

Patterns of Citations of Open Access and Non-Open Access Conservation Biology
Journal Papers and Book Chapters

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Patterns of Citations of Open Access and Non-Open Access Conservation Biology Journal Papers and Book Chapters

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Abstract: *Open access (OA) publishing, whereby authors, their institutions, or their granting bodies pay or provide a repository through which peer-reviewed work is available online for free, is championed as a model to increase the number of citations per paper and disseminate results widely, especially to researchers in developing countries. We compared the number of citations of OA and non-OA papers in six journals and four books published since 2000 to test whether OA increases number of citations overall and increases citations made by authors in developing countries. After controlling for type of paper (e.g., review or research paper), length of paper, authors' citation profiles, number of authors per paper, and whether the author or the publisher released the paper in OA, OA had no statistically significant influence on the overall number of citations per journal paper. Journal papers were cited more frequently if the authors had published highly cited papers previously, were members of large teams of authors, or published relatively long papers, but papers were not cited more frequently if they were published in an OA source. Nevertheless, author-archived OA book chapters accrued up to eight times more citations than chapters in the same book that were not available through OA, perhaps because there is no online abstracting service for book chapters. There was also little evidence that journal papers or book chapters published in OA received more citations from authors in developing countries relative to those journal papers or book chapters not published in OA. For scholarly publications in conservation biology, only book chapters had an OA citation advantage, and OA did not increase the number of citations papers or chapters received from authors in developing countries.*

Keywords: citation advantage, conservation biology, developing country, HDI, human development index, open access

Patrones de Citas de Artículos y Capítulos de Libros de Biología de la Conservación de Acceso Abierto y Acceso No Abierto

Resumen: *La publicación de acceso abierto (AA), en la que los autores, sus instituciones o sus organismos financiadores pagan o proporcionan un banco mediante el cual trabajos revisados por pares están disponibles sin costo en línea, es abanderada como un modelo para incrementar el número de citas por artículo y diseminar resultados ampliamente, especialmente a investigadores en países en desarrollo. Comparamos el número de citas artículos de AA y acceso cerrado en six revistas y four libros publicados desde 2000 para probar si el AA incrementa el número de citas en total y el número de citas hechas por autores en países en desarrollo. Después de controlar por tipo de artículo (e. g., trabajo de revisión o de investigación), extensión del artículo, perfiles de citación de los autores, número de autores por trabajo y si el autor o el editor liberaron el artículo a AA, el AA no tuvo una influencia estadísticamente significativa sobre el número de citas por artículo. Los artículos de revistas fueron citados más frecuentemente si los autores anteriormente habían publicado artículos muy citados, eran miembros de grupos grandes de autores o publicaron artículos*

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relativamente largos, pero los trabajos no fueron citados más frecuentemente si fueron publicados en una fuente de AA. Sin embargo, los capítulos de libro de AA acumularon hasta 8 veces más citas que los capítulos en el mismo libro que no estuvieron en AA, quizá porque no hay servicio de resúmenes en línea para capítulos de libro. También hubo poca evidencia de que artículos en revistas o capítulos de libros publicados en AA fueron más citados por autores en países en desarrollo que artículos o capítulos de libros no publicados en AA. En el caso de publicaciones científicas de biología de la conservación, solo los capítulos de libro tuvieron una ventaja de citación en AA, y el AA no incrementó el número de citas de artículos o capítulos recibidos de autores en países en desarrollo.

Palabras Clave: acceso abierto, biología de la conservación, IDH, índice de desarrollo humano, país en desarrollo, ventaja de citación

Introduction

In March 2009 the President of the United States Barack Obama signed into law the 2009 Consolidated Appropriations Act. The act included a provision that recipients of research funds from the U.S. National Institute of Health must, no later than a year after peer-reviewed publication of their research, deposit electronic versions of the publications with PubMed Central (the National Library of Medicine's online archive) (McLennan 2009). These versions are free and make the results of publicly funded biomedical research available without restriction. In the United Kingdom, many funders of biomedical and health research give financial support to the U.K. PubMed Central, which provides free online versions of medical research publications to the public within 6 months of publication (Bloom et al. 2008; Harnad et al. 2008).

