impact Index (WoS) 1990-2008	*SRI* (WoS) 1990-2008	Total articles (WoS)	Total cites (WoS)	Residual *h*-measure
Impact Factor (2008)	1										
5-year Impact Factor (2008)	0.901(**)	1									
Immediacy Index	0.644(**)	0.547(**)	1								
Eigenfactor score (2008)	0.724(**)	0.801(**)	0.563(**)	1							
h-index (WoS)	0.678(**)	0.693(**)	0.539(**)	0.900(**)	1						
Relative *h*-index (WoS) -1990-2008	0.999 (*)	0.110	0.007	-0.345(*)	-0.427(**)	1					
Impact-index (WoS) -1990-2008	0.754(**)	0.825(**)	0.565(**)	0.769(**)	0.825(**)	0.071	1				
SRI (WoS) -1990-2008	0.707(**)	0.799(**)	0.521(**)	0.672(**)	0.730(**)	0.200	0.976(**)	1			
Total articles (WoS)	0.431(**)	0.405(*)	0.389(*)	0.810(**)	0.906(**)	-0.704(**)	0.538(**)	0.423(**)	1		
Total cites (WoS)	0.638(**)	0.626(**)	0.518(**)	0.905(**)	0.985(**)	-0.503(**)	0.760(**)	0.655(**)	0.942(**)	1	
Residual *h* measure	0.440(**)	0.571(**)	0.313	0.411(**)	0.340(*)	0.261	0.598(**)	0.556(**)	0.071	0.280	1

Note: *** - correlations are significant at a 10% level of significance, ** - correlations are significant at a 5% level of significance, * - correlations are significant at a 1% level of significance.

factor score indicators. The rankings based on the article counts and the citation counts are also included.

According to our analysis, Canadian Journal of Forest Research, Journal of Vegetation Science, Forest Science, Tree Physiology and International Journal of Wildland Fire are the top five forestry journals. The top ten list in our ranking results is completed by Holzforschung, Trees-Structure and Function, Silva Fennica, Agricultural and Forest Meteorology, and Wood and Fiber Science.

In the top ten places are journals that publish articles related to all forest sectors, as Canadian Journal of Forest Research, Silva Fennica and Forest Science, journals addressed to a broader range of scientists, as Journal of Vegetation Science, Holzforschung, Wood and Fiber Science, Trees-Structure and Function or more specialized journals, related to an extremely contemporary and timely topic (as International Journal of Wildland Fire).

Some very interesting facts emerge from the ranks of the journals. Predictably, some of the most prestigious journals are included in the top ten of the list, such as Canadian Journal of Forest Research, Journal of Vegetation Science, Tree Physiology and Agricultural and Forest Meteorology, accordingly ranked in the top places by almost all bibliometric indices, and also highly placed by previously conducted journal rankings (Vanclay 2008a,b). Among these ten journals, however, relatively new journals can be found, not included in the majority of the previous qualitative studies (peer reviews): e.g. Silva Fennica, a journal relatively successful on generating citations in the recent years, or Wood & Fiber Science. Even when they are ranked by some quantitative studies, their ranks tend to result in lower positions for these newer journals, despite their emphasized citation productivity performance.

Indeed, Silva Fennica began to publish in 1994 and its citation data is available in the ISI database since 2001. It has received a total of 3,002 citations in the 9 years of ISI inclusion, in comparison with the relatively low number of published articles of the same time period (422 articles). International Journal of Wildland Fire start ed to publish in 1991, the citation data being available in the ISI database since 1995. It was ranked on the 5th place by the residual *h*-index, and on the 14th place by both *h*-index and *IF*.

Figure 1 presents the discrepancies between the *h*-index and the residual *h* measure. There are few journals positioned at the top right corner of the scatterplot, indicating that they have both high *h*-index values and residual *h* values.

These are Canadian Journal of Forest Research, Forest Science, Journal of Vegetation Science and Tree Physiology, all starting their publishing many years ago and being established in the scientific community as prestigious publications. In the bottom left corner of the plot are positioned the journals that have both a low *h*-index values and a residual *h* values (such as Allgemeine Forst und Jagdzeitung).

A very interesting result derived from the inspection of the graph is that there is a significant number of journals ranked low by the *h*-index (for instance Ciencia Florestal or Journal of Tropical Forest Science), whereas their ranking improves when considering the residual *h* measure. These journals are identified in the scatterplot as a cluster of points at the bottom of the graph, the majority with residual *h* values between 40 and 60. These are journals relatively recently included in the ISI database, thus not receiving many cites, but can be characterized as promising newcomers.

