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Research paper

Assessing the bibliometric productivity of forest scientists in Italy

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Abstract - Since 2010, the Italian Ministry of University and Research issued new evaluation protocols to select candidates for University professorships and assess the bibliometric productivity of Universities and Research Institutes based on bibliometric indicators, i.e. scientific paper and citation numbers and the h-index. Under this framework, the objective of this study was to quantify the bibliometric productivity of the Italian forest research community during the 2002-2012 period. We examined the following issues: (i) the bibliometric productivity under the Forestry subject category at the global level; (ii) compared the aggregated bibliometric productivity of Italian forest scientists with scientists from other countries; (iii) analyzed publication and citation temporal trends of Italian forest scientists and their international collaborations; and (iv) characterized productivity distribution among Italian forest scientists at different career levels. Results indicated that: (i) UK is the most efficient country based on the ratio between Gross Domestic Spending on Research and Development and bibliometric productivity under the Forestry subject category, followed by Italy; (ii) Italian forest scientist productivity has a significant positive time trend, but is characterized by high inequality across authors; (iii) one-half of the Italian forest scientist publications are written in collaboration with foreign scientists; (iv) a strong relationship exists between bibliometric indicators calculated by WOS and SCOPUS, suggesting that these two databases have the same potential to evaluate the forestry research community; and (v) self-citations do not significantly affect the rank of Italian forest scientists.

Keywords - Scientometrics, Forestry, Web of Science, SCOPUS, SCImago

Introduction

In the last few decades, increased attention has been paid to the scientific productivity of researchers and research institutions (Abramo & D'Angelo 2014; Adams 1990; Griliches 1998). Science policy increasingly includes productivity as a key factor in determining the financial budgets for research projects and scientists' careers (Bouyssou and Marchant 2010; Buela-Casal et al. 2010).

Chirici (2012) reported two main approaches applied to evaluate scientific productivity: (i) peer-review, where panels of appointed experts perform a qualitative evaluation; and (ii) bibliometrics, where a quantitative analysis of publications and citations is performed. In the last two decades, evaluation of researchers' work and careers has increasingly transitioned from peer-review to bibliometric evaluation (e.g. Seglen 1997b; Rogers 2002; Cameron 2005). Several studies were conducted that confirmed the use of bibliometric indicators as a suitable evaluation method (e.g. Falagas et al. 2006; Kumari 2006, Li & Zhao 2015). A measure of the publication and citation numbers provides an assessment of the respective quantity and quality of the research within a given field of science. For example, Vergidis et al. (2005) generated an analysis of microbiology researcher productivity; Falgas et al. (2006) examined global trends of research productivity in tropical medicine; Kumari (2006) compared the trends in different countries regarding synthetic organic chemistry research; Chirici (2012) analyzed Italian research productivity in forestry; and Li and Zao (2015) published a bibliometric assessment of global environmental research.

Measuring research strength is considered essential for a modern country's ongoing innovative and competitive capacity at the global level. A country's success in science, technology, and research determines its ability to compete for increasingly mobile resources and investment capital and to participate in global knowledge-sharing networks (The Council of Canadian Academies 2006). Monitoring research achievements in a specific field is crucial to measure a country's vitality in a specific research sector. The number of research publications in a certain scientific field reflects a country's commitment to science and is a reasonable indicator of its research

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and development (R&D) efforts in that field (Li & Zhao 2015; Falgas et al. 2006; Rajendram et al. 2006). Moreover, Hagen (2015) reported that participation in top-level international research is an indicator of national competitive ability and academic achievement. Multi-national teams has generated more than one-quarter of all publications in the world (Royal Society UK 2011). Collaboration has many benefits and is considered essential for groundbreaking research (Bidault & Hildebrand 2014; Sonnenwald, 2007).

The scientific output of a country is evaluated by assessing institutions or individual scientists. Two important parameters are examined, including overall production and impact of scientific publications (Bornmann 2011; Cronin 1984; Franceschini et al. 2007). The following three approaches are applied to evaluate these parameters using bibliometric indicators: i) counting the publication number; ii) counting the citation number; or iii) combining the first two counts to create hybrid indicators. Publication and citation counts are traditionally employed to indicate the influence or impact an author has within the research community (Adams 1990; Abramo & D'Angelo 2011, Wildegaard 2015). Hybrid indicators, such as the Hirsh index (h-index), provide a productivity measure and its impact using a single numerical value (Hirsch 2005; Jacso 2009; Alonso et al. 2009). An approach that offers an alternative to the combination of absolute output count and citation weight is to adjust citation measures directly for a range of factors, most commonly research age. For instance, the age-weighted citation rate (AWCR) adjusts citations by a given publication age (Jin 2007; Fedderke 2013).

A direct relationship exists between research and the overall development of a country (UNESCO, 2010). A viable approach to provide evidence of research productivity is to compare bibliometric indicators with Gross Domestic Spending (GDS) on research and experimental development (R&D) of a country (Meo et al. 2013; Leydesdorffa et al. 2009, Matthew et al. 2006). For example, the perfomance of a country in a specific field can be expressed as the number of scientific papers published or the number of citations received per 1 million USD investment in R&D (Clarke et al. 2007, Tarkowski 2007).

Another important performance aspect to analyze in a country or institution within specific scientific fields is productivity distributions among authors. Inequality indicators are applied to understand if productivity rates in a specific area are due to the efforts of a few or many authors (Cole & Eales 1917; Fuyuki et al. 2003; Bornmann et al. 2008).