Open access (OA) is the collective name for these and other publishing models that provide peer-reviewed papers online for free. (Suber [2009] has a timeline of the development of OA initiatives.) Under some models known as "green OA" (Harnad et al. 2004), electronic copies of papers are available through subject-based repositories (e.g., PubMed Central and U.K. PubMed Central), institutional repositories containing all work by the institution's employees, or are placed online by their authors (although authors' posting options may, in some cases, be restricted to text files of the paper to protect copyright holders (Harnad 2003). Alternatively, some journals are published exclusively in OA (sometimes called "gold OA" [Harnad et al. 2004]). In August 2009, the Directory of Open Access Journals listed 4278 such journals (including publisher Bentham Open's *Open Conservation Biology Journal*). Publishers may also make selected papers of a non-OA journal available by OA on their own website at their own discretion or give authors the option of OA publication on the publisher's site if they pay a fee (called a "Trojan horse" by Taylor et al. (2008) because they contend it could undermine journals that are fully OA).

Advocates argue that OA in all its forms allows the public to access the results of publicly funded research, achieves the widest possible dissemination of research findings, often speeds publication if the options are OA

online or a print version, garners a greater number of citations, and improves access to research findings in developing countries (Odlyzko 2002; Harnad et al. 2008; Taylor et al. 2008). Authors who publish in OA and pay fees of US\$1100 or more for publication of a paper under gold OA or on a publisher's website (Taylor et al. 2008) may be most interested in the dissemination aspect of the argument, especially the claims that OA publications are more likely to be cited and to reach colleagues in developing countries. This is especially important for conservation biology, a field in which wide dissemination of research may promote awareness of challenges and their solutions (Jacobson 1999; Jacobson et al. 2006).

Harnad and Brody (2004) suggest the ideal test of a citation advantage for OA papers is to compare the number of citations of OA and non-OA papers appearing in the same journals, thereby controlling closely for readership, editorial policies, and journal prestige. Early studies indicate statistically significant citation advantages for OA compared with non-OA papers in several disciplines, but critics suggest these results are likely an artifact of selection bias. Papers that were longer or had more authors and papers by authors whose publications were already highly cited, were supported by prestigious grants, or had a first author from a prestigious institution or with a prestigious reputation were more likely to be available through OA. These features, rather than OA, led to the higher number of citations (reviews in Craig et al. 2007 and Taylor et al. 2008).

We conducted three tests of the hypothesis that OA publication of conservation biology papers provides a citation advantage: green OA, comparison of the number of citations of non-OA (conventionally published) and OA papers (made available on the World Wide Web by their authors) from six conservation journals 8 years after publication, which considers the enduring relevance of conservation biology publications (Harrison 2006; Calver & Bryant 2008); gold OA, comparison of OA and non-OA papers in two journals in which OA papers were made available through the publishers' websites without delay; and green OA for book chapters, comparison of book chapters placed OA by authors or third parties, not the publisher, and non-OA chapters from four books. In each comparison we controlled for the number of

authors on papers, the length of the papers, the type of paper (review or research paper), and the citation records of the first and last authors on each paper or chapter. We used the same research design to test the hypothesis that authors from developing countries are more likely to cite OA than non-OA papers and book chapters.

Methods

Green OA Comparison for Journal Papers

We selected the six journals (Biodiversity and Conservation, Biological Conservation, Biological Invasions, Conservation Biology, Diversity and Distributions and Global Change Biology) we used to examine whether there is a citation advantage of OA compared with non-OA for journal papers 8 years after publication from the 24 journals listed by Thomson Reuters in their biodiversity conservation category for 2006. (See Calver and Bryant [2008] for comparative data on all journals in this category in that year.) We considered the research papers published in these six journals in 2000. We deemed 2000 recent enough to be relevant for our analyses and believe it allowed sufficient time for citations to accumulate (Leimu & Koricheva 2005). Reviews were excluded because only 21% of them were available in OA compared with 43.5% of standard papers. Thus including reviews would have introduced a bias because reviews tend to receive a greater number of citations than other papers (Davis et al. 2008; Falagas & Alexiou 2008; Davis 2009). Errata, letters to the editor, editorials, and book reviews were also excluded because they are rare relative to papers and cannot be expected to attract many citations (Davis et al. 2008; Davis 2009).

None of the journals we chose offered an option for papers to be available through OA on the publisher's website in 2000, so we assessed OA availability by searching for papers in Google Scholar, a free service provided by the Google internet search engine. If we found a paper we identified through our Google Scholar search available for free online in September 2008, we considered the paper available through OA. We considered but rejected the idea of contacting individual website administrators to determine how long each paper had been online because of the complexities of copyright laws. Therefore, we did not determine the length of time papers were available.

We used the Scopus database, rather than Thomson Reuters' Web of Science, to determine the number of citations papers received. Scopus collects citations from a much wider pool of journals than Web of Science (Pauly & Stergiou 2005; Meho & Yang 2007; Harzing & van der Wal 2008) and includes regional journals that are important outlets for locally applicable conservation research (Calver & Bryant 2008). For example, for 2009 Scopus lists 20 journals with *conservation* in the title that deal

with biological conservation rather than conservation of artifacts (Web of Science lists only 11).