Considering now the performance of the journals in relation to the residual *h* measure and *IF* (Figure 2), we observe that Agricultural and Forest Meteorology - which is by far the dominant journal as *IF* score - presents also a high value in residual *h* (in general, the superiority of Agricultural and Forest Meteorology is signified by the fact that the specific journal is ranked in the first 3 places by 8 out of the 11 indicators of Table 1 from Appendix). Besides the well-known journals already appearing in the previous scatterplot, here Tree Genetics & Genomes journal - receiving a low *h*-index (11) - has been ranked highly by both the residual *h* and the *IF*, indicating that the *IF* is a metric that is fairer in ranking new journals showing rapid development, mainly due to the fact that it only requires data from a recent and relatively small time period.

In order to further characterize the differences in the residual *h* ranking in comparison to the rankings given by the other indicators and also to assess the validity of the proposed method, we considered some examples emerging from the ranks produced. Let us consider, for instance, the journals ranked 3rd, 4th and 5th by the residual *h* (Forest Science, Tree Physiology and the International Journal of Wildland and Fire). Forest Science has an *h*-index of 77, followed by the Tree Physiology (*h*-index 75), while International Journal of Wildland and Fire, 34 (ranked 14th). Forest Science and Tree Physiology are ranked 4th and 6th respectively according to their *h*-indices.

However, it must be considered that the Forest Science is ranked based on a total number of 2,989 published papers, a considerably large number, especially when compared with the 572 papers of International Journal of Wildland and Fire. Another significant factor was the time passed since the inclusion of these journals in the database. While Forest Science has been included on ISI since 1970, Tree Physiology has only been included since 1986, while International Journal of Wildland and Fire since 1993. Given these significant factors, the residual *h* measure ranks the three journals in a more suitable manner, since it normalizes for the distortions caused by differences in output sizes or years of citing.

Another example can be found comparing Silva Fennica and Trees-Structure and Function. While the latter is ranked on 8th place according to its *h*-index (46) and the former is ranked on 19th (*h*-index: 23), when ranked by the residual *h* measure, Silva Fennica climbs to 8th place, just one place below the Trees-Structure and Function. The reasoning for this is that the residual *h* normalizes the fact that Silva Fennica is evaluated upon a number of 422 publications received over a time period of just 9 years, while Trees-Structure and Function use a total of 1,208 papers, receiving citations over a period of 22 years.

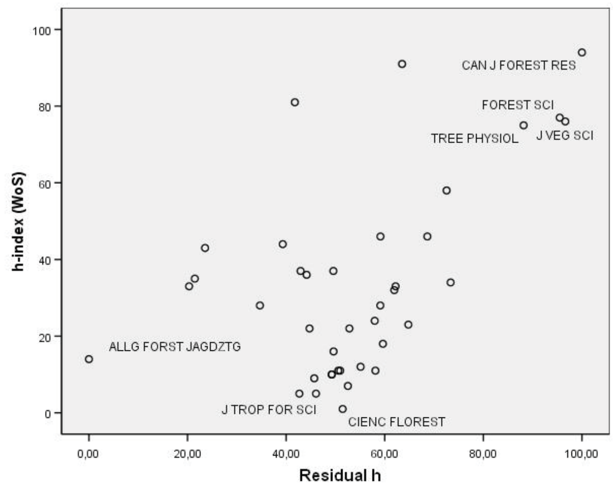

Figure 1 Scatterplot between the *h*-index (WoS) and the residual *h* measure of the 39 Forestry Journals

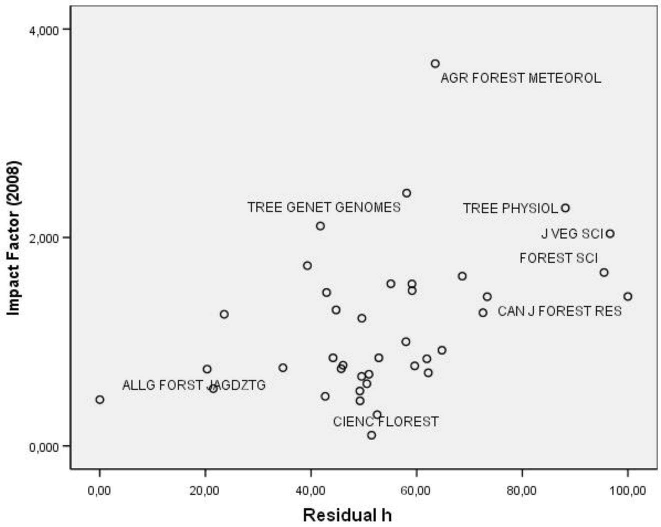

Figure 2 Scatterplot between the Impact Factor - 2008 (WoS) and the residual h measure of the 39 Forestry Journals

