The economics of ecology journals

Carl T Bergstrom[1] and Theodore C Bergstrom[2]

Over the past decade, scientific publishing has shifted from a paper-based distribution system to one largely built upon electronic access to journal articles. Despite this shift, the basic patterns of journal pricing have remained largely unchanged. The large commercial publishers charge dramatically higher prices to institutions than do professional societies and university presses. These price differences do not reflect differences in quality as measured by citation rate. We discuss the effect of price and citation rate of a journal on library subscriptions and offer an explanation for why competition has not been able to erode the price differences between commercial and non-profit journals.

Front Ecol Environ 2006; 4(9): 488–495

Scientists are the primary producers as well as the main consumers of scientific journals. Traditionally, they have had little reason to concern themselves with the economics of this industry. However, because journal prices consistently increase more quickly than library budgets, scientists, even at large research institutions, begin to feel the pinch of restricted access to the scholarly literature. This paper investigates the economic factors responsible, with a focus on ecology journals.

Methods

Journals

Our data cover 92 regularly published primary research journals in the field of ecology. These are the 107 ecology journals listed in 2005 Journal Citation Reports (JCR 2005), which reports citation data through the end of 2004, with the following exceptions: review journals (*Advances in Ecological Research; Annual Review of Ecology, Evolution, and Systematics; Trends in Ecology and Evolution*), irregularly published journals (*Bulletin of the American Museum of Natural History; Proceedings of the Academy of Natural Sciences of Philadelphia; Western North American Naturalist; Wildlife Monographs*), and popular journals (*Natural History*). We omitted the for-profit journal *Sarsia* because the 2005 price reflects a merger with *Ophelia*, but the 2004 citation data do not include both journals. The bundled pair *Molecular Ecology* and *Molecular Ecology Notes* were treated as a single journal, with circulation information estimated from the former; we treated the bundled trio *Diversity and Distributions*, *Global Ecology and Biogeography*, and *Journal of Biogeography* similarly, estimating circulation from the last of these. Finally, we omitted the three journals, all non-profit, that provide all of their content freely on the web (*Amazoniana; Conservation Ecology; Revista Chilena de Historia Natural*), to avoid underestimating the average prices per page and per citation.

In a nutshell:

- The transition to online distribution of scientific publications has done little to alter the basic pricing structure of scholarly publishing in the field of ecology
- On average, in 2005, commercial publishers charged university libraries several times as much per page for institutional access to scholarly journals as did non-profit publishers
- The price differences between commercial and non-profit publications do not reflect an underlying difference in quality as measured by citation rate
- Journal circulation is highly responsive to price differences

[1]*Department of Biology, University of Washington, Seattle, WA (cbergst@u.washington.edu)*; [2]*Department of Economics, University of California, Santa Barbara, CA (tedb@econ.ucsb.edu)*

Price

Price data are from 2005, with a few exceptions; where 2005 prices were unavailable we used 2004 instead. The ESA journals (*Ecology, Ecological Monographs, Ecological Applications*, and *Frontiers in Ecology and the Environment*) feature tiered pricing; we used 2004 circulation data to estimate the average cost to print plus electronic subscribers. Exchange rates to US dollars were Euro = $1.26, Canadian Dollar = $0.79, Australian dollar = $0.76, Danish Kroner = $0.17.

Page charges

Page charges were collected from the *Instructions for Authors* on journal websites in April 2006. For societies, we have used the higher non-member prices. Because some journals charge higher page charges for pages beyond the recommended paper length, we have used only the per-page price for normal length papers.

Recent citations

The number of recent citations is an indicator of the use-

fulness of a journal. While citation rates differ across disciplines, this measure serves as a reasonable statistic for estimating journal quality, within the field of ecology.

When comparing citation rates and prices, we used price per recent citation in order to properly adjust for differences in journal sizes. Price scales with the size of a journal, but impact factor divides out the journal size – so instead we measure recent citations which, like price, scales with journal size. We measured recent citations by estimating the number of times that issues published in 2002 or 2003 were cited in 2004. Our data source was the 2005 ISI Journal Citation Reports citation index; recent citations is simply the product of 2004 impact factor and twice the 2004 article count.

Table 1. The top ten journals in ecology, ranked by 2004 impact factor

Title	Publisher	Price/Page	Impact
1. *Ecological Monographs*	Non-profit	$0.35	5.02
2. *American Naturalist*	Non-profit	$0.25	4.48
3. *Global Change Biology*	For-profit	$1.42	4.33
4. *Ecology*	Non-profit	$0.28	4.10
5. *Ecology Letters*	Joint	$1.43	3.91
6. *Evolution*	Non-profit	$0.10	3.72
7. *Conservation Biology*	Joint	$0.34	3.67
8. *Journal of Ecology*	Joint	$0.79	3.40
9. *Frontiers in Ecology and the Environment*	Non-profit	$0.54	3.36
10. *Journal of Animal Ecology*	Joint	$0.81	3.34

Nine of the ten are published by non-profit publishers or jointly by scholarly societies in collaboration with a for-profit publisher.