We also used Scopus to identify several factors other than OA that could influence the number of times a paper is cited: number of authors, number of pages, and Hirsch index (a measure of research impact and career length) (Calver & Bryant 2008) of the first and last authors for each paper (in the case of papers by one author, the author's Hirsch index was used in both Hirsch-index categories). Hirsch indices may be biased if the database mistakenly classifies multiple authors with similar names under one name, so we scanned the papers that comprised the Hirsch index for each author to determine whether the index really referenced just one person. We found only one aberration: one author was attributed papers in ecology, epidemiology, and nuclear physics. The address lines in these papers suggested they were written by three different people, so we used only the ecology papers to calculate that author's Hirsch index. Some authors advocate correcting the Hirsch index for the length of time an author has been publishing or the number of coauthors (Bornmann & Daniel 2009). We rejected these approaches because of the difficulty in identifying and excluding "nonproductive career interruptions" (times when authors are not working and publishing in the field, e.g., because they are rearing children) (Harzing 2008); because we included the number of coauthors as a separate covariate; and because we intended the Hirsch index to indicate simply whether an author's publications were highly cited. Therefore the Hirsch index in our analyses reflects research impact and career length. We completed Scopus searches in September 2008.

We analyzed data in a two-way mixed-model analysis of variance (ANOVA) in which source (OA or non-OA) was a fixed factor and journal was a random factor, which allowed us to extrapolate our results to similar conservation biology journals. The dependent variable was number of citations. The number of authors, length of the paper, and Hirsch indices of the first and last authors were included as covariates. We transformed all covariates and the dependent variable to the fourth root before analysis because the fourth-root transformation was superior to the logarithmic transformation in normalizing the heavily skewed distributions (Calver & Bradley 2009).

Gold OA Comparison for Journal Papers

Two of the journals we analyzed (*Biological Invasions* and *Biodiversity and Conservation*) offer authors the opportunity of paying for OA on the publishers' websites. In addition to papers proposed by authors for OA, the editors sometimes release theme issues or significant papers as OA at their own volition, presumably without charge to the authors.

We considered the research papers published by *Biological Invasions* in 2005 and *Biodiversity and Conservation* in 2006; these were the earliest years when

OA papers were available on the publisher's sites for these journals. We excluded reviews, errata, letters to the editor, and book reviews and determined the total number of authors, number of pages for each paper, and the Hirsch index of the first and last authors for each paper from Scopus in September 2008. We used the same design described for the data on green OA journal papers to analyze the data on gold OA journal papers, with the addition of the extra covariate time since publication (in months, determined from the official month of publication of the print issue) because time might be an important factor over the shorter period in which citations were accumulating.

Green OA Comparison for Book Chapters

The four books (Soulé & Orians 2001; Rapport et al. 2003; Lunney 2004; Norse & Crowder 2005) we examined are relevant to conservation biology and each has at least two chapters that are available for download from the internet. Book chapters are seldom included in Scopus, so we used Google Scholar to determine the number of citations for chapters and the availability of the chapters through OA. Google Scholar includes citations from books, theses, reports, and journal articles and is more likely to include citations from non-English sources (Harzing & van der Wal 2008). Along with increased breadth comes a higher error frequency and the loss of user friendliness (e.g., output must be scanned carefully to detect duplications) (Gardner & Eng 2005; Bar-Ilan 2008). Nevertheless, we think our comparison between citations for OA and non-OA papers is still valid because these issues apply equally to both categories. As an additional check of the validity of our use of Google Scholar, we compared the number of citations reported on Google Scholar for the 12 chapters in Soulé & Orians (2001) with the number of citations of those chapters we found in a "cited reference search" in Web of Science, which finds citations classified by chapter authors. As expected (given its greater coverage), Google Scholar returned more citations per chapter (mean 17.2) than Web of Science (mean 12.4). Nevertheless, $r_{s(11)} = 0.93$, which indicated that the two databases provided similar rankings of the chapters on the basis of number of citations.

We conducted Google Scholar searches in September 2008. Lengths of chapters and numbers of authors were determined from the books' tables of contents, and first and last authors of each chapter were traced in Scopus in September 2008 to determine their Hirsch indices. We did not identify or exclude review chapters because in our experience book chapters often take a review or synthesis approach. We analyzed the data as for the green and gold-OA analyses for journal papers, but did not include a covariate for time since publication because we considered it a property of the book itself.

