Do terrestrial ecologists ignore aquatic literature?

Peer-reviewed letter

Conducting research that results in widely applicable, general concepts is a prime motivation for ecologists, and is key to advancing our understanding of community and ecosystem functioning. However, this can be hindered by a relative lack of awareness of progress in systems outside a researcher's expertise. For example, despite the broad applicability of many ecological concepts to all systems (Halley 2005; Paine 2005; Raffaelli *et al.* 2005), a communication gap exists between aquatic and terrestrial ecologists (eg Steele 1991; Chase 2000; Richardson and Poloczanska 2008).

Prompted by reports of criticisms from reviewers and editors that submissions of papers on marine ecology topics lacked generality (eg Underwood 2005), we examined generality as reflected in citation patterns of marine, freshwater, and terrestrial papers in publications focused on each of these three habitats. Reasoning that an indirect measure of an author's attentiveness to the broader literature should be how frequently each author cites papers from other systems, we surveyed seven general ecological journals with the highest impact factors (www.isiwebofknowledge.com; WebFigure 1; WebPanel 1; WebTable 1). We estimated the proportions of marine, freshwater, and terrestrial citations within marine, freshwater, and terrestrial publications. To assess the publication scenario against which these citation frequencies occurred, we summarized the frequencies of all marine, freshwater, and terrestrial papers in each journal. Hereafter, "aquatic" refers to marine and freshwater combined.

Citation frequencies of papers from other habitats were markedly asymmetric, leading to the rejection of hypothesis H_1: *the proportion of citations of papers is similar across all habitats* (Figure 1; WebPanel 1; WebTable 2). Log-likelihood analysis of frequencies resulted in rejecting hypothesis H_2: *the proportion of citations reflects the frequency of papers published* (WebPanel 1; WebTable 3). Although publication frequencies were higher in terrestrial versus aquatic papers (Figure 2; WebPanel 1; WebTable 3), citation frequencies of terrestrial papers were more strongly skewed than those of aquatic papers (WebPanel 1; WebTable 3). Thus, terrestrial ecologists do not cite aquatic papers as often as aquatic ecologists cite terrestrial papers, and this difference is not explained by differences in publication frequency.

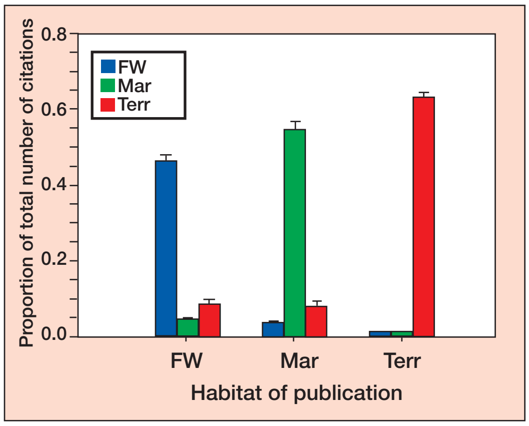

Figure 1. Frequencies of citation of papers from freshwater (FW), marine (Mar), and terrestrial (Terr) habitats in papers from each of these three habitats. Error bars represent 1 standard error of the mean.

It is possible that the higher frequency of publication of terrestrial papers (Figure 2) generates higher terrestrial citation frequencies in aquatic papers. This difference might therefore simply reflect the numerical predominance of terrestrial ecologists. However, the analyses' results do not support this hypothesis (WebPanel 1).

The overall publication rate of terrestrial papers in the "general" ecology journals was six to seven times higher than that of aquatic papers, suggesting that terrestrial journals may be more common than aquatic journals. However, using the Journal Citation Reports database (www.isiwebofscience.com), we determined the frequencies of general, terrestrial, and aquatic ecological journals: 47% (n = 63), 11.1% (n = 15), and 42% (n = 57), respectively. The greater number of aquatic versus terrestrial journals contradicts the notion that publication frequencies simply reflect a larger community of terrestrial ecologists.

Most journals with high impact factors are general/terrestrial (eg WebPanel 1; WebTable 1). None of the top 20 journals, and only six of the top 40 journals, were exclusively aquatic. Average impact factor for general/terrestrial journals was approximately double that for aquatic journals (WebPanel 1; WebTable 4). Aquatic ecologists evidently have more limited opportunities to publish in high-impact "general" journals than do terrestrial ecologists.