The residual h-measure ranking vs. qualitative assessments

The relation of each of the citation metrics with the peer review classification (Figure 3) shows the averages of the *h*-index and residual *h* measure for each one of the three classes (A1, A, and B) of the expert ranking.

Thus, the residual *h* measure ranking tends to alleviate differentiations between the journals of the A and B categories of the classification allocated by the experts. We believe that this behaviour constitutes an advantage of the newly proposed measure for journal evaluation in relation to the assigned ranks of both the peer review example and the *h*-index.

Our opinion is that *h*-index ranking is based essentially on the idea of ranking according to the journal perceived prestige. For instance, the calculated WoS journal *h*-index is highly correlated with the time of inclusion of the journal in the database, which in turn is a reflection of the journal prestige in the scientific community (Saad 2006).

The residual *h* measure, as already described, tries to alleviate the time differences in the entries of the journals in the ISI list and, accordingly, to minimize the advantages gained by journals publishing articles for a longer period, in comparison with the newer journals.

To examine the validity of these claims we have calculated the mean and median years from the journal inclusion in the WoS list for the categories A and B. The journals from group A exhibit an average of 20.27 years (median years = 15), while the journals belonging to group B share an average of only 9.5 years (median years = 5.5). Now, we easily can conclude that in the group B appear only few journals included in ISI database, while in the group A is their majority.

Discussion

There is no universal quantitative measure for assessing journal quality and impact, although some metrics such as the *IF* have been widely used and accepted as appropriate measures for deriving valid journal rankings. The initial proposal for incorporating the *h*-index in the assessment of journal impact has proven in

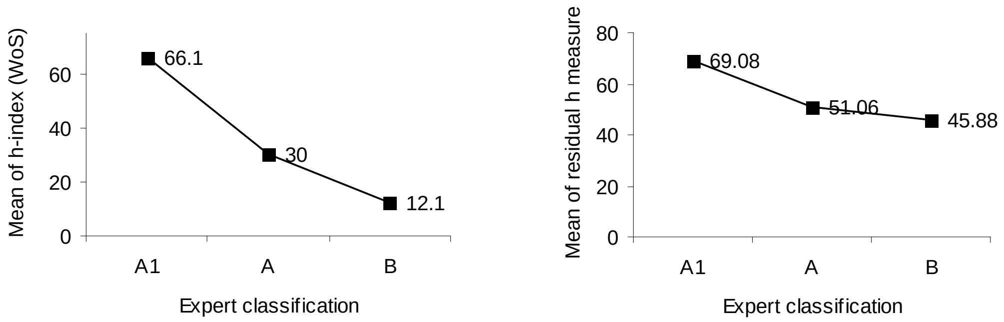

Figure 3 Mean of the h-index (left) and residual h measure (right) on expert classes

practice to suffer from several shortcomings, mainly its inability to differentiate between journals of different publication outputs and different years of life.

The ranking of forestry journals provides an indication for the academic staff and researchers where is best to publish. This is particularly important for researchers who are embarking on their career, but also Could contributes to the interdisciplinary research and collaboration among researchers in various domains of forestry (wood science, forest ecology, forest management, forest policy and economics etc). In the recent years, a lot of journals have been established, not only in forestry. Besides the current results, this study could be further extended by replicating the calculation of the residual *h* measure for other categories, related but not included in forestry (e.g. environmental sciences, ecology, biodiversity conservation, soil science), allowing in this way to test the performance and scalie the proposed measure for the different fields of research. Also, the performance of forestry journals against journals belonging to related categories would provide interesting information.