Citation of OA Papers by Authors in Developing Countries

We examined whether authors in developing countries cite OA papers more often than non-OA papers separately for the green-OA journal articles, gold-OA journal articles, and green-OA book chapters. For each relevant article or book chapter, we chose a single source that cited the article or chapter at random. We then chose a single author from that source at random and determined the author's country of origin. Where an author listed multiple affiliations, we chose the first affiliation listed. This avoided possible biases arising from the unequal number of citations for each article if articles varied in their interest to authors from developed or developing countries. We determined citing sources and the country of origin of citing authors from entries in Scopus for the 2 categories of journal articles and from Google Scholar for the book chapters.

We used the United Nations Development Program's Human Development Index (HDI) (UNDP 2009) for 2009 (covering the period up to 2007) as an indicator of the relative development of the countries of citing authors. This composite index incorporates information on life expectancy, education participation, and standard of living. Index values are between 0 and 1 for each country (higher values indicate a higher level of development). Values range from 0.340 (Niger) to 0.971 (Norway). According to UNDP (2009), all but 13 countries that did not provide the relevant data in time for the UN analysis have an HDI, although the definition of country may be inconsistent. For example, there is no entry for Taiwan, but there is one for Hong Kong. This created a problem in our analysis only for the three cases in which authors used a Taiwan affiliation. We assigned these papers the value for Hong Kong because, in our opinion, Hong Kong is the closest equivalent to Taiwan.

We reasoned that if authors from developing countries were more likely to cite OA articles than non-OA articles, then the mean HDI for countries citing OA articles should be significantly lower than that for countries citing non-OA articles. We tested this hypothesis with two-way mixed-model analysis of variance in which the fixed factor was source (OA or non-OA) and the random factor was journal or book. This allowed us to extrapolate results to similar conservation biology journals or books. The dependent variable was the HDI of the citing author's country. Before analysis we transformed the HDIs by reflecting the data and then calculating the logarithm of each value to normalize the long left tail of the distribution (Tabachnick & Fidell 2001).

Results

The percentage of green-OA papers across the six journals ranged from 13% (*Biodiversity and Conservation*)

Table 1. The data set used to test whether open-access (OA) publishing affects citation rates.^a

Hypothesis tested and journals or books used ^b	Years covered ^c (journals) or year published (books)	Number of papers or chapters considered	Number of OA papers or chapters (%)
Green OA journal papers are more likely to be cited than non-OA journal papers from the same journal.			
<i>Biological Conservation</i>	2000	167	39 (23)
		167	39 (23)
<i>Biodiversity and Conservation</i>	2000	93	12 (13)
		89	12 (13)
<i>Diversity and Distributions</i>	2000	24	5 (21)
		24	5 (21)
<i>Biological Invasions</i>	2000	31	5 (16)
		30	4 (13)
<i>Global change Biology</i>	2000	98	19 (19)
		98	19 (19)
<i>Conservation Biology</i>	2000	171	87 (51)
		170	86 (50)
Gold OA journal papers are more likely to be cited than non-OA journal papers from the same journal.			
<i>Biodiversity and Conservation</i>	2006	248	194 (78)
		218	171 (78)
<i>Biological Invasions</i>	2005	78	15 (19)
		76	15 (20)
Green OA book chapters are more likely to be cited than non-OA book chapters from the same book.			
Lunney 2004	2004	62	3 (5)
		43	2 (5)
Rapport et al. 2003	2003	137	7 (5)
		26	3 (11)
Soulé & Orians 2001	2001	12	2 (17)
		12	2 (17)
Norse & Crowder 2005	2005	30	3 (10)
		13	2 (15)

^aRows are paired: the first row of a pair pertains to papers or chapters analyzed with respect to citations. The second row pertains to papers or chapters analyzed with respect to the country of origin of authors citing them. Figures in the second row are lower in some cases because a country of origin for a citing author could not be assigned where papers or chapters were not cited.

^bGreen OA, authors place the paper or chapter online; gold OA, publisher places paper or chapter online on the publisher's website.