Pages

Full information on the number of pages was not available beyond 2003, so we have used page counts from that year. In general, the number of pages is estimated using the last page number listed in the table of contents of each volume, with tables of contents taken from *Infotrieve* (www.infotrieve.com) whenever available and from websites or paper journals otherwise. When volumes split across years, the first page number listed for the first 2003 issue is subtracted. Average price per page is computed as Σ price / Σ pages.

Circulation

We estimated library circulation using the Online Computer Library Centre (OCLC) WorldCat interlibrary loan database (OCLC 2005). In August 2005, for each journal, we used a perl script to count the number of OCLC member libraries that reported an active subscription to the journal, as indicated by an open date range (eg "v.4– 1995–"). Because the OCLC database truncates holdings information at 24 characters, journals with complex holdings descriptions (eg "Vol/No: 1–2, 18–35, 37–38, 65–70, 74– 1968–1969, 1975–1979, 1984–") are not returned in full and thus have been omitted. This introduces a bias toward underestimating the active subscriptions to older journals (most of which are non-profit). Based on known circulation for the ESA journals, we can conservatively estimate that the actual number of institutional subscriptions is at least three times the number of OCLC subscribers.

Cost and value

Institutional subscription prices differ dramatically between publishers. In the field of ecology, as defined by the Institute for Scientific Information (ISI) in their *Journal Citation Reports* (JCR 2005), journals published directly by non-profit societies and university presses charge an average of $0.29 per page. Journals published jointly by scholarly societies with for-profit publishers cost an average of $0.92 per page, while those produced by for-profit publishers without an affiliated society cost an average of $1.42 per page (Figure 1).

The higher prices of for-profit journals do not reflect higher quality. In fact, non-profit journals tend to be

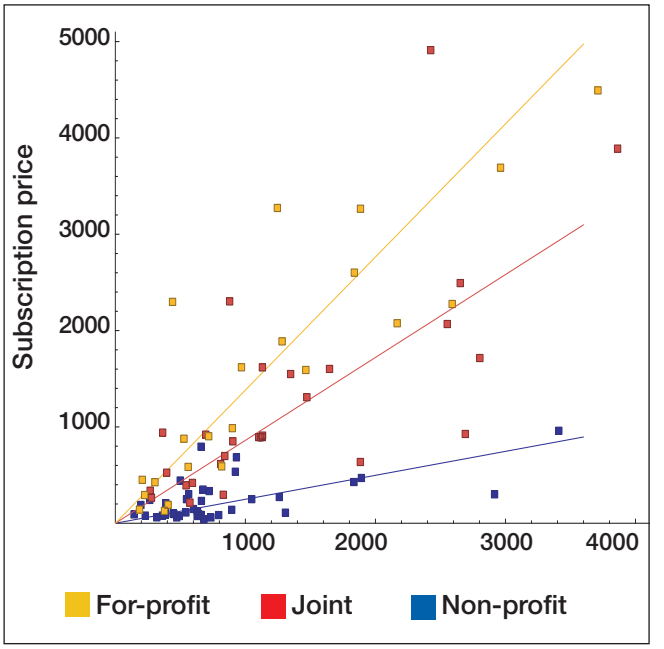

Figure 1. *For-profit publishers (yellow) charge institutions more per page for journal subscriptions than do non-profit publishers (blue) such as scholarly societies and university presses. Journals published jointly by scholarly societies and for-profit publishers (red) are typically priced intermediately. Solid lines indicate linear regression through the origin (Non-profit: slope = 0.25, $R^2 = 0.67$. Joint: slope = 0.86, $R^2 = 0.83$. For-profit: slope = 1.38, $R^2 = 0.90$. Note that the regression slopes are not equal to average prices per pages, because the latter effectively weights each journal by its size.)*

