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Citation pattern and lifespan: a comparison of discipline, institution, and individual

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Abstract Citation frequency is often used in hiring and tenure decisions as an indicator of the quality of a researcher's publications. In this paper, we examine the influence of discipline, institution, journal impact factor, length of article, number of authors, seniority of author, and gender on citation rate of top-cited papers for academic faculty in geography and forestry departments. Self-citation practices and patterns of citation frequency across post-publication lifespan were also examined. Citation rates of the most-highly cited paper for all tenured forestry ($N = 122$) and geography ($N = 91$) faculty at Auburn University, Michigan State University, Northern Arizona University, Oklahoma State University, Pennsylvania State University, Texas A&M University, University of Florida, University of Massachusetts, University of Washington, and Virginia Tech were compared. Foresters received significantly more citations than geographers ($t = 2.46$, $P = 0.02$) and more senior authors received more citations than junior researchers ($r^2 = 0.14$, $P = 0.03$). Articles published in journals with higher impact factors also received more citations ($r^2 = 0.28$, $P = 0.00$). The median self-citation rate was 10% and there was no temporal pattern to the frequency of citations received by an individual article ($x^2 = 176$). Our results stress the importance of only comparing citation rates within a given discipline and confirm the importance of author-seniority and journal rankings as factors that influence citation rate of a given article.

Keywords Citation biases · Author seniority · Co-authorship · Article length · Citation rates

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Introduction

Journal articles have been called the currency of science (Figà-Talamanca 2007) and researchers use publications to ensure the inclusion of their own work into the ever growing body of scientific knowledge (Aksnes 2003). New research is only successfully incorporated into our collective knowledge if other scientists read and more importantly cite the journal articles. The importance of citation rates of individual papers has been recognized since the early 1900s (Bornmann and Daniel 2008); however, the connection between citation rate and scientific merit remains highly debated (MacRoberts and MacRoberts 1989; Seglen 1991). Debate focuses on whether a paper becomes highly cited because of its scientific merit or because of documented biases such as author's seniority, gender, institutional affiliation, practice of self-citation, collaboration habits, and choice of publication outlet (Anderson et al. 1978; Bonzi and Snyder 1991; Borrego et al. 2010). These biases represent a hazard in relying solely on citation counts as an indicator of scientists' importance in their fields, yet citations are used regularly in hiring and promotion decisions (Dries et al. 2008).

The seniority of researchers, as defined by their professional age (the number of years since dissertation), has been shown to have mixed effects on citation rates. Within the discipline of dendrochronology, senior researchers were cited more frequently than their junior colleagues (Copenheaver et al. 2010). In information science, the majority of highly cited articles (those cited 40 or more times) were published 10–20 years after the researchers completed their doctorate (Ding and Cronin 2011). In psychology, citation rates did not correlate with chronological age or professional age of researchers (Over 1988). This relationship appears to vary across disciplines.

Gender bias in citation rates has been observed in several scientific disciplines. In many disciplines, papers published by females are cited more often than those by males (Long 1992; Symonds et al. 2006; Borrego et al. 2010). Female researchers tend to publish fewer papers of higher quality (more highly cited) than their male counterparts (Long 1992). In male-dominated disciplines, papers authored by male researchers are cited more frequently than papers authored by females; possibly because female researchers experience more difficultly becoming fully integrated into the male-dominated research network (Stack 2002; Penas and Willett 2006). The third documented pattern is a lack of difference in citation rates between publications authored by males and females (Lewison 2001; Ledin et al. 2007; Copenheaver et al. 2010). This seems to be particularly common in fields where co-authorship frequently includes both sexes (Copenheaver et al. 2010).