Glänzel and Thjis (2004) has stressed the influence of self-citations in calculating bibliometric indicators. In fact, where citations are used as a proxy to evaluate impact on the scientific community, self-citations are problematic, as they do not represent the influence of the work on other researchers, and therefore might distort citation rates (Asknes 2003; Glänzel et al. 2006).

In the present study, these issues of individual and institutional productivity were examined with reference to Italy, and specifically to the Forestry subject category. Italy is a suitable case study: since 2010, the Ministry of University and Research introduced new evaluation protocols to select candidates under the National Scientific Habilitation (ASN – Abilitazione Scientifica Nazionale) and University and Research Institute productivity is assessed under the Evaluation of Research Quality (VQR – Valutazione della Qualità della Ricerca). Both evaluations are based on bibliometric indicators, i.e. number of scientific papers, citations and h-index (MIUR 2012). The assessments are also used to determine fund allocations to Universities.

Citation databases are employed to calculate bibliometric indicators. Comparisons of existing citation databases have been performed to assess scientific productivity of authors or organizations using Thomson Reuters Web of Science (WOS), Elsevier SciVerse Scopus (SCOPUS), and Google Scholar (Chirici 2012; Abrizah et al. 2013; Bartol et al. 2014). Franchescet (2010) completed a detailed literature review and demonstrated a moderate to high correlation between h-indexes produced by WOS and SCOPUS. In Italy, the National Agency for the Evaluation of Italian Universities and Research Institutes (ANVUR, Agenzia Nazionale per la Valutazione del Sistema Universitario e della Ricerca) recommended calculating bibliometric indicators on the basis of either WOS or SCOPUS.

The aim of the present study was to conduct a quantitative assessment of the bibliometric productivity of the Italian forest research community for the 2002-2012 publication period. Specific objectives were targeted to: (i) assess the global aggregated bibliometric productivity of Italian forest scientists using SCOPUS data available from the SCImago Journal & Country Rank (SCImago) systems; (ii) compare aggregated bibliometric productivity of Italian forest scientists with the most productive countries in Forestry on a global level (USA, UK, China, Germany, and France) on the basis of GDS on R&D; (iii) show publication and citation temporal trends by Italian forest scientists; (iv) analyze international collaborations by Italian forest scientists; (v) investigate inequality of bibliometric productivity among Italian forest scientists; (vi) show main subject categories of publications by Italian forest

scientists; and (vii) compare productivity of Italian forest scientists at different career levels.

2. Materials and methods

2.1 Time frame and indicators

The 2002-2012 time period was analyzed, the same officially adopted by the Italian Ministry of University and Research for the last ASN evaluation.

The following bibliometric indicators were obtained from WOS and SCOPUS databases: i) number of publications (NP); ii) number of citations, including self-citations (NC) and without self-citations (NCws); and iii) h-index. NP is the number of scientific papers published by a given author; authorship sequence and journal ranking were not factored into the analysis. NC is the number of times papers written by an author were cited by other papers; the journal ranking where the citation was referenced was not considered; self-citations, defined as citations from papers authored or co-authored by the individual were either included or excluded. The last indicator was the well known Hirsch or h-index (Hirsch 2005). The h-index is defined by how many h of a researcher's publications have at least h citations each. The h-index requires the following: the total number of papers published by an author (NP) and the total citation number (here NC and NCws).

We also evaluated the following two additional bibliometric indicators useful in analyzing author efficiency: (i) mean citation number per paper, i.e. CPP (with self-citations) or CPPws (without self-citations); and (ii) age-weighted citation rate (AWCR), which enhances contributions from early stage researchers (Jin 2007; Fedderke 2013).

2.2 Global level analysis

Global comparisons of aggregated bibliometric productivity under the Forestry subject category were conducted on the basis of the SCImago database (SCImago 2007). For each year, NP, NCws, and AWCR were queried to determine the most productive countries of those included in the analysis, i.e. USA, France, Germany, China, UK, and Italy. The perfomance of a country was evaluated by calculating the GDS Index-NP as the ratio between GDS on R&D (GDS, in millions $USD); and NP and the GDS Index-NC as the ratio between GDS and NC. GDS was defined as the total expenditure (current and capital) on R&D conducted by all resident companies, research institutes, universities, and government laboratories in a country; it included R&D funded entities from abroad, but excluded domestic funds for R&D spent outside the domestic economy; this indicator was measured in millions USD and as a percentage of Gross Domestic Product (OECD 2015). The data on GDS were acquired from OECD (2015) as an mean over the 2002-2012 period.

The aggregated bibliometric productivity in Forestry of Western Europe was also compared with the USA and Italy based on NP, NC, and CPP. We integrated the definition adopted in SCIMAGO (SCImago, 2007) for Western Europe.

The international collaboration rate of a country was calculated as the percentage of publications whose affiliations of the authors include other countries on the total publications of the considered country.

2.3 Italian level analysis

An Italian forest scientist database including individuals with permanent positions was created from an official list of professors and researchers at Italian Universities and the Agricultural Research Council (CRA). The database included two different subject subcategories: forest management and silviculture (coded AGR05 for VQR and ASN), and wood technology and forest operations (coded AGR06 for VQR and ASN). As concerns the researchers at the National Research Council (CNR), who were not included in the list, we selected individuals officially affiliated with the Italian Society of Silviculture and Forest Ecology. The final database resulted in a total of 144 authors.

For each author, the following indicators were obtained: NP, NC, NCws, and h-index derived from WOS and SCOPUS, and h-index, excluding self-citations (NC), from SCOPUS only. We extracted author publications from 2002-2012 and citations attributed to those publications until the end of 2014. Differences in indicator means were tested for statistical significance using Wilcoxon's signed ranks test (Wilcoxon 1945). Statistical association among indicators derived from the two databases was calculated using the methodology of González-Pereira et al. (2010) and further developed by Chirici (2012).