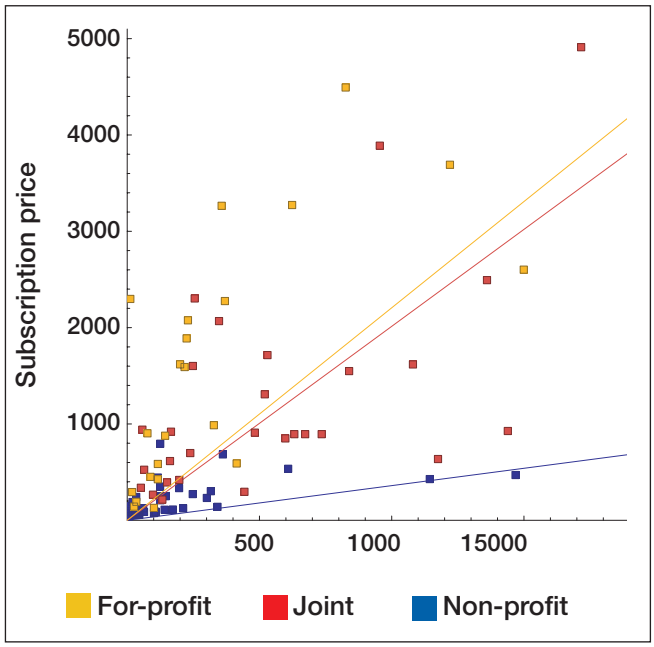

Figure 2. *For-profit publishers (yellow) charge institutions more per citation for journal subscriptions than do non-profit publishers (blue). Journals published jointly (red) are again priced intermediately, though with an average cost per citation close to that of for-profit journals. Solid lines indicate linear regression through the origin (Non-profit: slope = 0.36, $R^2 = 0.53$. Joint: slope = 2.01, $R^2 = 0.72$. For-profit: slope = 2.21, $R^2 = 0.52$. Note that the regression slopes are not equal to average prices per citation, because the latter effectively weights each journal by its size).*

older, more prestigious, and more highly cited than their for-profit counterparts. In 2004, five of the ten highest impact ecology journals were published by non-profit publishers and four more were published jointly by a scholarly society and a for-profit publisher (Table 1).

We constructed an index called recent citations, which measures the annual citations of articles published within the previous 2 years. The average cost per recent citation for journals published by non-profit societies is \$0.78. Journals published jointly between a scholarly society and a for-profit publisher cost on average \$2.42 per recent citation and those produced by for-profit publishers without an affiliated society cost on average \$4.33 per recent citation (Figure 2). Thus, whether we measure cost as price per page or price per citation, for-profit journals are approximately five times as expensive as their non-profit counterparts. A library that subscribes to all of the ecology journals considered here receives 30% of its citations and 29% of its pages from non-profit journals, but spends only 10% of its total budget on these non-profit publications.

Many non-profit journals and a few jointly published journals ask authors to help defray the costs of publication by contributing author fees or page charges, typically between \$30 and \$150 per page. Few, if any, for-profit journals request page charges. In comparing the revenue that non-profit and for-profit publishers collect from the academic community, it is appropriate to account for these page charges. Subscription costs are measured as a cost per page, per subscribing library. To include page charges in a comparable measure, we need to divide page charges assessed to the author by the number of libraries subscribing to the journal. We use three times the number of OCLC subscriptions (see Methods) as a conservative estimate of the number of institutional subscribers. Thus, our adjusted measure of cost per page is

$$\text{Total cost per page} = \text{Subscription price per page} + \frac{\text{Author fees per page}}{\text{Number of library subscribers}}$$

Revenues received from page charges account for only a small proportion of the difference in subscription prices between non-profit journals and for-profit journals. As shown in Table 2, total revenue – including page charges – is approximately three times as high per page for the for-profit journals as for non-profit journals.

Table 3 lists page charges and the total price per page for 20 top journals. Author fees, when charged, typically run \$0.03 to \$0.25 per page per US library subscription. Page charges may present an obstacle to authors in developing nations who are unable to pay such charges. But many non-profit journals have anticipated this problem and waive fees for those unable to afford them. Of the 27 journals with page charges in our sample, ten state in their "Instructions for Authors" that they will waive, or consider waiving, page charges. Another seven journals offer page charge waivers to members of their societies, while ten make no mention of the issue.

Table 2. Several measures of cost for non-profit, jointly published, and for-profit journals

	Price/page	*Price/cite*	*Median page charge*	*Total \$/page*
Non-profit	\$0.29	\$0.78	\$30	\$0.46
Joint	\$0.92	\$2.42	0	\$0.94
For-profit	\$1.42	\$4.33	0	\$1.42

Many non-profit journals charge page charges, with a median cost of \$30 per page. Total price per page estimates the publisher's total revenue per library subscription per page, including both subscription fees and page charges. Even accounting for page charges in this way, non-profit journals are considerably less expensive than their jointly-published or for-profit counterparts.

Trends over time

Research interest in ecology has exploded over the past 30 years, and over that period many new ecology journals have been founded (Figure 3). Many of these new journals are produced by for-profit publishers.

As the number of journals has risen, expenditures at research libraries have increased even more rapidly. Not only are libraries subscribing to more journals, but their collections are composed of increasing

proportions of expensive for-profit publications. Real library expenditures (ie corrected for inflation) on serials have more than doubled since 1986 (ARL 2004). Between the price increases and the increasing number of journals being published, many libraries have been forced to cancel journal subscriptions and to reduce their purchases of scholarly books and other non-journal media (Krillidou 1999).