The journal in which an article is published may also affect its citation rate. Regardless of an article's scholarly merit, the extreme specialization of a journal may limit an article's exposure and result in a low-citation frequency (Van Dalen and Henkens 2001). The introduction of impact factors for journals, lends *high-ranked* journals to be perceived as *high-quality* journals and thus causes articles published in them to be cited more often than articles in lower-ranked journals (Larivière and Gingras 2010). However, publishing in a highly ranked journal does not guarantee that an article will be highly cited because there is a high article-to-article variation in citation rates. Two different studies found that 10–15% of the papers published in a given journal account for 50% of the citations received by that journal (Chew and Relyea-Chew 1988; Seglen 1994); therefore, it is important to remember that journal ranks identify the average citations received by all articles and this average has a high variance.

Numerous other factors affect the citation rate of a scholarly article. Bornmann and Daniel (2008) identify time since publication, discipline, number of authors, length of

article, and language of publication all as factors that influence citation rate. In general, papers written in English and/or by a greater number of authors receive more citations (Leimu and Koricheva 2005). Whether an article is freely available on the internet can increase the citation rate of a paper (Chen et al. 2009). Within academia, the ranking of an author's affiliated organization can influence citation frequency. Faculty who work for highly ranked universities typically receive more citations than authors from lower-ranked universities (Anderson et al. 1978; Leimu and Koricheva 2005; Lee et al. 2010). The number of researchers within a discipline also has a strong influence on citation rates with large fields, like medicine, having higher citation rates than small disciplines, such as agricultural economics (Castellano and Radicchi 2009).

Given the variety of factors that influence citation rates, the objectives of this study were to (1) identify the influence of discipline, institution, journal impact factor, length of article, number of authors, seniority of author, and gender on citation rate of top-cited papers for faculty in geography and forestry departments across ten major public universities in the United States; (2) within this same population compare self-citation practices and (3) compare the patterns of citation frequency that a paper received over its post-publication lifespan. Our goal is to provide administrators and faculty members in positions of promotion decisions with a quantifiable basis for understanding the biases in citation that exist within these two disciplines.

Methods

Data source

We selected ten, public universities with forestry and geography programs from across the United States: Auburn University (Alabama), Oklahoma State University, Michigan State University, Northern Arizona University, Pennsylvania State University, Texas A&M University, University of Florida, University of Massachusetts, University of Washington, and Virginia Tech. The ten universities we selected provide representation from the major forested regions in the United States—presence of forest was a limiting factor for university selection because although geography programs are widely distributed, forestry programs are limited to states where forests dominate the landscape. Within the ten universities, we identified all forestry and geography faculty at the Associate Professor and Professor rank. At some universities, discrete forestry or geography departments did not exist. For example the Department of Geosciences at the University of Massachusetts houses faculty from geology, geography, and earth systems. In these situations, we identified faculty who represented themselves as foresters or geographers through their web pages and research areas. This yielded a total of 122 forestry faculty members and 91 geography faculty members. Assistant Professors were excluded from the analysis because their publication history was shorter than faculty at senior ranks.

For each faculty member ($N = 223$), we used Web of Science (copyright by the Institute for Scientific Information of Thomson Reuters) to identify the single first-authored publication for each faculty member that had received the highest number of citations. This publication, although not a full representation of a faculty member's scholarship, represents the single scholarly output that has received the highest recognition (number of citations) by others. Working with first-authored publications eliminated the risk of a single paper being identified for two different faculty members. Additionally, in forestry and geography first authorship identifies the individual who has made the largest intellectual

contribution, and therefore, first-authorship indicates primary scholarly ownership of the ideas and results presented in the publication. For each of the publications, the length (number of pages), number of authors, year of publication, journal impact factor, and number of citations (both self-citations and from other authors) were recorded by year from publication until 2010. Although several publications received citations for 2011, we only recorded up to the year 2010 so that there would not be a temporal bias in terms of when we examined a particular paper (citation data collection spanned a 3 month period). Gender and year of doctorate completion, were identified for each author through their faculty web pages and the World Cat Dissertations Database (part of the Online Computer Library Center, Inc.).