^cPapers from the year indicated were analyzed to test the respective hypotheses.

to 51% (*Conservation Biology*) (Table 1). The mean number of citations for OA papers exceeded those for non-OA papers for each journal (Fig. 1), but the effect was not significant ($F_{1,5} = 4.52$, $p = 0.08$). There was, however, a significant difference in number of citations between journals ($F_{(5568)} = 14.32$, $p < 0.01$) and a significant interaction between journals and OA availability ($F_{(5568)} = 3.26$, $p < 0.01$). The number of OA and non-OA citations for *Biological Invasions* differed little, whereas this difference was large for *Diversity and Distributions* (Fig. 1). Post hoc tests (Tukey honestly significant difference for unequal sample sizes) for the interaction effect indicated number of OA citations significantly exceeded number of non-OA citations for *Diversity and Distributions* ($p < 0.01$) but not for any other journal ($p \geq 0.08$ in all cases). All covariates (number of authors, Hirsch index of first author, Hirsch index of last author, and length of paper) had a positive and significant ($p \leq 0.001$) effect on number of citations.

The percentage of gold-OA papers ranged from 19% (*Biological Invasions*) to 78% (*Biodiversity and Conservation*) (Table 1). *Biological Invasions* received significantly more citations than *Biodiversity and Conservation* ($F_{(1317)} = 10.76$, $p = 0.001$). The mean number of citations for OA papers exceeded those for non-OA papers for both journals (*Biological Invasions* mean [SE] for OA = 11.00/paper [8.43] and mean for non-OA = 6.51/paper [4.74]; *Biodiversity and Conservation* mean for OA = 3.03/paper [3.65] and mean for non-OA = 2.98/paper [3.27]), but neither the effect of OA ($F_{(1,1)} = 20.42$, $p = 0.14$) nor the interaction between journals and OA availability was significant ($F_{(1317)} = 0.12$, $p = 0.79$). The covariates Hirsch index of first author, Hirsch index of last author, length of paper, and time since publication were all significantly ($p \leq 0.01$) positively associated with number of citations. The covariate number of authors was not significant ($p = 0.14$).

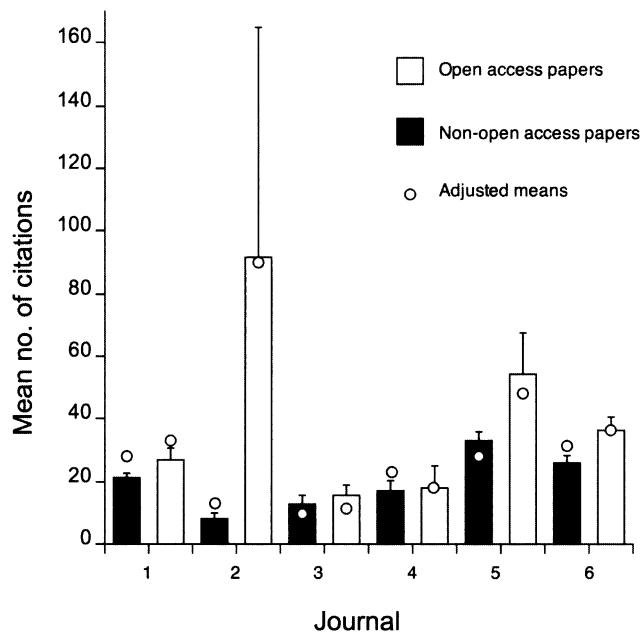


Figure 1. Mean (SE) citations for green OA (archived by authors) and non-OA papers published in six journals of conservation relevance in 2000 (open circles, adjusted means for the effects of the covariates number of authors, length of the paper, and Hirsch indices of the first and last authors; 1, Biological Conservation; 2, Diversity and Distributions; 3, Biodiversity and Conservation; 4, Biological Invasions; 5, Global Change Biology; 6, Conservation Biology). Data were transformed by taking the 4th root before analysis.

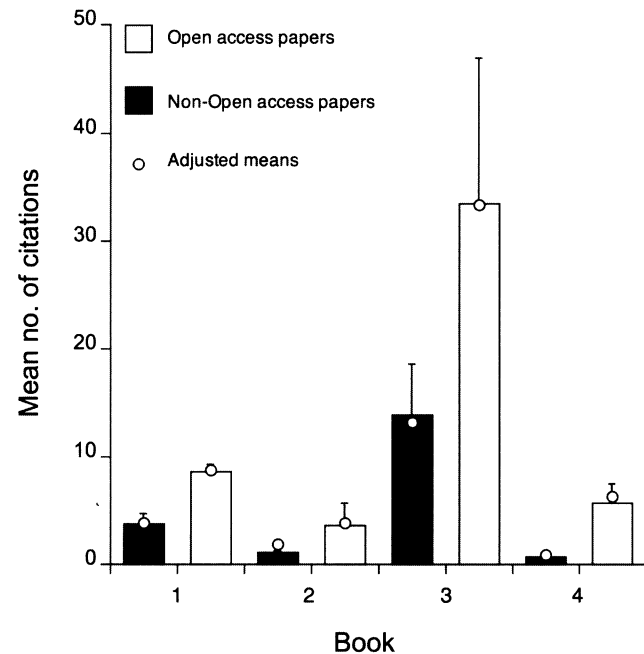


Figure 2. Mean (SE) citations for green OA (archived by authors) and non-OA chapters published in four books of conservation relevance (open circles, adjusted means for the effects of the covariates number of authors, length of the paper, and Hirsch indices of the first and last authors; 1, Norse and Crowder [2005]; 2, Lunney [2004]; 3, Soulé and Orians [2001]; 4, Rapport et al. [2003]). Data were transformed by taking the fourth root before analysis.