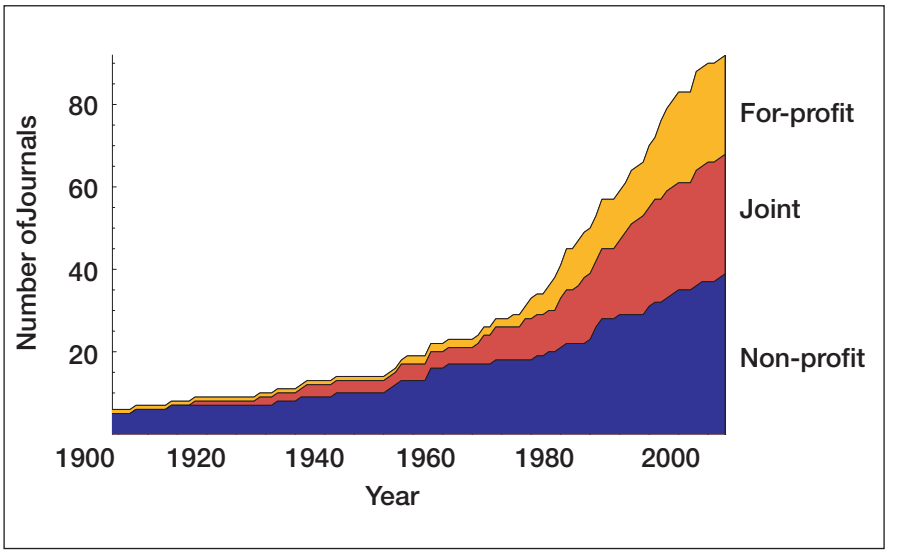

Figure 3. *The number of ecology journals currently listed in ISI that were published over the past century. For-profit publishers supply an increasing fraction of the ecology literature.*

The transition to online access

In the year 2000, print editions were still the primary mode of journal access for most scholars. By 2005, electronic access had come to dominate. In 2001, before most of the electronic transition occurred, we conducted a study on cost and value in the ecology literature (Bergstrom and Bergstrom 2001). At that time, a print subscription had an average cost per page of $0.21 for the non-profit journals included in the present study, $0.81 for jointly published journals, and $1.11 for for-profit journals, measured in 2005 dollars. In 2005, a combination print and electronic subscription cost on average $0.29 per page for non-profit journals, $0.92 for jointly published journals, and $1.42 for for-profit journals.

Non-profit journals have therefore added electronic access to their journals at a cost of about 8 cents per page and jointly published journals have done so for about 11 cents per page. During the same period, while adding electronic access, for-profit journals increased their prices by approximately 31 cents per page. The transition from print-only to print and electronic distribution, with all of the accompanying benefits to researchers, has been accomplished at a relatively low cost by non-profits and for-profits alike. However, this transition did little to disturb the pricing structure of the journal market. The pricing patterns that we observed back in 2001 are similar to those in 2005, as reported in detail here. In 2001, for-profit journals cost 5.3 times as much per page as non-profit journals, and jointly published journals cost 3.8 times as much per page. In 2005, those ratios were 4.8 and 3.1, respectively.

Bundling

Publishers are moving away from the practice of selling single titles to single libraries. Instead, they offer large bundles of journals on an all-or-nothing basis, leaving the subscriber with little leeway to pick and choose individual titles. A recent study of top North American research libraries (Hahn 2006) found that 93% subscribe to one or more bundles from five leading publishers. Moreover, large publishers often negotiate with consortia made up of numerous

Table 3. The top 20 journals in estimated library circulation in 2004

Title	Publisher	OCLC circ	$/Cite	Author fee ($/page)	Total $ page
1. *Ecology*	Non-profit	591	0.71	60	0.32
2. *Evolution*	Non-profit	409	0.30	55	0.15
3. *Ecol Monogr*	Non-profit	386	1.54	60	0.41
4. *Ecol Appl*	Non-profit	385	0.75	60	0.29
5. *Am Nat*	Non-profit	378	0.64	55	0.30
6. *J Wildlife Manage*	Non-profit	361	0.82	150	0.29
7. *Am Mid Nat*	Non-profit	355	1.57	50	0.15
8. *Conserv Biol*	Joint	304	1.08	150	0.50
9. *J Ecology*	Joint	274	2.82	0	0.79
10. *Wild Soc B*	Non-profit	269	1.56	120	0.23
11. *J Anim Ecol*	Joint	236	2.43	0	0.81
12. *J Soil Water*	Non-profit	230	1.48	120	0.32
13. *Paleobiology*	Non-profit	195	1.68	100	0.31
14. *Oikos*	Joint	190	1.29	0	0.34
15. *Southwest Nat*	Non-profit	162	2.81	80	0.25
16. *Oecologia*	Joint	151	5.72	0	2.03
17. *J Appl Ecol*	Joint	149	2.66	0	0.80
18. *Behav Ecol Socio Biol*	For-profit	135	10.50	0	2.63
19. *Microb Ecol*	Joint	127	5.03	0	0.89
20. *J Freshwater Ecol*	Non-profit	122	2.74	30	0.21

Many non-profit journals charge page charges, with a median cost of $30 per page. Total price per page estimates the publisher's total revenue per library subscription per page, including both subscription fees and page charges. Even accounting for page charges in this way, non-profit journals are considerably less expensive than their jointly-published or for-profit counterparts.