Data analysis

For the test of differences in citation rate by discipline (forestry vs. geography) and gender (male vs. female), we were concerned that there may be a lack of homogeneous variance within our dataset and therefore, tested for equal variance between both groups with an F-test. The error variance was not constant within discipline ($F = 4.72$, $P = 0.00$) or gender ($F = 1.59$, $P = 0.04$). Therefore, we used the Welch's t-test for samples with unequal variance. We used Levene's test for homogeneity of variance to compare the variances across institutions ($N = 10$) and found variance was constant ($F = 1.37$, $P = 0.21$). Then we used analysis of variance to compare the mean citations across institutions. To compare differences in citation rate in relation to time since doctorate earned, number of authors, number of pages, and impact factor of journal we calculated a Pearson's correlation coefficient between these variables and the number of citations. To characterize self-citation rate across time and individuals, we calculated mean (number of self citations/total number of citations), median, maximum, and minimum for all faculty members in the study. To characterize citation patterns through time, we plotted the number of citations a paper received every year since it was published and visually compared the different patterns. On a subset of our oldest papers ($N = 55$), we used a chi-squared test to compare whether a paper received an equal number of citations across 2 year classes. We were limited to working with 2 year classes because the test requires a minimum of an expected value of five for each class.

Results

There was a significant difference ($t = 2.46$, $P = 0.02$) between the mean citations received for papers published by foresters ($\overline{x} = 62.31$) compared to geographers ($\overline{x} = 40.23$, Table 1). However, no significant difference was observed ($t = 0.23$, $P = 0.82$) between mean number of citations received by males ($\overline{x} = 52.22$) compared to females ($\overline{x} = 55.41$). Although the mean number of citations varied from 11.87 (Oklahoma State University) to 76.61 (University of Washington), there was no significant difference among the citations received by different institutions ($F = 1.59$, $P = 0.12$). Although somewhat low, there were significant, positive correlations between number of citations earned and time since doctorate ($r^2 = 0.14$, $P = 0.03$), impact factor of the journal ($r^2 = 0.28$, $P = 0.00$), and publication length ($r^2 = 0.19$, $P = 0.01$, Fig. 1). In the analysis of publication length, it appeared that a single paper, which received 524 citations and was 75 pages in length, may have unduly influenced the correlation between publication length and citations (Fig. 1b); therefore, we removed this single data point and with this

Table 1 Mean number of citations per paper and sample size by discipline, gender, and institution

Item	Mean	Number of samples
Discipline*		
Forestry	61.31	122
Geography	40.23	91
Gender^{NS}		
Female	55.41	44
Male	52.22	169
Institution^{NS}		
University of Washington	76.61	38
Michigan State University	66.88	16
Northern Arizona University	64.71	14
Pennsylvania State University	64.30	27
University of Massachusetts	62.82	17
University of Florida	54.14	25
Virginia Tech	41.67	18
Auburn University	40.55	20
Texas A&M University	37.52	23
Oklahoma State University	11.87	15

* indicates significant difference in this category at $P > 0.05$ and NS indicates no significant difference existed within a category

new data set there was no longer a significant correlation between publication length and number of citations ($r^2 = -0.05$, $P = 0.48$). There was not a significant correlation between number of authors and citations ($r^2 = 0.09$, $P = 0.17$). The mean self-citation rate was 14% with a range from 0 to 100%. The median self-citation rate was 10% (Fig. 2). Within the 2 year age classes that we tested, there was a uniform distribution of citations throughout the lifespan of a publication ($df = 10$, $\chi^2 = 176.28$). Thus, indicating a lack of statistical variation in the frequency of citations received along a gradient in time since published. However, there are some visual patterns that commonly appeared in the dataset, but perhaps cancel each other out when the dataset is examined as a whole (Fig. 3). Several publications demonstrated a normal distribution of citations with few citations at the beginning and end of the paper's lifespan (Fig. 3a, e). Some publications showed a decrease in citations with time (Fig. 3b) and others an increase (Fig. 3d). The final pattern observed was a bi-modal distribution with two peak periods of citations separated by a period of fewer citations (Fig. 3f).