We also analyzed NP, NC, and CPP temporal trends of the 144 authors during 2002-2012, the authors' international collaborations, and the specific subject categories where the papers were published. The international collaboration rate was calculated as the percentage of publications with international co-authors based on the total publication number (Morel et al. 2009). Co-author country affiliations were used to analyze the international co-authorship network (ICN) (Leydesdorff et al., 2014).

The Lorenz curve displays statistical distributions and the dimension of production unevenness or inequality. The approach was applied to conduct an in-depth investigation of differences between NP and NC among authors. The information in the Lorenz curve was also examined using the Gini coef-

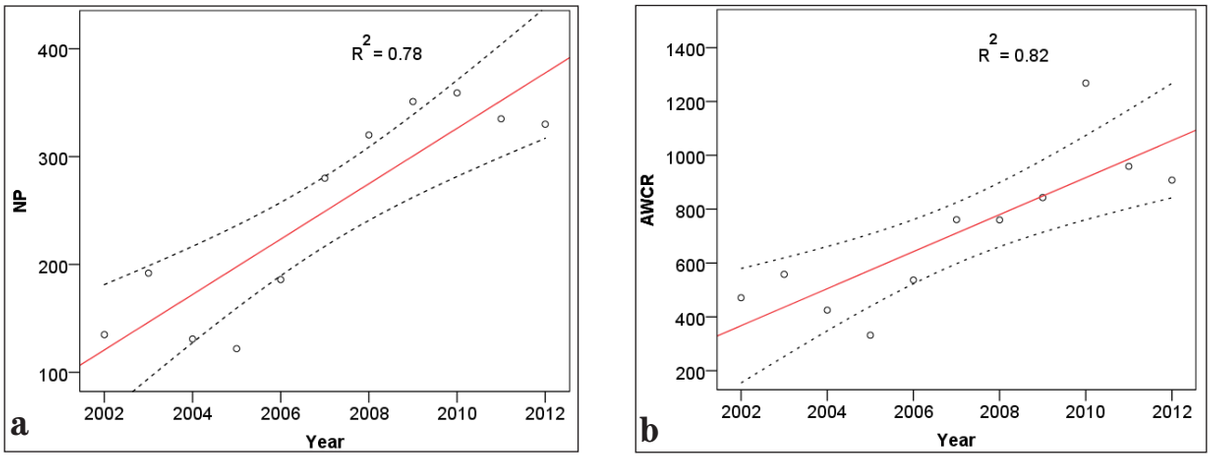

Figure 1 - Time trend of number of publications (a) and AWCR (age-weighted citation rate) (b) in Italy under the subject category Forestry in the period 2002-2012. Dotted lines are the 95% confidence interval of the linear regression. Data source: SCImago database.

ficient, a measure of statistical dispersion (Allison & Stewart 1974), similarly to Dundar and Lewis (1998) and Hagen (2015).

Self-citation relevance was analyzed to determine the rank position of individual authors in terms of citations and h-index. We chose the SCOPUS database and calculated Spearman's correlation coefficient (Spearman 1904) between each indicator determined with and without self-citations.

In Italy, scientists of Universities (UNI), the National Research Council (CNR), and the Agricultural Research Council (CRA) achieve three career levels: A-level (UNI: full professor; CNR: executive researcher; CRA: executive researcher); B-level (UNI: associate professor; CNR: first researcher; CRA: first researcher); C-level (UNI, CNR, CRA: researcher). Forest scientist productivity at different career levels (A-level, B-level, C-level) was analyzed using Wilcoxon signed-rank test; the mean, median, variance, maximum and minimum values, and standard deviation of each indicator were generated. We also compared CPP temporal trends per author per year among scientists at different career levels. The Gini coefficient was employed to quantify productivity inequality among authors at the same career level.

3. Results

3.1 Global results

Throughout 2002-2012, the cumulative bibliometric productivity of forest scientists at the global level was 0.60% of the total productivity of scientists for NP (118,561 vs. 20,117,441) and NC (1,503,622 vs. 249,752,677). The cumulative bibliometric productivity of Italian forest scientists (NP = 2824; NC = 49,214) was 0.013% NP and 0.015% NC in global bibliometric productivity and 2.3% NP and 2.6% NC in Forestry global bibliometric productivity. On a national level, the cumulative bibliometric productivity of Italian forest scientists was 0.44% of the total number of Italian scientific publications and 0.27% of the total citations received by Italian scientists.

Globally, the four scientific subject areas with the highest bibliometric productivity were Medicine (30% NP and 35% NC); Biochemistry, Genetics, and Molecular Biology (12% NP and 24% NC); and Engineering (19% NP and 9% NC). Agriculture and Biological Sciences, which include Forestry, represented 6.8% NP and 7.8% NC. The results from Italy were similar. The highest bibliometric productivity was represented by Medicine (35% NC and 41% NC); Biochemistry, Genetics, and Molecular Biology were consistent with global results (15% NP and 21% NC); and Engineering (15% NP and 9% NC). Results indicated Agriculture and Biological Sciences produced 6.6% of total NP and 6.9% of total NC in Italy.

In the Forestry subject category, the USA was the most productive country, with 32,032 total publications (35% of the total at the global level) and 71,808 citations (40% of the total), resulting in an h-index = 241. In 2012, Italy was ranked 9th based on its h-index (97); and 13th and 10th respectively from NP (2782), and NC and NCws (2722); and 8th from average citations per publication (CPP). While NP and AWCR increased from 2002-2012 (Fig. 1), Italy's h-index and NC rank remained stable over the examined period (Fig. 2).