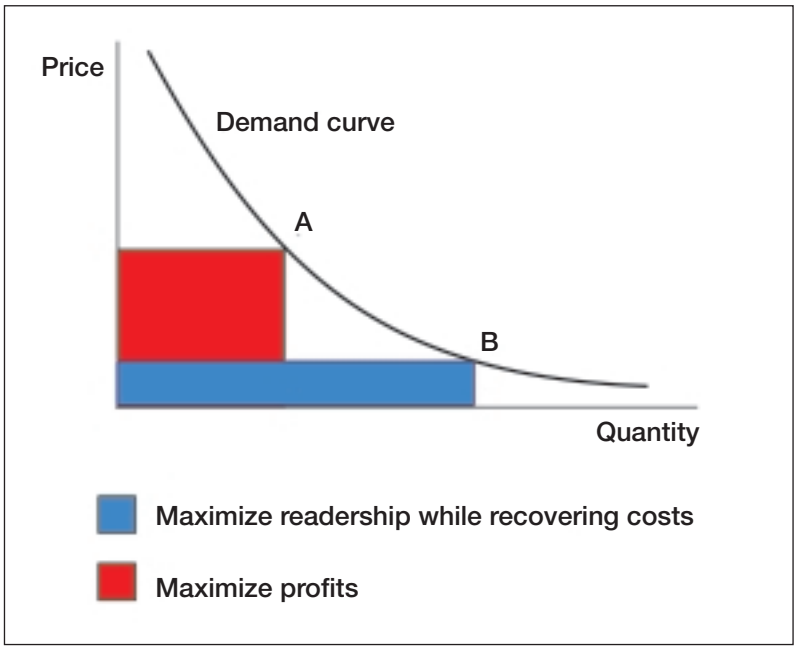

Figure 4. *A hypothetical demand curve for journals shows the relationship between price and quantity sold (ie circulation). The publisher's revenue for any given (price, quantity) combination is simply the product of price and quantity, and is represented geometrically as the rectangle below that point. For a product with virtually no marginal cost of production, such as electronic access to a scholarly journal, the publisher maximizes profits by maximizing revenue. The red rectangle shows the publisher's revenue under the profit-maximizing combination of price and quantity (A), whereas the blue rectangle shows revenue under the combination (B) that maximizes circulation while recovering the publisher's fixed costs. In this illustration, the quantity sold by the circulation-maximizing publisher is more than twice the quantity sold by the profit-maximizing publisher.*

schools that jointly negotiate pricing. Elsevier's Big Deal is a prominent example (Frazier 2001).

In recent years, bundle agreements between publishers and major universities or consortia have been the subject of intense bargaining between the two parties, with very substantial variation across universities regarding price and other terms of the agreement. Systematic data on bundle pricing would be very interesting. However, such data is not easily obtained, since a large proportion of universities have agreed not to disclose the terms of their agreement with the publishers. Our price data is therefore confined to prices for individual journals. For broad comparisons of prices between non-profit and commercial journals, the use of individual journal prices is still quite useful. The opening bargaining position of publishers when negotiating bundle prices is (a multiple of) the sum of the individual subscription prices in a bundle. For example, Elsevier's Science Direct Complete option (www.info.sciencedirect.com/licensing/primary/complete/) offers a package consisting of "an exact match with your entire print journal holdings". Additional titles are offered on an online-only basis if desired. Elsevier announces that the "Electronic access fee is a percentage of the print price for subscribed print journals (in addition to the fee)". Moreover, publishers interested in selling bundles of journals will be careful to set the prices of individual journals high enough so that university libraries will be tempted to buy the bundle at the bundle price rather than to purchase its constituents separately at individual journal prices. There will therefore be a close correspondence between individual journal prices and the prices of bundles of those same journals.

What is happening?

Substitutes and complements

Why do these price differences persist? The markets for most ordinary "durable goods" will not support such radical differences in cost and value. If one television manufacturer charged five times as much as its rivals for a product of equal or lesser quality, no one would buy it. People who want only one television would purchase it from the cheaper manufacturer; people who want a television for every room in the house would buy multiple televisions, but all from the cheaper manufacturer. Because televisions produced by one company are substitutes for televisions produced by another, the television market is a highly competitive one.

The difference in the publishing industry is that competing journals are not substitutes in the way that competing television brands are (Bergstrom and Bergstrom 2004). Copyright laws prevent a rival publisher from producing a competing journal as similar to the original journal as a television of one brand is to that of another. Instead, competing journals are complements, providing related articles. A library cannot substitute a second copy of a cheap journal for a first copy of an expensive journal in the same field. Libraries need to subscribe to most or all of the important journals in each field, irrespective of price differences. As a result, commercial publishers have considerable monopoly power, even when selling second-tier journals. This allows them to sell their products far above the average cost of production, and at prices far above the prices set by their non-profit competitors.

Under these circumstances, publishers will typically maximize profits by setting prices high enough to exclude a large fraction of the potential readership from access to the journal. Figure 4 shows a hypothetical demand curve for access to a single journal. The publisher can maximize circulation while recovering costs by setting its price at (B), or maximize revenue by setting the price at (A).