Discussion

Author's influence on citation rate

With regards to the gender of an author, both positive and negative biases in citation rates of scholarly papers have been documented across a variety of disciplines (Long 1992; Penas and Willett 2006). One cause of a negative gender bias is that researchers cite women's papers at a lower rate than men's papers because their work is perceived to have less value than male-authored research (Hutson 2002; Hakanson 2005). Alternatively, one of the main causes attributed to positive gender bias is that women publish higher-quality papers, which results in higher citation rates (Long 1992). In geography and forestry, we

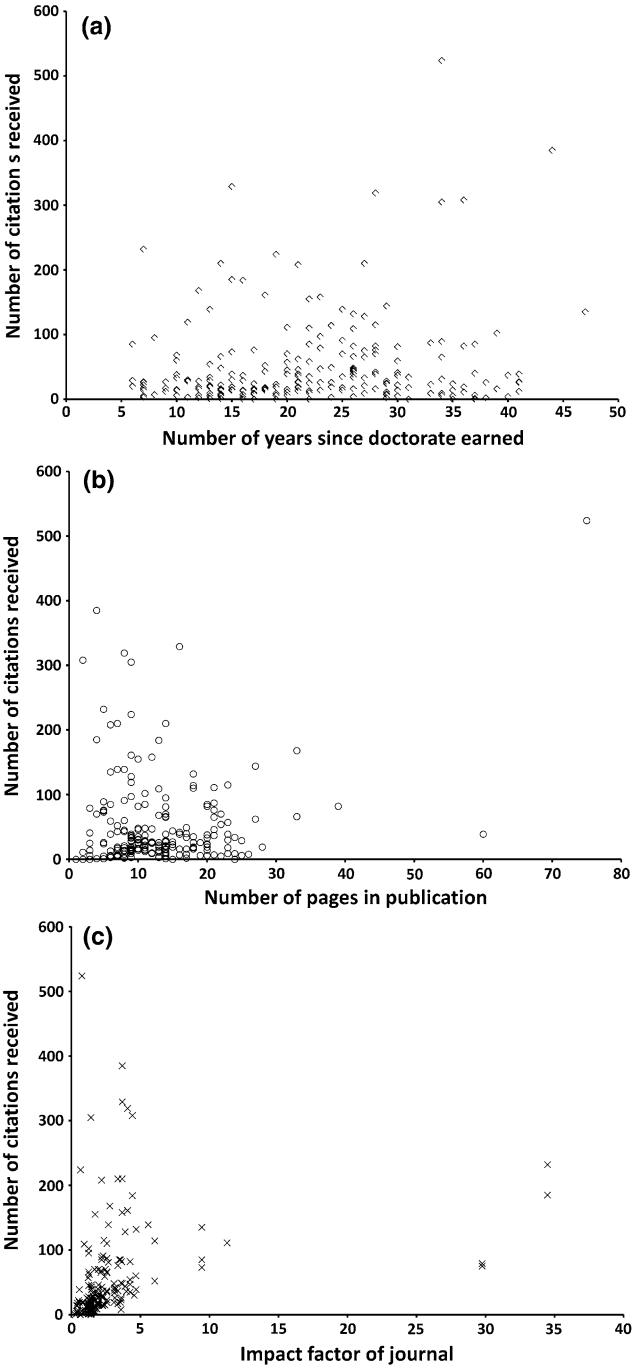

Fig. 1 **a** Number of citations by number of years since doctorate completed; **b** number of citations by publication length; **c** number of citations by journal impact factor