On a global level, France, Germany, and the United Kingdom, which traditionally publish the largest number of European forestry papers, were respectively 2nd (142), 3rd (136), and 4th (133) in h-index results; and respectively 6th (5124), 4th (5931), and 5th (5280) in NP; and 5th (16015), 3rd (5732), and 2nd (17233) in NC, respectively.

The country demonstrating the highest improvement during the 2002-2012 period was the P.R. China, with results showing increased NP (from 7th position in 2002 to 2nd in 2006) and NC (from the 18th position in 2002 to 5th in 2012).

Among the countries examined, China had the

Figure 2 - Trend of number of publications (NP), number of citations with self-citations (NC) and without self-citations (NCws), mean citations per publication (CPP) and h-index of Italian authors under the subject category Forestry in the period 2002-2012. Bold numbers mark the position of Italy in the annual international ranking. Data source: SCImago database.

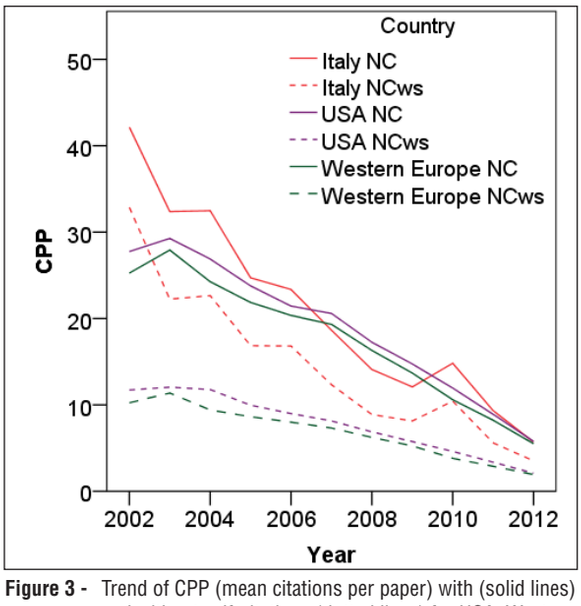

Figure 3 - Trend of CPP (mean citations per paper) with (solid lines) and without self-citations (dotted lines) for USA, Western Europe and Italy under the subject category Forestry. Data source: SCImago.

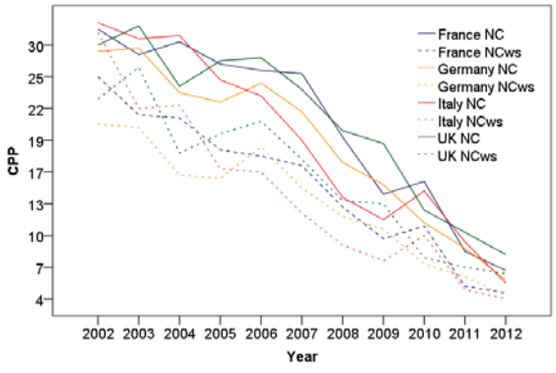

Figure 4 - Trend of CPP (mean citations per paper), with (solid lines) and without (dotted lines) self-citations, as concerns scientific papers from France, UK, Germany and Italy under the subject category Forestry.

lowest pro-capita GDS (106 USD), followed by Italy (392 USD) (Table 1). The UK was the most efficient in terms of total expenditure per article and per citation, followed by Italy. On average, Italy spent 32% less than China, 17% less than the USA, 23% less than Germany, 5% less than France, and 9% more than the UK to publish a paper. Italy spent 72% less than China, 22% less than Germany, 15% less than the USA, the same as France, and 13% more than the UK to generate a citation.

From 2002-2006 and 2010-2012, Italy demonstrated higher CPP values than the USA and Western Europe. Furthermore, Italy showed higher CPPws values than the USA and Western Europe over the entire period (2002-2012) (Fig. 3).

Italy's CCP was comparable to the three European countries with the most productive h-indices (France, UK, Germany). Italy ranked first in 2002 and 2004 and second in 2010 and 2011 (Fig. 4).

Italy demonstrated active international collaboration, evidenced by at least one co-author from a different country, always for at least 42% of the papers (minimum value in 2008) and the highest result was observed in 2002 with 64% of the papers (Fig. 5). Italy was more active than the USA with its international co-authorship.

Table 1 - Comparison of the efficiency of bibliometric productivity with respect to the gross domestic spending on research and experimental development (GDS). Data source: GDS: OECD (2015); NP and NC: SCImago.

	OECD data			Productivity		Productivity in Forestry				GDS Indices in Forestry	
Country	GDS (Million USD)	Population (Millions)	GDS pro capita (USD)	Total number of publications	Total number of citations	Number of publications (NP)	Number of citations (NC)	% of total number of publications	% of total number of citations	GDS Index-NP (Million USD per publication)	GDS Index-NC (Million USD per citation)
United Kingdom	36632	63.70	575	1526627	44011201	5344	102236	0.35	0.23	6.86	0.36
France	48185	65.63	734	984010	24700140	5248	103566	0.53	0.42	9.18	0.47
United States	381343	314.11	1214	5494335	177434935	32452	594488	0.59	0.34	11.75	0.64
Germany	80159	80.42	997	1141980	35721869	5977	107474	0.52	0.30	13.41	0.75
Italy	23316	59.53	392	648963	18019464	2824	49214	0.46	0.27	8.26	0.47
PR China	143672	1350.69	106	2482078	19110353	8882	48494	0.36	0.25	16.18	2.96