The simple economics illustrated here lead to a conflict of interest between the authors of scientific papers and the publishers of the for-profit journals in which they publish their work. The author of a scientific paper

(unlike the author of a textbook or of a popular mystery novel) is typically unpaid and thus has little interest in the publisher's revenue. Instead, most authors of scholarly publications aim simply to maximize the readership – and thus the impact – of their work. As Figure 4 illustrates, the gulf between the revenue-maximizing and circulation-maximizing price points can be dramatic. The conflict between authors and non-profit publishers is much smaller, because non-profit publishers commonly set prices much closer to the circulation-maximizing price.

Many non-profit and for-profit publishers recognize the authors' interests by allowing authors to freely distribute their papers on the internet, typically by placing a final version of the paper in a preprint archive, in an institutional repository, or on a personal website (Harnad 2001) For example, Elsevier's copyright assignment agreement allows authors to "post the final text of their articles, as accepted by the journal, ie with all of the changes made during the peer-review and editing process, on the authors' personal or their institutions' web sites". Springer, Wiley, and some Blackwell journals offer similar terms. As more authors take advantage of this opportunity, it is likely that subscriptions to expensive journals will become less of a necessity for university libraries. Even without subscriptions, they would have access to a large portion of its contents. Thus, self-archiving, by increasing the responsiveness of demand to price, is likely to be a strong force in inducing profit-maximizing publishers to moderate their prices.

A coordination game

Why is monopoly pricing sustainable? Why are new entrants, charging lower subscription prices, not more readily able to attract authors and subscribers away from overpriced incumbents? Why do authors persist in submitting their papers to high-priced journals? In part, until recently, most authors simply were unaware of price differences. But even well-informed authors have strong incentives to publish in expensive journals, if those are the ones in which other top authors publish their work. Libraries have strong incentives to subscribe to these journals, if top authors are publishing good articles in them.

To see how this works, consider the problem faced by three scientists, Alice, Bob, and Carol, as they decide where to send their latest work. Alice, Bob, and Carol are the most highly-esteemed scientists in their subfield, and all three authors have been publishing their best work in the historic and respected for-profit journal *Ecology Diatribes*. Another for-profit publisher introduces a competing journal, entitled *Ecology Polemics*, and sets its price much lower than that of *Ecology Diatribes*. Because it is cheaper and thus has the potential to circulate more widely, Alice considers sending her next paper to the upstart, *Polemics*. But if Bob and Carol continue to publish in *Diatribes*, most readers will prefer to read *Diatribes* instead of *Polemics*, and libraries with limited budgets will only subscribe to the former.

In game theoretic terms, Alice, Bob, and Carol are playing a coordination game with one another in their choice of journals (Bergstrom 2001). This game has two stable Nash equilibria. (A Nash equilibrium for this three-player game is a trio of strategies, one for each player, such that no single player can benefit from unilaterally changing strategy if the other two continue to behave as specified.) In one equilibirum, all three publish in *Ecology Diatribes*; in the other, all three publish in *Ecology Polemics*. Because *Ecology Diatribes* is the established journal, the players are currently coordinating on it in their submissions. Moreover, once the convention of publishing in *Diatribes* is established, none of the three players can alter the convention by any sort of unilateral action – even though all three would be better off if they could somehow coordinate on the less expensive journal. The publisher of *Ecology Diatribes* is able to charge significant "rents" (in the form of high subscription prices) by virtue of its position in the equilibrium of the coordination game.

Suppose that Alice, Bob, and Carol get together at an annual meeting and manage to coordinate a one-time shift to the new for-profit startup journal, *Ecology Polemics*. Readers will follow and this new coordination location is also a Nash equilibrium. But now the for-profit publisher of *Ecology Polemics* can raise its prices, because once again, none of the authors can move away unilaterally.

In essence, the ecology community faces a version of this coordination game, scaled up so that there are dozens of appropriate journals and thousands of participating authors. Without some coordinating mechanism that the scholarly community can use to shift its coordination equilibria to those journals that do not charge exorbitant prices, it can become trapped at an inefficient equilibrium, where journal prices run far above the average cost of production.

When scientists start low-cost, non-profit journals in response to overpriced commercial offerings – as Michael Rosenzweig did with *Evolutionary Ecology Research* and the *Public Library of Science* (*PLoS*) founders did with their family of journals – they do more than simply lower the prices of scholarly publishing in the new journal's narrow field. When scientists leverage their time and reputations to shift the coordination equilibrium from an expensive journal to a new, non-profit alternative, they send a powerful message to for-profit publishers that scientists are sensitive to price and able to overcome the coordination problem described above. By doing so, they impose a strong check upon the power of commercial publishers to raise the prices of their journal offerings.