The contribution of the present paper is twofold: first, from a methodological point of view, we have presented an *h*-type complement to the journal *h*-index, which measure attributes not explained by *h*-index, for a better and more accurately estimation of the impact of journals. It is based on a method which uses the residuals of regression analysis to produce an alternative measurement of the journal quality. Examining the performance of the proposed measure using a list of forestry journals included in the ISI Web of Science database, the method produced a series of rankings that seems intuitively correct. However, it should be stressed out that it can be seen mainly as a complement to *h*-index, and not as a replacement. Journal *h*-index deals quite well with some important aspects of journal standing, whereas the residual *h* explicitly accounts for some other - omitted – but yet important aspects.

The derived measure for each journal is not unique, but depends each time on the specific dataset used for the analysis. However, given the fact that the existing bibliometric indices for the journal evaluation fail to capture important aspects of the journal performance, measures such as the residual *h* are useful, especially when comparisons between journals are based on citation data of varying parameters. From the presented examples, we can conclude that the new measure provides a more balanced view of the scientific impact of forestry journals under study.

Second, by providing a well-established and valid ranking of forestry journals, we are motivating the researchers to send their publications to the best of these journals and thus, to improve their academic and research careers, their financial rewards and their social recognition (status).

In the top ten of our forestry journals are publications issued in countries with an advanced approach of forestry. The published articles are related to all the fields of the forest science. Included are also the specialized journals dealing with specific issues, not only addressed to forestry professionals, but also to professionals from other fields of science.

Conclusions

We derived a comparative ranking on the most important forestry journals which, in addition to the previous analyses, proposes an indicator supplementary as to the journal *h*-index, as an effort to account for the different dimensions of the forestry journals. We also verifyied the empirical findings of previous studies, e.g. the correlations between journal *h*-index and expert rankings. The new measure, in conjunction to the already existing bibliometric indices assessing the impact of the journals, results in a better and more accurate estimation of the journal impact, as shown from this study. Specifically, analysis provide a strong indication that the proposed measure is clearly differentiated from the existing bibliometric indicators.

The empirical results indicate that although the alternative measures reveal differences on the rankings of the journals, the high correlations between the most indices suggests is no considerable differentiation among them. The most significant differences were observed for two indices - the relative *h*-index and the residual *h*-measure - which indicates that the two seems to measure different aspects of the scientific performance. Therefore, the residual *h* proposed in this study does not measure similar aspects as the journal *h*-index. When used complementary, these could conduct to a clearer picture of the status of a journal. For instance, a journal scoring high in these two measures is an indication of its overall quality over the years (*h*-index) and that, additionally, it exhibits quality in specific dimensions (residual *h*), e.g. it is still a journal with rapid development and good dynamics, being thus still a suitable candidate for authors seeking for future publications.

Aknowledgements

We are gratefull to three anonymous reviewers for the helpful comments on the early version of the manuscript.

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Appendix

Table 1 Spearman's rank correlation coefficients between the journal impact indicators