The percentage of green-OA chapters in the four books ranged from 5% (Rapport et al. 2003 and Lunney 2004) to 17% (Soulé & Orians 2001) (Table 1). The books received significantly different mean numbers of citations per chapter ($F_{(3,229)} = 5.84, p < 0.001$) (Fig. 2). The effect of OA on the mean number of citations was significant. The mean number of citations for OA chapters was at least twice that for non-OA papers for each book (Fig. 2) ($F_{(1,3)} = 23.34, p = 0.02$). The interaction between individual books and OA availability was not significant ($F_{(3,229)} = 0.79, p = 0.50$) (Fig. 2). None of the covariates was significant ($p \geq 0.16$).

The sample sizes for HDIs were sometimes lower than those for number of citations because a country of citing author could not be attributed to papers or chapters with a citation score of 0 (Table 1). A wide range of countries was represented in the analyses (green OA: mean [SE] = 24.17/journal [4.11]; gold OA: 37.5/journal [14.5]; green OA books: 6.75 [2.99]). Green-OA journals had significantly different HDIs for their citing authors ($F_{(5,575)} = 2.56, p = 0.03$), but the effect of OA on HDI was not significant ($F_{(1,5)} = 0.51, p = 0.51$) and the journal by OA interaction was not significant

($F_{(5,575)} = 0.58, p = 0.71$) (Fig. 3). The result for gold-OA journals was similar. *Biological Invasions* had a significantly higher HDI for its authors than *Biodiversity and Conservation* ($F_{(1291)} = 12.85, p < 0.001$), but neither the effect of OA on HDI (*Biological Invasions* mean [SE] for OA = 0.933/citing author [0.017] and mean for non-OA = 0.934/citing author [0.007]; *Biodiversity and Conservation* mean for OA = 0.883/citing author [0.009] and mean for non-OA = 0.861/citing author [0.022]) ($F_{(1,1)} = 4.034, p = 0.29$) nor the journal by OA interaction was significant ($F_{(1291)} = 0.09, p = 0.76$).

Green-OA books also differed significantly among themselves with regard to the HDIs of their authors. Authors publishing in Soulé and Orians (2001) had the lowest HDIs and authors publishing in Lunney (2004) the highest ($F_{(3,87)} = 8.73, p < 0.001$), probably because Lunney (2004) focuses on Australian forests and attracted most of its citations from Australian authors. Although the effect of OA was not significant ($F_{(1,3)} = 1.18, p = 0.36$), there was a significant book by OA interaction ($F_{(3,87)} = 3.45, p = 0.019$). Authors in Soulé and Orians had lower HDIs for OA chapters compared with non-OA chapters, and authors in Rapport et al. (2003) had higher

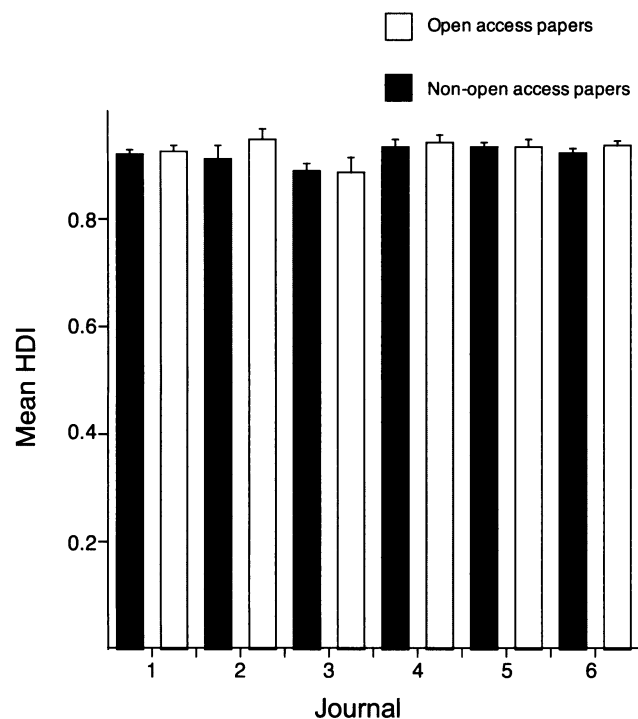


Figure 3. Mean (SE) human development index (HDI) for country of origin of authors citing green OA (archived by authors) and non-OA papers published in six journals of conservation relevance in 2000 (1, Biological Conservation; 2, Diversity and Distributions; 3, Biodiversity and Conservation; 4, Biological Invasions; 5, Global Change Biology; 6, Conservation Biology).