Value and circulation

How broadly are the various journals circulated? It is not easy to collect precise data on how many institutions subscribe to particular journals. These circulation data are the closely guarded secrets of the large commercial publishers. Nonetheless, we can use the OCLC WorldCat database

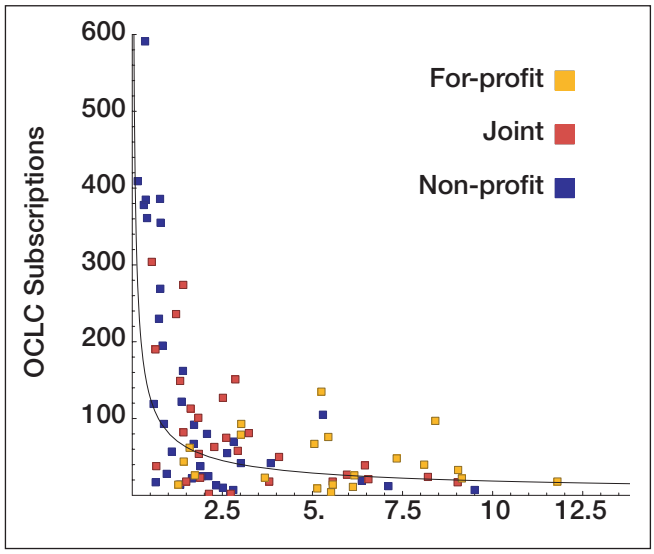

Figure 5. *OCLC subscriptions as a function of price per recent citation. Non-profit journals are shown in the blue, for-profit journals are shown in yellow, and jointly published journals are shown in red. The solid black curve shows the best fit under a model with constant elasticity of demand:* $y = e^{4.41 - 0.64 \ln x}$.

(OCLC 2005) to estimate circulation rates for ecology journals. This database records journal holdings, volume by volume, for a sample of US libraries, accounting for roughly one third to one fifth of total US subscriptions.

The top-tier non-profit journals, published by scholarly societies, are the most widely circulated. This is not surprising; in general, these journals have been around longer, have better reputations, are cheaper per page, and are more widely cited than their competitors. Table 3 lists the 20 ecology journals that have the largest circulations according to the OCLC database.

The magnitude of the circulation differences is more surprising: a small number of journals are held by a very large number of libraries and a large number of journals are held by a relatively small number of libraries. A good fraction of this variation can be attributed to differences in the value offered. Figure 5 shows the OCLC circulation as a function of price per recent citation, along with a trend line indicating the best fit under the common assumption that the price elasticity of demand – the fractional change in demand resulting from a fractional change in price – is constant. This fit suggests that doubling the price or halving the citation rate reduces circulation by more than 35%. Librarians appear to be basing subscription decisions upon criteria similar to, or at least highly correlated with, the price-per-citation measure. In theory, some of this pattern could be explained by causality operating in the opposite direction: broader circulation could in principle reduce journal prices by reducing the average cost of production.

A cautionary tale

In 1844, 15 years before the publication of *The Origin of Species*, Charles Darwin published a pair of articles (Darwin 1844a,b) in a fledgling natural history journal, *The Annals and Magazine of Natural History*. This journal had been founded by publisher Richard Taylor and his son William Francis in 1840, merged several British natural history titles dating back to 1828. The journal published five of Darwin's papers in total. Darwin's contributions to *The Annals* focused on the specifics of natural history rather than on the theory of evolution. However, the journal earned a prominent place in the history of evolutionary biology, as the venue for Alfred Russell Wallace's 1855 manuscript "On the Law which has regulated the Introduction of New Species" (Wallace 1855) In that paper, published 3 years before the famous Darwin–Wallace outline of natural selection (Darwin and Wallace 1858), Wallace drew upon his own phylogeographic observations to conclude that new species must arise from pre-existing species, giving rise to a tree-like relationship among taxa.

One hundred and fifty years later, *The Annals and Magazine of Natural History* continues to be published, still under the name of Taylor and Francis, which has morphed into an international publishing conglomerate that publishes 800 periodicals. The journal is now titled *The Journal of Natural History*. Perhaps due to shifts of scientific fashion, the journal's prestige is not what one might expect given its history: its impact factor was an unimpressive 0.611 at the time of our first survey in 2001. While the 2001 price per page, $0.77, was modest for a for-profit publisher, the price per citation, $19.21 was among the highest in the field of ecology.

Taylor and Francis responded to the low impact factor in two surprising ways. First, they increased the size of the journal, from 2323 pages in 2000 to 3347 pages in 2004. Second, they dramatically increased the price, from $1784 for print in 2001 to $6735 for the print plus online combination in 2005. Even accounting for the increased number of pages, this represents a near-doubling of the price per page. By 2004, the impact factor had dropped to 0.514 and price per recent citation rose to a staggering $90.37. (Only the translated *Russian Journal of Ecology* is more expensive per recent citation; the next closest is *Ekologia Bratislava*, which costs $34.50 per recent citation.)

Why is it that, despite its low impact factor and falling subscriptions, Taylor and Francis has radically increased the subscription price of the oldest journal in ecology, and the only one that can claim Darwin as an author? Evidently the publisher is banking on the proposition that libraries will be slow to cancel a journal with such an illustrious history, even at $6735 per year. In the long run, it is unlikely that pricing at $90 per recent citation is sustainable. We suspect that the journal may be heading into a "death spiral" of increased prices, reduced circulation, and falling impact factor. Although the publisher may earn substantial profits along the way, charging ever higher prices to ever fewer subscribers, this would be a sad end for a venerable publication.