Journal	*h*-index (WoS)	Relative *h*-index	Impact index	*SRI* Index	Residual *h* Measure	Number of articles (wos)	Total cites (WoS)	Impact Factor (2008)	5-year Impact Factor (2008)	Immediacy Index	Eigenfactor score (2008)	Years from lusion in the ISI tabase	Yearly freq-uency of pu-bli-cation
Canadian Journal of Forest Research	94 (1)	0.0135 (33)	2.7292 (5)	5.1347 (12)	100 (1)	6,962 (3)	120,655 (1)	1.434 (13)	2.058 (8)	0.252 (12)	0.01979 (3)	31	12
Journal of Vegetation Science	76 (5)	0.0421 (12)	3.7855 (2)	5.7752 (1)	96.62 (2)	1,806 (10)	39,942 (6)	2.037 (5)	2.756 (3)	0.384 (6)	0.01008 (6)	18	6
Forest Science	77 (4)	0.0258 (25)	3.1353 (4)	5.4279 (6)	95.49 (3)	2,989 (6)	47,737 (5)	1.664 (7)	2.171 (7)	0.081 (28)	0.00592 (7)	38	6
Tree Physiology	75 (6)	0.0295 (23)	3.2568 (3)	5.5057 (5)	88.17 (4)	2,545 (9)	51,482 (4)	2.283 (3)	2.768 (2)	0.457 (5)	0.01461 (4)	22	15
International Journal of Wildland Fire	34 (14)	0.0594 (5)	2.6824 (7)	5.554 (4)	73.36 (5)	572 (22)	6,422 (20)	1.432 (14)	2.28 (5)	1 (2)	0.00385 (10)	15	4
Holzforschung	58 (7)	0.0195 (29)	2.3645 (10)	5.0757 (13)	72.55 (6)	2,980 (7)	31,899 (7)	1.278 (16)	1.336 (18)	0.278 (9)	0.00569 (8)	38	6
Trees-Structure and Function	46 (8)	0.0381 (17)	2.6911 (6)	5.3949 (7)	68.64 (7)	1,208 (17)	16,324 (11)	1.629 (8)	2.174 (6)	0.193 (15)	0.00592 (7)	22	8
Silva Fennica	23 (19)	0.0545 (8)	2.0493 (14)	5.1869 (9)	64.78 (8)	422 (26)	3,002 (24)	0.918 (20)	1.273 (19)	0.098 (26)	0.00186 (21)	9	4
Agricultural and Forest Meteorology	91 (2)	0.0354 (19)	3.9349 (1)	5.7445 (2)	63.52 (9)	2,572 (8)	54,730 (3)	3.668 (1)	4.486 (1)	0.8 (3)	0.02204 (2)	24	24
Wood and Fiber Science	33 (15)	0.0232 (28)	1.8086 (21)	4.8162 (23)	62.2 (10)	1,422 (15)	9,492 (16)	0.702 (28)	0.905 (26)	0.25 (13)	0.00259 (16)	25	4
Scandinavian Journal of Forest Research	32 (16)	0.0247 (26)	1.8213 (20)	4.8367 (22)	61.93 (11)	1,294 (16)	8,531 (18)	0.836 (22)	1.411 (15)	0.12 (25)	0.00356 (14)	15	6
Forest Policy and Economics	18 (21)	0.0405 (13)	1.5715 (23)	4.7415 (25)	59.63 (12)	444 (25)	2,131 (26)	0.768 (24)	1.132 (23)	0.122 (24)	0.00247 (17)	7	4
Wood Science and Technology	46 (8)	0.0321 (22)	2.5148 (8)	5.2692 (8)	59.13 (13)	1,431 (14)	15,961 (12)	1.49 (11)	1.57 (12)	0.271 (11)	0.00358 (13)	38	6
Annals of Forest Science	28 (17)	0.0321 (22)	1.8653 (19)	4.9206 (19)	59.1 (14)	873 (20)	6,894 (19)	1.554 (10)	1.592 (11)	0.141 (21)	0.00452 (9)	9	8
Tree Genetics & Genomes	11 (25)	0.0625 (4)	1.3905 (27)	4.6377 (27)	58.11 (15)	176 (36)	734 (30)	2.426 (2)		0.532 (4)	0.00086 (31)	3	4
Iawa Journal	24 (18)	0.0432 (10)	1.915 (17)	5.0279 (15)	57.96 (16)	556 (24)	3,702 (22)	1 (19)	1.176 (20)	0.031 (34)	0.00137 (25)	15	4
European Journal of Forest Research	12 (24)	0.0583 (6)	1.4244 (26)	4.664 (26)	55.1 (17)	206 (34)	904 (29)	1.556 (9)	1.567 (13)	0.319 (7)	0.00171 (22)	4	4

Table 1A (continuation)