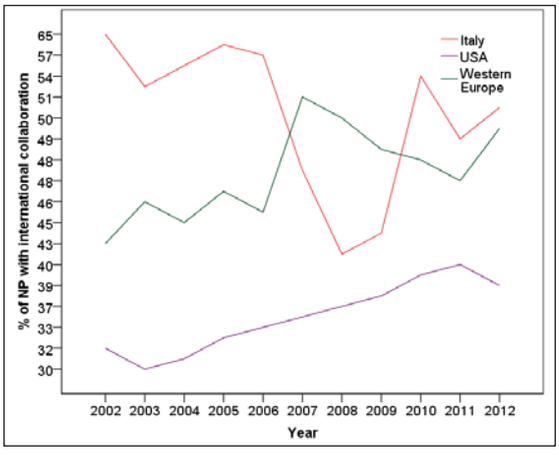

Figure 5 - Trend of the percentage of papers with international coauthorship under the subject category Forestry as concerns USA, Western Europe and Italy. Data source: SCImago

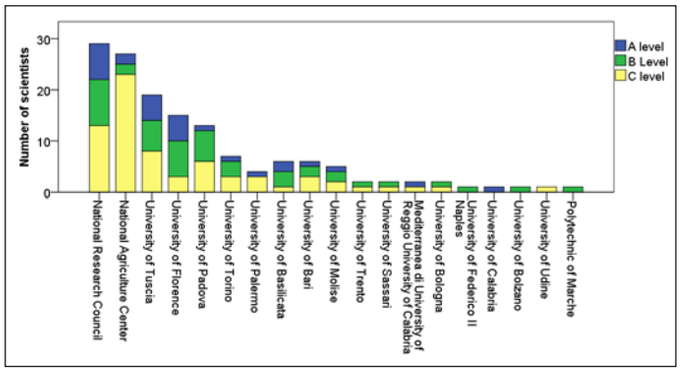

Figure 6 - Number of Italian forest scientists with a permanent position in the period 2002-2012, reported by Institution (National Research Council – CNR, Agricultural Research Council – CRA, and several universities - UNI) and career level.

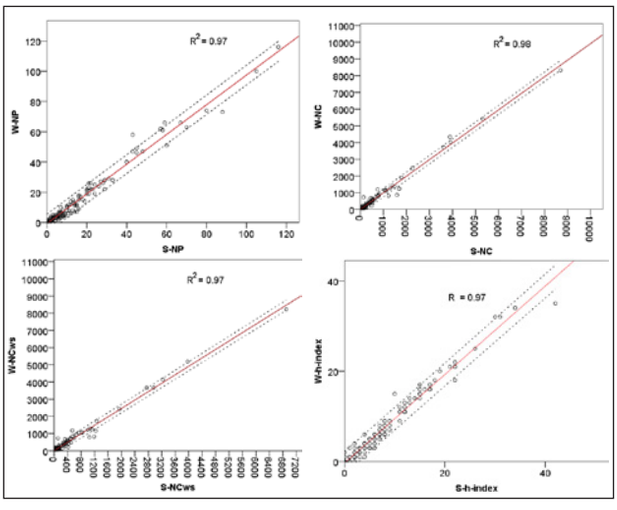

Figure 7 - Linear regressions between the WOS and SCOPUS values concerning: (a) NP - number of publications; (b) NC - number of citations with self-citations; (c) NCws - number of citations without self-citations; (d) h-index. Dotted lines are the 95% confidence interval of the linear regression. Data source: SCOPUS and WOS.

3.2 Italian forest scientist results

One hundred forty-four Italian forest scientists with permanent positions at 19 Italian research institutions (17 Universities [UNI]; the National Research Council [NRC]; and the Agricultural Research Council [CRA]) were analyzed. The forest scientists were classified as 28 A-level scientists, 46 B-level scientists, and 70 C-level scientists (Fig. 6).

NP per author ranged from 0 to 116 using both databases (WOS and SCOPUS) (Table 2). WOS results indicated NC per author was between 0 and 8323 (8227 excluding self-citations) and SCOPUS queries resulted in 0 to 8697 NP (6903 excluding self-citations). The h-index ranged between 0 and 42 using SCOPUS and 0 and 35 using WOS.

The Wilcoxon signed ranks test found no significant differences among mean values for the three indicators following WOS and SCOPUS bibliometric queries (NP: Z = 0.274, P = 0.073; NC: Z = 0.323, P = 0.342; NCws: Z = 0.267, P = 0.0789; h-index: Z = 0.765, P = 0.393). Correlation analyses showed strong atatistical association (P < 0.001) between WOS and SCOPUS for all the three indicators: R = 0.98 for NP; R = 0.99 for NC and NCws; R = 0.98 for h-index (see also Fig. 7). These results confirm that SCOPUS and WOS produce comparable and closely related bibliometric data.

The notable differences between mean and median values for NP and NC (Table 2) were due to variability in productivity among scientists. The Gini coefficient for NP (Gini = 0.84 SCOPUS; Gini = 0.85 WOS) and NC (Gini = 0.81 SCOPUS; Gini = 0.80 WOS) provided support for these observations. Among Italian forest scientists, we found the absence of publications for 9.1% of them in WOS and

Table 2 - Bibliometric indicators of Italian forest scientists over the period 2002-2012. Values refer to individual scientists. Data source: SCOPUS and WOS.