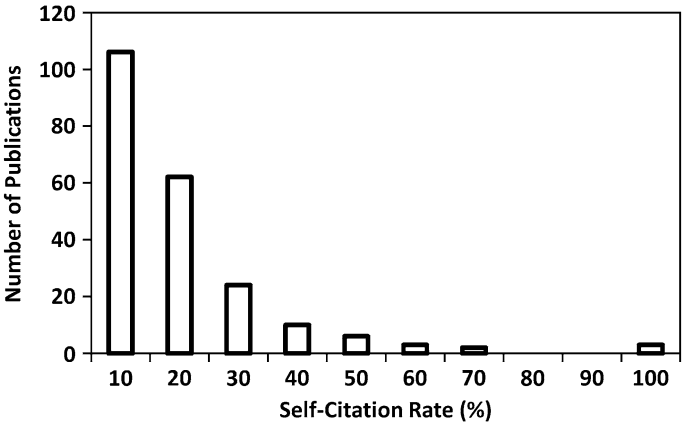

Fig. 2 Self-citation rate for 213 papers authored by foresters and geographers

found no existence of gender bias in citation rates (Table 1), a pattern that has also been identified in other science and social science disciplines (Lewison 2001; Penas and Willett 2006; Ledin et al. 2007). This has been explained by frequent co-authorship among male and female authors, improved equality between the male and female researchers in the workplace, and because the authorship gender may not be known or considered when citing other's research (Xie and Shauman 1998; Copenheaver et al. 2010).

Geographers had significantly lower citation rates than foresters (Table 1). One explanation for this difference could be that geographers, particularly cultural geographers, are more likely to communicate their research through books rather than journal articles and this form of communication would not be identifiable through Web of Science. Another reason could be that geography journals tend to have lower impact factors which leads to a smaller audience and fewer citations (Quiring 2007; Sarmiento and Butler 2011). Our results would indicate that geographers receive less recognition for their scholarship than foresters; however, we would caution against direct comparison across disciplines because of the variation in type of publishing outlets, size of the field, and degree of specialization in publishing (Larivière and Gingras 2010).

An author's institutional affiliation had no significant influence on citation rate (Table 1). This result differs from previous work that has shown researchers from higher-ranked institutions receive more citations(Anderson et al. 1978; Leimu and Koricheva 2005). Bias due to a researcher's university can occur for several reasons, but one documented one is that larger universities provide greater opportunities for scientists to collaborate and work on similar topics and co-authorship can lead to higher citation rates (Zucker and Darby 1996). Additionally some scientists will cite work from top-ranked institutions because they believe it will make their argument more convincing because higher-ranked universities are perceived to generate higher-quality science (Leimu and Koricheva 2005). However, institution-ranking systems often have their own biases, tending to favor larger universities and colleges over smaller institutions (Vieira and Gomes 2010). Our study used universities that were all major land-grant universities, while, other studies have included a wider range of institution sizes. This may explain why institution did not influence citation rate in our study because of the relative uniformity in institution.

Authors who have been working in a discipline longer receive more citations than those who are new to the discipline (Fig. 1; Copenheaver et al. 2010). Although Over (1988)