New Forests	22 (20)	0.0386 (16)	1.738 (22)	4.8711 (21)	52.83 (18)	570 (23)	3,320 (23)	0.845 (21)	1.008 (25)	0.133 (22)	0.00145 (23)	12	6
Tree-Ring Research	7 (28)	0.1346 (1)	1.4411 (25)	4.9248 (18)	52.53 (19)	52 (39)	201 (37)	0.3 (37)	1.375 (17)	0 (36)	0.00044 (35)	5	2
Ciencia Florestal	1 (30)	0.0145 (31)	0.1838 (39)	0 (39)	51.46 (20)	69 (38)	14 (39)	0.103 (38)		0.04 (33)	0.00012 (37)	1	1
Southern Journal of Applied Forestry	11 (25)	0.0570 (7)	1.3402 (28)	4.5564 (28)	50.96 (21)	193 (35)	574 (35)	0.688 (29)	0.838 (29)	0.16 (17)	0.00083 (32)	6	4
International Forestry Review	11 (25)	0.0353 (20)	1.1059 (32)	4.1753 (33)	50.57 (22)	312 (28)	681 (32)	0.597 (31)	1.058 (24)	0 (36)	0.00138 (24)	6	4
Forest Pathology	16 (22)	0.0479 (9)	1.5654 (24)	4.7712 (24)	49.62 (23)	334 (27)	1,719 (28)	1.225 (18)	1.161 (22)	0.158 (18)	0.00115 (28)	8	6
Silvae Genetica	37 (11)	0.0242 (27)	1.9709 (16)	4.9255 (17)	49.57 (24)	1,527 (13)	12,978 (13)	0.667 (30)	0.862 (28)	0.068 (30)	0.00125 (27)	32	6
Western Journal of Applied Forestry	10 (26)	0.0422 (11)	1.1223 (31)	4.211 (30)	49.27 (25)	237 (33)	640 (33)	0.433 (36)	0.696 (31)	0.156 (19)	0.00103 (29)	6	4
Northern Journal of Applied Forestry	10 (26)	0.0403 (14)	1.1021 (33)	4.1763 (32)	49.23 (26)	248 (31)	684 (31)	0.527 (33)	0.667 (33)	0 (36)	0.00092 (30)	6	4
Journal of Forest Economics	5 (29)	0.0714 (3)	0.914 (36)	3.7882 (37)	46.06 (27)	70 (37)	127 (38)	0.774 (23)		0 (36)	0.00045 (34)	3	4
Journal of Forest Research	9 (27)	0.0370 (18)	1 (35)	4 (35)	45.71 (28)	243 (32)	595 (34)	0.741 (26)		0.02 (35)	0.0013 (26)	3	6
Applied Vegetation Science	22 (20)	0.0843 (2)	2.3756 (9)	5.5549 (3)	44.74 (29)	261 (30)	2,218 (25)	1.305 (15)	1.629 (10)	0.273 (10)	0.00191 (20)	7	2
Agroforestry Systems	36 (12)	0.0232 (28)	1.9067 (18)	4.8786 (20)	44.16 (30)	1,549 (12)	11,511 (14)	0.845 (21)	1.164 (21)	0.162 (16)	0.00262 (15)	22	4
Forestry	37 (11)	0.0339 (21)	2.2538 (13)	5.1616 (10)	42.94 (31)	1,092 (18)	8,903 (17)	1.472 (12)	1.385 (16)	0.13 (23)	0.00211 (19)	38	5
Journal of Tropical Forest Science	5 (29)	0.0171 (30)	0.5162 (38)	2.8351 (38)	42.68 (32)	292 (29)	255 (36)	0.476 (34)	0.317 (35)	0.054 (31)	0.00049 (33)	5	4
Forest Ecology and Management	81 (3)	0.0111 (34)	2.3092 (12)	4.941 (16)	41.76 (33)	7,287 (1)	101,641 (2)	2.11 (4)	2.633 (4)	0.296 (8)	0.04188 (1)	32	24
Plant Ecology	44 (9)	0.0279 (24)	2.3143 (11)	5.1397 (11)	39.31 (34)	1,576 (11)	18,516 (8)	1.73 (6)	2.026 (9)	0.212 (14)	0.01097 (5)	11	12

Table 1A (continuation)

Natural Areas Journal	28 (17)	0.0393 (15)	2.0238 (15)	5.0733 (14)	34.68 (35)	712 (21)	4431 (21)	0.75 (25)	0.791 (30)	0.15 (20)	0.00115 (28)	16	4
Journal of Forestry	43 (10)	0.0061 (37)	1.2411 (29)	4.2437 (29)	23.55 (36)	7,065 (2)	16,887 (10)	1.263 (17)	1.55 (14)	0.053 (32)	0.00367 (12)	38	8
Forest Products Journal	35 (13)	0.0075 (35)	1.192 (30)	4.2078 (31)	21.48 (37)	4,672 (5)	18,290 (9)	0.55 (32)	0.669 (32)	0.093 (27)	0.0038 (11)	32	12
Forestry Chronicle	33 (15)	0.0064 (36)	1.0793 (34)	4.0893 (34)	20.32 (38)	5,169 (4)	10,608 (15)	0.737 (27)	0.873 (27)	1.086 (1)	0.00224 (18)	38	6
Allgemeine Forst und Jagdzeitung	14 (23)	0.0138 (32)	0.878 (37)	3.8122 (36)	0 (39)	1,015 (19)	2,051 (27)	0.444 (35)	0.435 (34)	0.069 (29)	0.0003 (36)	28	12