This imbalance should concern all ecologists. Impediments to "cross-fertilization" of advances between fields hinder progress. Both aquatic and terrestrial systems have been fruitful in

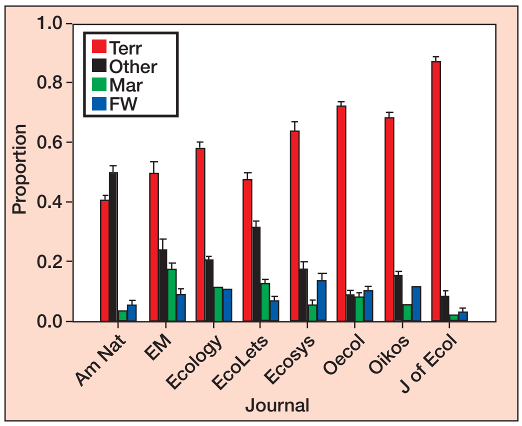

Figure 2. Frequencies of publication of terrestrial, "other", marine, and freshwater papers from 2002–2006 for seven general journals surveyed, with 3 years (2002–2004) of data from Journal of Ecology *for comparison. Based on a total of 5824 papers, with 3516 terrestrial, 1302 "other", 542 freshwater, and 464 marine. Totals by journal were 766 in* American Naturalist *(Am Nat), 151 in* Ecological Monographs *(EM), 1617 in* Ecology*, 676 in* Ecology Letters *(EcoLets), 322 in* Ecosystems *(Ecosys), 912 in* Oecologia *(Oecol), 1116 in* Oikos*, and 264 in* Journal of Ecology *(J of Ecol). Error bars represent 1 standard error of the mean.*

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generating broad ecological concepts. Terrestrial ecology would be very different if concepts like keystone predation (Paine 1966), ecological stoichiometry (Redfield 1934), and trophic cascades (Carpenter *et al.* 1985) had not diffused from aquatic research. Likewise, advances such as metapopulation dynamics (Hanski 1989), island biogeography (MacArthur and Wilson 1967), and watershed biogeochemistry (Bormann and Likens 1967) have enriched aquatic ecology. Clearly, diverse life-history strategies, divergent scales of processes, and varying suites of methodological approaches across the aquatic–terrestrial continuum mean new advances will emerge where research is most tractable and productive, irrespective of habitat type. Persistence of citation asymmetry may marginalize an even larger fraction of aquatic research to more specialized, lower-impact journals (WebPanel 1; WebTable 1), and cause it to be viewed as intellectually parochial. The pace of new conceptual and technical discoveries may suffer if the full benefits of intellectual exchanges continue to be asymmetrical.

This issue could be resolved by (1) easing pressure on aquatic authors to cite non-aquatic literature or (2) increasing pressure on terrestrial authors to cite aquatic literature. As we "scale up" from local to global perspectives, use more interdisciplinary approaches, and examine connections between adjacent ecosystems (eg Polis *et al.* 1997; Loreau *et al.* 2003), cross-system communication is necessary. We urge editors and reviewers to equalize pressure on authors to cite broadly, regardless of habitat. A "sea change" could result from bottom-up pressure from the scientific community on the publication process.

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Please refer to the WebReferences and WebPanel 1 for the references and acknowledgements, respectively.

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Wildlife-friendly farming vs land sparing

Fischer *et al.* (*Front Ecol Environ* 2008; **6[7]**: 380–85) discussed the important debate between approaches addressing the global biodiversity crisis and the pressures to provide for the increasing human population. Although we agree with the general thrust of their argument, we feel that they miss several crucial points in comparing "land sparing" (intensifying agriculture in some areas to save biodiversity elsewhere) and "wildlife-friendly farming" (farming that integrates conservation and production).

First, their argument regarding lower yields in wildlife-friendly farming might be better supported with more recent literature. For example, Badgley *et al.* (2007) reviewed 293 examples comparing alternative and conventional agriculture from 91 studies (broadly speaking, alternative agriculture may be considered as "wildlife friendly"). This study found that even under conservative global estimates taking nitrogen sourcing into account, alternative agriculture could provide almost as much food on a caloric basis as is produced today by conventional means, whereas the more realistic estimate indicated the potential for a substantial increase in production. Likewise, many farmers in poorer nations use low-intensity or subsistence methods – intensification, either by conventional or wildlife-friendly means, would increase yields. Considering the biodiversity-related benefits of wildlife-friendly agriculture, these findings alone obviate much of the basis for the "land sparing" approach.

We also feel that a more skeptical view (questioning whether "sparing land for nature" schemes work) is warranted, as we are unaware of any *empirical* evidence showing that any type of intensification can reliably yield "spared land". We would add that (1) intensification itself may produce economic incentives encouraging expansion of the intensified land base, possibly endangering the very land that is to be saved (Perfecto and Vandermeer 2008), and (2) population pressure and hunger have little direct relationship with actual agricultural production. To the latter point, it is capitalization and conspicuous consumption that most affect agricultural expansion, since enough food is already produced on a caloric, *per capita* basis (Badgley *et al.* 2007). Often, increased production does little for the poorest people, who lack effective economic demand (eg Patnaik 1991; Waldman 2002).

Continuing business-as-usual (as assumed by Balmford *et al.* 2005) means overconsumption by some, while others remain hungry. Addressing socioeconomic inequalities has the potential to decrease the need for agricultural expansion. Without a relinking of resource use to actual need, there is little reason to think expansion would stop if or when the global population stabilizes. By overlooking such points, Fischer *et al.* miss perhaps the most important point of contention in the "sparing land" debate. Inclusion of these factors would strengthen their valuable call for careful consideration of options in this crucial area.

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