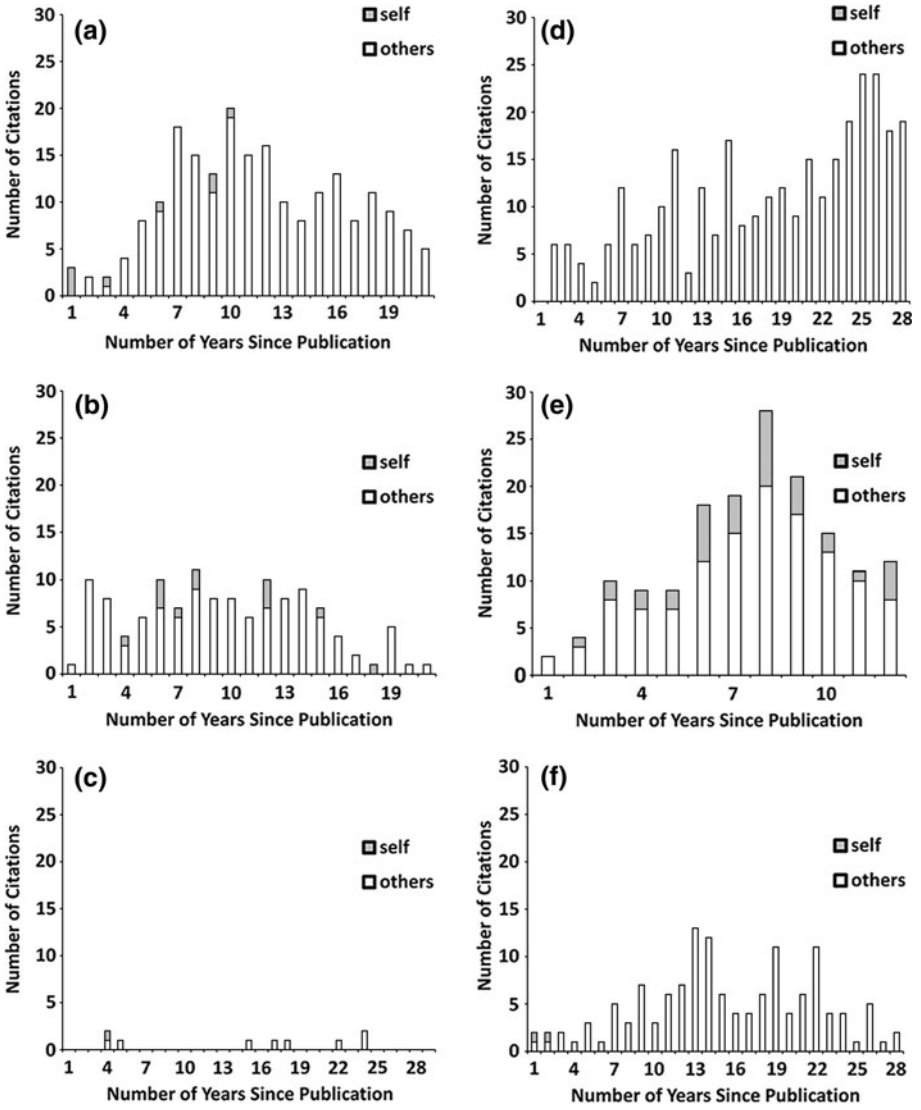

Fig. 3 Number of total citations (self and other) since year of publication

found that junior scientists had greater research productivity, he also found that previous publication rate was a better predictor than age of the number of citations received for a given paper. Therefore, a scientist who was producing high-quality work early in their career would continue to do so. The scientific reward system states that new scientists are under a great deal of pressure to produce publishable work in order to succeed in the field (Cole 1979). Scientists who are unable to produce high-quality work are generally removed from the profession, leaving a cohort of senior scientists who all have the proven ability to produce high-quality work. It is not actually age that determines citation rate, but rather that senior scientists are a smaller population that produces higher quality publications than the larger population of junior scientists who have a higher variability in the quality of their work.

Influence of the article on citation rate

Positive correlations have been found between the number of authors and the citation rate for journal papers (Leimu and Koricheva 2005). This relationship has been explained by an article's connection to the broader professional network of many authors instead of the smaller network of a single author. Co-authorship may also result in papers that cross more disciplines and thus are cited across more research areas. Additionally, there are higher levels of self-citation associated with co-authored articles (Leimu and Koricheva 2005; Padial et al. 2010). However, among foresters and geographers, we found no significant relationship between the number of authors and the citation rate. Perhaps when foresters and geographers selecting articles to cite, quality of the article outweighs networking and this reduces the benefits of co-authorship to citation rater (Bonzi and Snyder 1991; Bridgstock 1991).

Article length may be indicative of quality because only those articles perceived to be of higher quality by the editor will be allocated a greater number of pages in journals (Leimu and Koricheva 2005). Bornmann and Daniel (2008) suggest that longer publications, as measured by number of pages, are cited more often because they have more content that may be cited. Longer articles also tend to be more visible, particularly in hardcopy journals, making them more likely to be cited (Leimu and Koricheva 2005). However in our analysis, we found no significant correlation between article length and citation rate (Fig. 1b). This lack of correlation may be explained by shorter articles presenting clear, accessible, and concise arguments, which cancels out the influence of page length on citation frequency (Varian 1997).