	Number of publications		Number of citations		Number of citations without self-citations		h-index		h-index without self-citations
	SCOPUS	WOS	SCOPUS	WOS	SCOPUS	WOS	SCOPUS	WOS	SCOPUS
Average	15	14	421	423	320	402	7	7	6
Maximum	116	116	8697	8323	6903	8227	42	35	37
Median	8	6	75	70	52	61	5	4	4
Minimum	0	0	0	0	0	0	0	0	0
Standard Deviation	20	20	1040	1039	813	1005	7	7	6

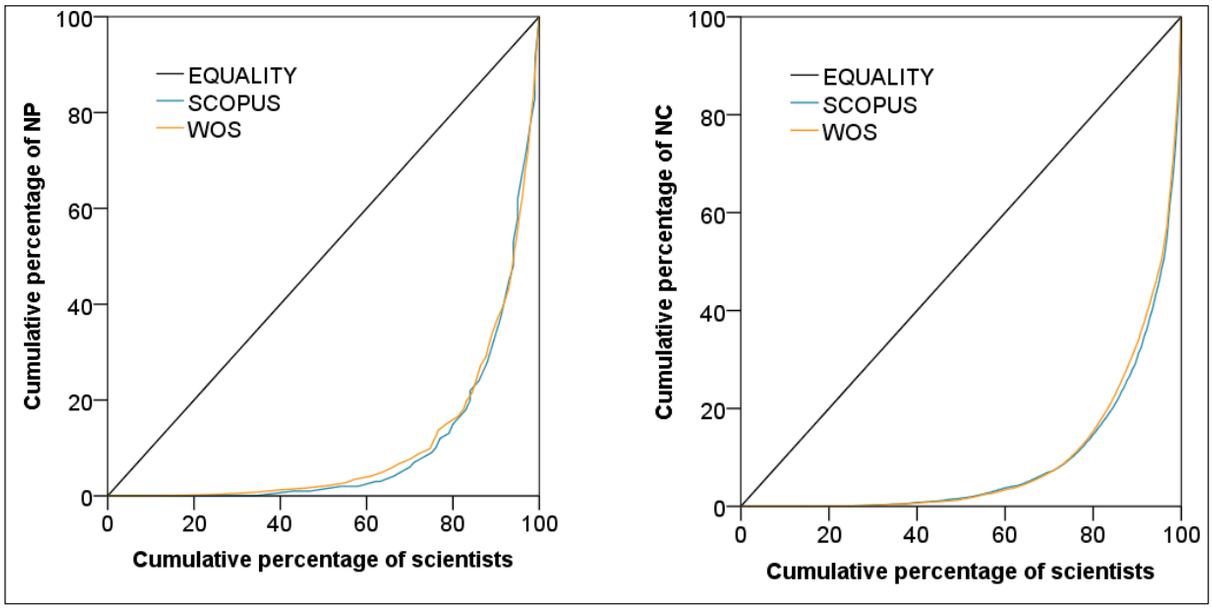

Figure 8 - The Lorenz line plots the cumulative percentage of authors vs. (a) the cumulative percentage of number of publications (NP) and (b) the cumulative percentage of number of citations. The Gini coefficient represents the area between the equality line (dotted) and the Lorenz curves: the larger the area, the higher the inequality indicator.

Table 3 - Classification by subject areas of the publications by the Italian forest scientists in the period 2002-2012. Data source: SCOPUS.

Subject Area	Number of publications
Agricultural and Biological Sciences	995
Environmental Science	619
Biochemistry Genetics and Molecular Biology	234
Earth and Planetary Sciences	231
Social Sciences	64
Medicine	61
Engineering	53
Mathematics	34
Materials Science	30
Immunology and Microbiology	27
Energy	26
Physics and Astronomy	25
Pharmacology Toxicology and Pharmaceutics	22
Chemistry	19
Computer Science	17
Arts and Humanities	16
Multidisciplinary	14
Business Management and Accounting	13
Chemical Engineering	11
Economics Econometrics and Finance	11
Decision Sciences	7
Neuroscience	3
Veterinary	2
Health Professions	1

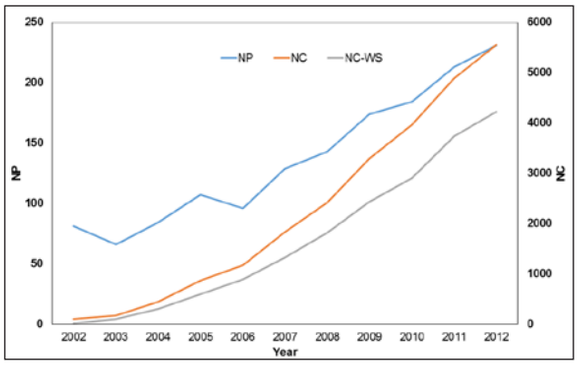

Figure 9 - Trend of number of publications (NP), number of citations with self-citations (NC) and number of citations without self-citations (NCws) of the Italian forest scientists. Data source: SCOPUS.

SCOPUS, while 35% of them represented over 90% of the total NP and NC (Fig. 8).

Following analysis of SCOPUS data over the 2002-2012 period, papers published by the Italian scientists totaled 1508, with 38723 citations (29318 NCws) and h-index = 91 (h-index ws = 80). The papers were classified under a wide range of subject areas in SCOPUS and some were classified in more than one subject area. Agricultural and Biological Science (66%) was the most common subject area, which include the subject category Forestry. However, a large number of publications were also included in Environmental Science (41%), Biochemistry, Genetics, and Molecular Biology (15%), Earth and Planetary Science (15%), and other subject areas (20%) (Table 3).

The annual figures for total NP, NC, and NCws for the Italian forest scientists strongly increased from 2002-2012. In terms of publications, 81 were found in 2002 and 231 in 2012 (Fig. 9).

More than 42% of the publications had one or more international co-authors. The level of international collaboration remained stable over the considered time period (Fig. 10).