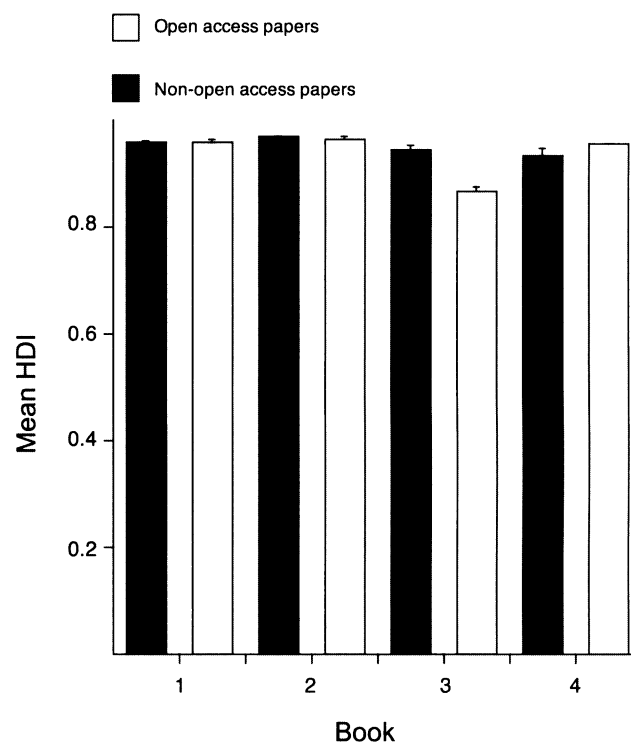


Figure 4. Mean (SE) human development index (HDI) for country of origin of authors citing green OA (archived by authors) and non-OA chapters published in four books of conservation relevance (1, Norse and Crowder [2005]; 2, Lunney [2004]; 3, Soulé and Orians [2001]; 4, Rapport et al. [2003]).

HDI for OA chapters compared with non-OA chapters (Fig. 4).

Discussion

Proponents of OA in all its forms argue consistently that one of its main advantages is an increase in the number of citations (Harnad & Brody 2004; Eysenbach 2006; Taylor et al. 2008). Taylor et al. (2008) claims that because citations improve authors' competitiveness for securing research grants, there is a financial advantage to increasing number of citations through OA. Any financial gain, however, is diluted in models of OA in which authors must pay a fee for their papers to be made available through the publisher's internet site. The fee-paying model leads to the complaint that articles "may be free for readers, but . . . [are] becoming more and more costly for authors" (Taylor et al. 2008:31). Nevertheless, a survey of 3059 authors from 14 academic fields who had published papers in "gold-OA" journals found that in approximately 55% of cases the authors' institutions paid all fees (Swan &

Brown 2004), although it was unclear whether payments emanating from an institution were from authors' grants.

For journal publications in conservation biology, OA is not returning financial rewards because OA journal papers did not receive a greater number of citations than non-OA journal papers. After correcting for confounding factors, neither green-OA nor gold-OA journal papers received a significantly greater number of citations than non-OA journal papers, with the sole exception of increased citations for green-OA papers in *Diversity and Distributions*. Although our results for green OA may be biased by uncertainty in length of time individual papers had been available online, the results for gold OA had no such bias and were consistent with a lack of citation advantage for OA. Given the significance of the covariates, authors who wish to increase the number of citations their papers receive might seek to write longer papers in collaboration with teams of experienced colleagues, rather than making their work available online themselves (in potential contravention of copyright) or paying for gold OA.