In this study we found a significant, positive relationship between journal impact factor and number of citations (Fig. 1). One explanation for this correlation is that highly ranked journals typically have higher circulation rates, which results in higher visibility and subsequently higher citation rates (Van Dalen and Henkens 2001). Along this same line of argument, impact factors are frequently used by libraries in making subscription decisions, causing articles published in highly ranked journals to be more accessible through libraries and thus more likely to be cited (Adam 2002). Having an article published in a highly ranked journal is often viewed as a indication of the quality of the research, so articles published in these journals may also receive more citations because of the prestige of the journal (Larivière and Gingras 2010). However, within our dataset, there was high variability in citation rates across journal rankings, although the overall trend was positive (Fig. 1c), indicating that factors other than journal impact factor may influence the citation rate of a particular article (Seglen 1994; Leimu and Koricheva 2005). This is also demonstrated by the correlation coefficient (0.28) identified in this study, which although significant, was substantially lower than correlation coefficients identified in other disciplines. In physics the correlation coefficient between mean citations per article and impact factor of the journal was 0.94 and in biology it was 0.99 (Vieira and Gomes 2010)—indicating a much closer connection between citations and journal ranking than was identified in forestry and geography.

Self citation and lifespan patterns

We found a mean self-citation rate for forestry and geography of 14%, which falls within the range of 10 to 20% for the natural sciences; however it is lower than the fields of ecology (self-citation rate = 19%) and plant and animal sciences (20%) (Aksnes 2003). Given that the number of citations an article receives increases its visibility, it is to the

author's benefit to cite their own work (Aksnes 2003). Authors cite their own papers because it establishes their authority in the field and builds on their earlier work, rather than for self-promotion (Bonzi and Snyder 1991). In slight contrast, authors cite others' papers to demonstrate their knowledge of important findings in the field (Bonzi and Snyder 1991).

Citation longevity is often used for analyzing the scientific quality of an individual paper (Luzar et al. 1992) and for evaluating of the productivity of scientists (Petersen et al. 2010). The citation longevity of an individual paper depends on the topic of the paper because some topics or themes persist across multiple decades and lead to a longer span of being actively cited, while other topics are transient and papers covering these topics are cited for a shorter time period (Chen et al. 2008). In the fields of forestry and geography, we found no overall pattern in the number of citations received throughout the lifespan of our older papers, indicating that most of the papers we examined were on persistent topics. Trends in persistence of topics vary across disciplines and it could be that forestry and geography do not tend to respond to fads in the discipline as much as other fields (Steininger et al. 2009). This could also be because our sample only included the most-cited paper published by authors, a sampling technique that may exclude the more transient topics.

Conclusions

Given that publication numbers and quality (typically measured by the impact factor of a journal) of academic researchers directly affect institutional and departmental rankings administrators and senior faculty consider these metrics highly in promotion and tenure decisions for junior faculty it is important to understand all of the causes of citation frequency (Anderson et al. 1978; Zhu et al. 1991). In disciplines that demand high publication rates (Bonzi and Snyder 1991), but have a publishing culture dominated by a select number of well-established senior scientists (Parker et al. 2010), it can be particularly difficult for junior faculty to achieve the publication numbers and recognition expected. Many of these junior faculty members use self citation as a means of getting their research noticed and in disciplines where lower publication rates are expected, self citations are relatively more important for achieving recognition of one's scholarship (Lillquist and Green 2010). For lower productivity researchers who depend upon the citation lifespan of one or two major publications for promotion and tenure, understanding the factors that contribute to a paper's citation rate can be critical (Petersen et al. 2010). Our analysis shows that for geographers and foresters working at large, public universities citation rates of their most highly cited paper depend upon journal ranking, seniority of author, and discipline. Faculty cannot change their seniority or discipline, but it appears that the best publication strategy for junior faculty to achieve the professional recognition of their scholarship required for promotion is to publish in highly ranked journals.

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