INC, calculated on the basis of SCOPUS data in the period 2002-2012, reported Italian forest scientists co-authored publications with 64 different countries, including the USA (co-authorship number = 459), France (380), Germany (236), and the UK (182) (Fig.11). Interestingly, these countries are those with the highest h-indices in Forestry during the analyzed time period.

Author rank was not influenced by self-citations; in fact, author position with and without self-citation

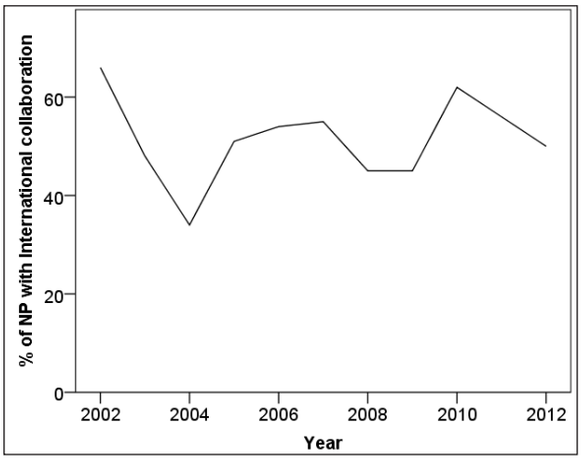

Figure10 - Temporal trend of percentage of papers written by Italian forest scientists in collaboration with foreign scientists. Data source: SCOPUS.

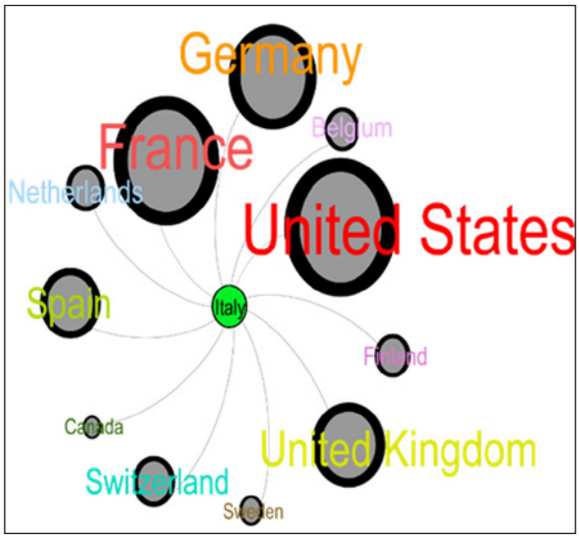

Figure 11 - International collaboration network showing the top 11 countries linked with Italy under the Forestry subject category. The circle size is proportional to the number of collaborative papers.

showed a high linear relationship based on NC and h-index (Fig. 12).

The comparison of scientists at different career levels (A, B, C) showed that A-level scientists exhibited higher mean values than B- and C-levels for NP, NC, and h-index (Table 4). However, A-level authors showed the highest variability relative to the other two groups for all three indicators. In fact, within the A-level group, 70% of the total NP were authored by only 20% of the A-group scientists (Gini SCOPUS = 0.62; Gini WOS = 0.63), 10% of the A-group had not published any paper (NP = 0), and 90% of the total NC, including NCws (Gini SCOPUS and WOS=0.79), were represented by 10% of the authors.

Results showed 40% of the B-level group authors published 80% of the total NP (Gini SCOPUS = 0.53; Gini WOS = 0.57); and 4% of authors did not have any publications (NP = 0). Eighty percent of NC was attributed to 20% of the B-level scientists (Gini SCOPUS = 0.72; Gini WOS = 0.74). Analysis results indicated 90% of the C-level group publications were authored by 40% of the scientists (Gini SCOPUS = 0.57; Gini WOS = 0.61), publications were not detected in the databases for 13% of the authors (NP = 0), and 80% of NC were attributed to 80% of C-level authors (Gini SCOPUS = 0.77; Gini WOS=0.78).

Analyzing the mean CPP per author, we found C-level scientists exhibited the lowest values during the 2002-2012 analysis period (Fig. 13).

Discussion and conclusions

At the global level, the Forestry subject category represented 0.6% of the total number of scientific publications and citations, and in Italy the subject category was detected in 0.4% of NP and 0.3% of NC. Italy published fewer scientific papers in Forestry compared with the USA, China, France, Germany and UK, which were the most productive countries in terms of NP during the analysis period (2002-2012). However, if the economic investments in research (on the basis of GDS in R&D) are considered, then Italy becomes the most productive country following UK. These results are consistent with global research efficiency analysis conducted by the Royal Society of UK (2011), reported by Nature (2013). China and the USA, the most productive countries per NP were last in terms of CPP (mean citation per paper), emphasizing these two countries produce a high number of publications with fewer citations compared to Italy, UK, France, and Germany. Based on aggregated bibliometric productivity under the Forestry subject category, results showed Western Europe exceeded the USA in terms of NP. Comparable results are reported for other scientific fields, including Parasitology (Falagas et al. 2006) and Microbiology (Vergidis et al. 2005).

Overall, our study identified the following essential bibliographic results to assess scientific performance of forest scientists in Italy.

(i) Bibliometric indicators (number of publications; number of citations; h-index) shows a strong relationship between WOS and SCOPUS, suggesting the two databases have the same potential to evaluate the Italian forestry research community.

(ii) Self-citations do not significantly affect author rank under the Forestry subject category, therefore evaluation of individual productivity can be conducted using indicators with or without self-citations.

(iii) Bibliometric productivity under the Forestry subject category in Italy increased rapidly over the evaluated time period. This trend was also observed for other subject categories in Italy (Aspen Report 2012; Dario & Moed 2011).