What can an ecologist do?

After speaking on this subject at a recent society meeting, one of the authors (CB) was approached by a colleague who commented, "That was all very interesting, but it's utterly irrelevant to us. You need to be telling librarians, not practicing scientists, about these results. They're the ones who buy the journals."

We disagree! First of all, academics have considerable influence over the subscription decisions of the libraries that serve them. Librarians commonly look to faculty and graduate students for guidance in their subscription decisions. As practicing scientists come to a more sophisticated understanding of the prices that various journals charge for access, and of the value that they deliver, they will be able to make better recommendations to their librarian colleagues.

Even if researchers had no influence on the libraries' subscription decisions, there are strong reasons to be concerned about the facts reported here. Many of us are authors as well as readers – and as authors, we benefit from publishing in venues that are widely read. Authors who benefit from broad distribution should therefore be critically concerned with the most direct measure of this distribution: the circulation of a journal. Unfortunately, circulation is not generally available from the publishers or even from third-party databases. Given the strong relation between price and circulation, authors would do well to factor journal pricing into their decisions about where to submit their work. Such information is available from pricing websites such as Bergstrom and McAfee's www.journalprices.com. Authors may also wish to consult with librarians, who typically have good information about journal price and value, when deciding where to submit their work.

In the sections above, we have illustrated large price differences among ecology journals; similar patterns are observed in other fields, including physics (Barshall 1986a,b), mathematics (AMS 2005), and economics (Bergstrom 2001). Here we have also shown that circulation is both highly variable and strongly responsive to price. Thus, when deciding whether to submit one's work to a society journal, *Ecology Jeremiads*, or to a for-profit journal, *Ecology Philippics*, one would do well to recognize that, despite similar impact factors, the former costs roughly a fifth as much per page and that, as a result, it is found in three times as many university libraries as its competitor.

Finally, from the broader community perspective, the scientific community as a whole would benefit if overpriced journals were displaced by journals priced at or near average cost. The fraction of library budgets that is currently going to the shareholders of large commercial publishers could instead be used to provide services of genuine value to the academic community. Professional societies and university presses could help by expanding their existing journals or starting new ones. Individual scholars could advance this process in many ways: by contributing their time and efforts to the expansion of these non-profit journals, by refusing to do unpaid referee work for overpriced commercial publications, by self-archiving their papers in preprint archives or institutional repositories, and by favoring reasonably priced journals with their submissions.

References

American Mathematical Society (AMS). 2005. AMS journal price survey 1999–2004. www.ams.org/membership/journal-survey.html. Viewed 19 September 2006

Association of Research Libraries. 2005. ARL Statistics 2003–2004. Washington, DC: ARL Publications.

Barshall HH. 1986a. The cost-effectiveness of physics journals. *Physics Today* **41**: 56–59

Barshall HH. 1986b. The cost of physics journals. *Physics Today* **39**: 34–36.

Bergstrom CT and Bergstrom TC. 2001. The economics of scholarly journal publishing. http://octavia.zoology.washington.edu/publishing/. Viewed 19 September 2006.

Bergstrom CT and Bergstrom TC. 2004. The costs and benefits of library site licenses to academic journals. *P Nat Acad Sci USA* **101**: 897–902.

Bergstrom TC. 2001. Free labor for costly journals? *J Econ Perspect* **15**: 183–98

Darwin C. 1844a. Observations on the structure and propagation of the genus *Sagitta*. *Ann Mag Nat Hist* **13**: 1–6.

Darwin C. 1844b. Brief descriptions of several terrestrial planariae, and of some remarkable marine species, with an account of their habits. *Ann Mag Nat Hist* **14**: 241–51.

Darwin C and Wallace AR. 1858. On the tendency of species to form varieties; and on the perpetuation of varieties and species by natural means of selection. *J Proc Linnean Soc Lond* **2**: 45–62.

Frazier K. 2001. The librarians' dilemma: contemplating the costs of the "Big Deal". *D-lib Mag* **7(3)**.

Hahn K. 2006. The state of the large publisher bundle: findings from an ARL member survey. *ARL Bimonthly Report* **245.** www.arl.org/newsltr/245/bundle.html. Viewed 19 September 2006.

Harnard S. 2001. The self-archiving initiative. *Nature* **410**: 1024–25

Journal Citation Reports. 2005. Thompson Scientific, Institute for Scientific Information.

Kryillidou M. 1999 Spending more for less. *ARL Bimonthly Report*. **204**.

Online Computer Library Center (OCLC). 2005. OCLC Worldcat Database, 2005. www.oclc.org/worldcat/default.htm. Viewed 19 September 2006.

Wallace AR. 1855. On the law which has regulated the introduction of new species. *Ann Mag Nat Hist* **16**: 184–96.