Our results, in conjunction with published studies in which confounding variables were controlled for in assessments of the advantages of OA, suggest that effects of

OA are time, journal, or discipline specific. For example, controlling for confounding factors, Eysenbach (2006) examined OA and non-OA papers published in the interdisciplinary *Proceedings of the National Academy of Sciences* (PNAS) for up to 16 months after publication and concluded that OA papers on the journal's website were cited earlier and a greater number of times than author-archived papers or non-OA papers. In a broader study, controlling for several possible confounding factors, Davis (2009) considered OA and non-OA papers in 11 science journals (including PNAS) for up to 57 months after publication and concluded that only PNAS and *The Journal of the National Cancer Institute* had a positive and statistically significant OA advantage. The OA advantage was 17% for all journals and 11% when PNAS was excluded. In addition, the advantage of OA decreased over time. Thus, any OA advantage may be specific to discipline or even journal and sensitive to the time elapsed since publication. Davis (2009) estimated that the cost to authors per extra citation a paper gained in OA ranged from \$US400 to \$9000 (estimated OA citation advantage for the journal \times the journal's impact factor [to project the citation gain in the first 2 years after publication]/the publisher fee for OA). This cost suggests that authors who publish under the gold-OA model are probably paying substantially for a small number of extra citations.

The situation was different for conservation biology books, where there was a significant increase in the number of citations of green-OA book chapters relative to non-OA chapters. Unlike journal papers, book chapters are seldom included in major bibliometric data bases (Google Scholar is an exception) (Harzing & van der Wal 2008), so researchers cannot trace them easily. Although authors may not incur costs when self-archiving book chapters online and so have an incentive to do so, online availability may decrease book sales and be a substantial cost to publishers. Book chapters were also unusual in that no covariates explained citations significantly. We suggest that this is because authors of book chapters are invited or otherwise selected (e.g., papers chosen after a conference), so there is less of a spread in the number of authors and in authors' track records. Book chapters often have tightly specified upper and lower word limits too, which removes much of the variation in length.

Bloom et al. (2008) and Taylor et al. (2008) argue that OA allows researchers in developing countries access to important research, although Frandsen (2009) found that these authors do not necessarily use open-access publications or regard OA more highly than researchers from developed countries. Our results are similar to those reported by Frandsen (2009) because we found no consistent evidence that authors from developing countries cite OA papers or chapters disproportionately, with the possible exception of some OA book chapters. Therefore, OA may not be increasing the utility of conservation biology research in developing countries.

The limitation of an OA citation advantage to conservation biology book chapters and the weak evidence of improved communication with researchers in developing countries do not mean conservation biology authors should reject OA. Citation is only one use of a research publication. People may download and read papers and apply them in teaching, professional practice, or politics without ever citing them, a point already recognized by editors of many applied journals (Cameron 2005; Jones et al. 2006). Furthermore, the argument that results of publicly funded biomedical research should be free to the public (Bloom et al. 2008; Harnad et al. 2008) applies equally to conservation research.

Accordingly, Bollen et al. (2009) argue that number of citations is only one measure of the multidimensional concept of "impact" of scientific research and that it should be complemented by other measures, including data on downloading. In this context, Davis et al. (2008) tested whether OA affected number of downloads and citations in a manipulative experiment. For the first 6 months after publication, they randomly assigned 247 articles from 11 journals of the American Physiological Society to OA and compared their number of citations and downloads with 1372 control articles available only by subscription. OA reduced the number of citations by about 5% and downloads of abstracts by 24% relative to non-OA articles, but the number of full-text downloads of OA articles was 89% higher and PDF (portable document format) downloads was 42% higher than the number of downloads of non-OA articles. Thus, OA articles in that study were more highly read (and probably the full articles, not just the abstracts), but not more highly cited.

Overall, OA is unlikely to result in a greater number of citations per publication for conservation biology authors unless they are invited to write book chapters. Additionally, it does not appear, on citation-based evidence, that OA publications are used more by researchers in developing countries. Nevertheless, OA may provide other benefits that could emerge in a multivariate analysis of a range of uses of papers and chapters other than citations.

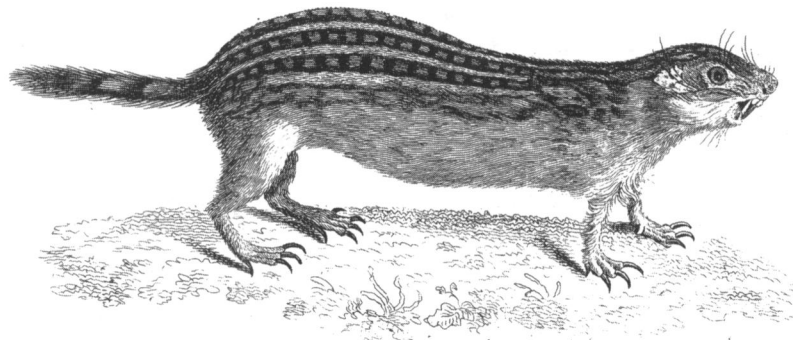
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