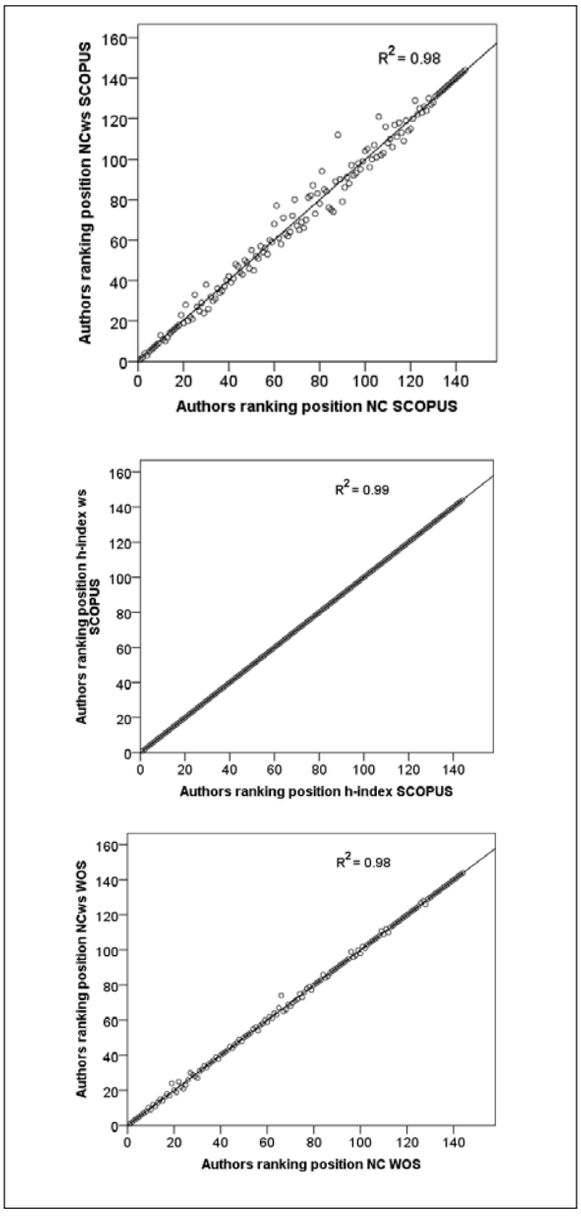

Figure 12 - Correlation between the ranks of Italian forest scientists calculated with and without self-citations: (a) SCOPUS citations, (b) WOS citations, (c) SCOPUS h-index.

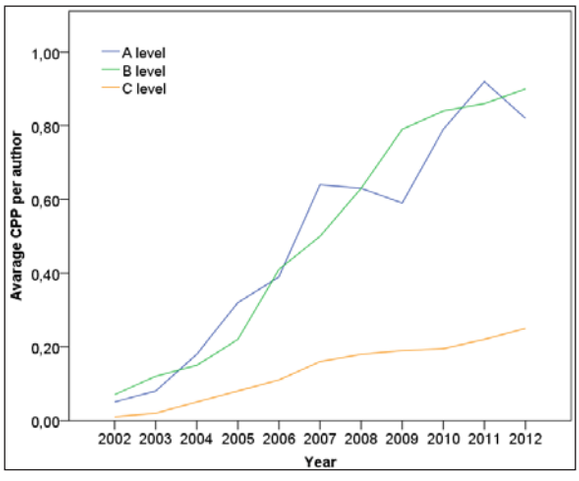

Figure 13 - Trend of mean CPP (NC/NP) of the Italian forest scientists by career level.

(iv) The productivity of Italian forest scientists is not equitable; a small number of active researchers produces the largest number of scientific publications, while a small number of forest scientists are inactive (with no publications registered on WOS or SCOPUS during the 2002-2012 period). This variability is even higher for scientists at top career levels (A-level). These results are consistent with Paulina and Francesconi (2007) for other subject categories in Agricultural and Biological Sciences in Italy.

(v) A high number of publications by the Italian forest research community (50% of the total) is written in collaboration with one or more foreign scientists. This result reflects the global internationalization trend of Italian research emphasized by Glänzel and Schlemmer (2007). Elsevier (2013) reported on a global level the rate of co-authorship among different countries increased from 14% in 2003 to 17% in 2011. The countries exhibiting more co-authorship with the Italian forest

Table 4 - Bibliometric indicators of the Italian forest scientists by career level. Means are calculated per author.

Career level		Number of publications		Number of citations		Number of citations without self-citations		h-index		h-index without self-citations
		SCOPUS	WOS	SCOPUS	WOS	SCOPUS	WOS	SCOPUS	WOS	SCOPUS
A	Average	24	23	891	900	698	864	10	10	9
	Maximum	116	116	8697	8323	6903	8227	42	35	37
	Median	7	7	55	80	38	75	6	5	5
	Minimum	0	0	0	0	0	0	0	0	0
	Standard Deviation	32	32	1848	1822	1468	1771	11	11	9
B	Average	17	16	423	408	322	387	8	7	7
	Maximum	80	74	3620	3709	2749	3665	22	22	19
	Median	11	8	109	95	81	92	7	5	6
	Minimum	0	0	0	0	0	0	0	0	0
	Standard Deviation	18	18	707	711	548	689	6	6	5
C	Average	11	10	232	242	169	228	6	5	5
	Maximum	67	66	5317	5410	3966	5190	31	32	28
	Median	7	5	58	48	39	46	4	3	3
	Minimum	0	0	0	0	0	0	0	0	0
	Standard Deviation	14	14	675	695	501	662	6	6	5

research community (USA, France, Germany, UK) are also the most productive on a global level under the Forestry subject category.

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