human welfare and the biological variables that conservation planners seek to maximize (e.g. global number of species) are rare [7]. However, we know that species-poor habitats supply important environmental services [6] and that society's preferences for species and habitats might not coincide with those of 'experts' [7,8]. Hence, the value of conservation is unlikely to have a simple correlation with any purely biological variable. Naidoo *et al.* [1] note that the variability of conservation costs often exceeds that of proxies for benefit (e.g. species richness), implying that attention should be focussed on costs. If benefits were measured directly, this might not be true: further investigation of the economic benefits of conservation is merited.

We must be alert to hidden value judgments when the benefits of conservation are measured using biological proxies, and species are traded off against one another by experts. More positively, and to echo the conclusions reached by Naidoo *et al.* [1] for costs, we believe that incorporating economic benefits into conservation planning will result in greatly increased efficiency of conservation, defined as its net effect on present and future human welfare.

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Letters Response

Response to Hockley: The merit of economic and biological measures in conservation planning

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We welcome Hockley *et al.*'s response [1] to our recent article in *TREE* [2] and have few disagreements with its central argument. In particular, we agree that research into the economic benefits provided by natural systems is sorely needed. In our review, we did not intend to advocate that conservation benefits be measured solely in biological terms; we focused on biological measures because they were used by most of the cost studies that we examined. Because our review topic was the cost side of conservation, we are grateful for this opportunity to stress the importance of conservation benefits. Indeed, a significant amount of our own research involves quantifying the value of ecosystem services [3–5].

However, we do wish to highlight several important issues surrounding valuation of the benefits of conservation that are not raised by Hockley *et al.* First, we disagree with the notion that quantification of the economic benefits of conservation is as straightforward as using biodiversity metrics such as species richness. In our experience, comprehensive valuation of ecosystem services, especially in a spatial context, is challenging, owing to the necessity of combining estimates of flows of diverse services (many of which are barely characterized, let alone properly understood) with spatially explicit information on beneficiaries, prices and preferences [6].

In principle, quantifying all the economic benefits of conservation would enable us to compare costs and benefits directly. Given the enormity of this task, however, it might be more immediately useful to keep biodiversity measures in their native, non-monetary units; doing so can provide valuable insights into the tradeoffs between biodiversity and conservation cost [7]. Far from being illogical, this 'cost-effectiveness' analysis has provided much useful information to policy-makers in varied cases from environmental, health and policy arenas [8].

Finally, Hockley *et al.* appear to believe that if only we could quantify all the economic benefits of conservation, we would arrive at a value-free 'correct' estimate of the worth of an ecosystem. However, valuation by definition involves

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a host of value judgments: whose benefits should be estimated [9]? How should disparities in wealth be dealt with? Which are the appropriate measures of welfare changes [10]? Which of the multitude of ecosystem services should be considered in an analysis [11]? All of these require judgments on the part of researchers that are no less value laden than those associated with biodiversity measures. In addition, some aspects of nature's worth are simply not amenable to economic valuation and will never be captured in a cost–benefit analysis [12].

For these reasons, it seems sensible to increase research on the economic benefits of conservation, while recognizing that improved measurements of biodiversity will (and should) continue to have a central role in conservation planning.

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Book Review

Does an Earth system perspective provide fundamental insights into ecology?

Fundamental Processes in Ecology: An Earth Systems Approach by David M. Wilkinson, Oxford University Press, 2006. £45.00, hbk (200 pages) ISBN 978 0198568469

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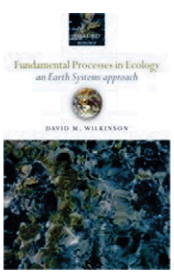

Earth systems science focuses on exciting and integrative concepts that have emerged in the past few decades, catalyzing synthetic research among a variety of disciplines and examining processes that link the atmosphere, hydrosphere, geosphere and biosphere. Ecology is a key component of Earth system science, but an Earth systems perspective has yet to emerge strongly in ecological journals. In *Fundamental Processes in Ecology: An Earth Systems Approach*, Wilkinson argues that an Earth systems perspective leads to the question, 'what are the fundamental processes in ecology?' and thereby provides a novel and thought-provoking organizational framework for ecology.

From the perspective of ecologists, arguably the most intriguing aspect of Earth system science is the Gaia hypothesis, which characterizes the relationships among the biosphere and the other 'spheres' on Earth: atmosphere, hydrosphere and (less euphoniously named) geosphere. The Gaia hypothesis asserts that life alters and stabilizes the environment and that these changes contribute to the persistence of life. Wilkinson focuses the chapters of his book on six 'fundamental processes' in ecology through which life interacts with the environment to produce conditions that are favorable to life: (i) energy flow; (ii) the formation of multiple guilds; (iii) the development of biological diversity; (iv) ecophysiology; (v) photosynthesis; and (vi) carbon sequestration. For each of these processes, he pursues several questions (which he calls 'thought experiments'), many of which are inspired by the Gaia hypothesis. For example, in the chapter on biodiversity, Wilkinson discusses whether the existence of tradeoffs (i.e. adaptations that favor survival of a species under one set of conditions but not under others) would be expected to favor speciation; he then considers whether speciation would tend to make a diversity of species more stable.

The Gaia hypothesis, specifically the concept that life involves processes whose feedbacks are positive or negative for life, provides an intriguing point of departure and unifying theme for the book. Within each chapter, Wilkinson pursues this general question using observations from present and past ecosystems to explore several specific questions. In places, he adopts metaphors from sports or finance to illustrate his arguments and much of his reasoning involves simple mathematical models.

Although all the fundamental ecological processes addressed by Wilkinson can be observed today, their origins and (according to the Gaia hypothesis) initial positive

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