

**Response to letters concerning Bateman et al., *Science*, 341: 45-50, 5<sup>th</sup> July 2013. DOI: 10.1126/science.1234379**

We are grateful for each of these letters and particularly appreciate the many positive comments therein. Obst et al., provide a welcome opportunity to clarify the difference between environmental-economic cost-benefit analyses (such as ours) and environmental accounting exercises (such as the UN-SEEA (<sup>1,2</sup>) initiative). Put simply, accounting studies attempt to assess the total value of ecosystem service (ES) related goods in a manner comparable to that used for market priced goods in national accounts. This tells the decision maker about the relative value of these differing goods and a decline in the ES account over time signals a potential need to invest in underlying natural capital. However, such accounts do not indicate the form of that investment. Environmental economic analyses, such as ours, typically consider changes in value from the status quo provided by alternative investments; identifying those which yield higher value for money. There are some other fairly important differences between economic analysis and accounting (e.g. the former typically allow for changes in the unit value of ES related goods as their supply changes). However, as outlined above, the two approaches are complements rather than substitutes and serve differing but highly compatible elements of the decision making process.

Graham et al., criticize our use of “the value of non-market goods like biodiversity” which is an unfortunate choice of critique as this is the one ES which we explicitly do not attempt to define in terms of economic values, noting throughout the paper that available estimates are unreliable and instead applying a non-monetary quantitative constraint prohibiting the degradation of biodiversity within our scenario analyses. That aside, the claim by Graham et al., that we should not have compared non-market values for (other) ES with the market price of agricultural output ignores the fact that, as stated, we are conducting an economic analysis of marginal changes from the status quo and not attempting to assess the total value of food (see <sup>3</sup>, p.48). In such assessments of changes, the use of market prices is standard (<sup>4</sup>). Indeed, there is an argument (ibid.) that such analyses should subtract subsidies (including income support) which would reduce agricultural values (<sup>5</sup>). However, we agree with their remaining comments regarding wider matters.

As we state elsewhere (<sup>6</sup>) a variety of factors make the future balance of global food supply and demand increasingly uncertain. This means that the UK (and indeed many countries) should be wary of irreversible reductions in its potential to deliver increased food security in the future. However, this does not imply that present improvements should be ignored; ES are crucial to both the sustenance and quality of life. More fundamentally, as future food security depends upon underpinning natural capital stocks, it is essential to ensure the sustainability of the ecosystem service flows provided by those stocks. Finally, the Graham et al., comment on climate change allows us to expand on this issue, confirming that UK farming will generally benefit from warmer temperatures but noting that (as detailed in (<sup>7</sup>)) within areas of lower rainfall, increased droughtiness has the potential to reverse these gains.

We agree with Aspinall and Gregory that it would be better to consider net profits rather than farm gate prices, although again this would have reduced estimates of agricultural values. The need to link land use to its ES impacts mitigated in favour of using Agricultural Census<sup>8</sup> data which omits profits. We are currently addressing this through a link to the Farm Business Survey<sup>9</sup> database. However, we disagree with the authors’ contention that we should have included the added-value of post-farm food processing. Aside from the fact that

the UK food processing industry is a major importer of non-UK produce, such an approach would be analogous to valuing timber at the price of fine furniture. It is the raw material value which is relevant here. Similarly, we emphasise throughout the paper and SM that our analysis explicitly links agricultural land use to its impacts upon the ES considered.

Finally, we readily agree with Turner et al., that our analysis is far from the last word in this field and that, while the study emphasizes the importance of spatially explicit analyses, it fails to capture all of the complex inter-relations generated by both the physical and social configuration of real world environments. Such an advanced analysis needs to consider not only the 'supply side' of ecosystem services but also the 'demand side' of human interaction with those services through which values are generated. Nevertheless, we believe that even our imperfect analysis is an improvement over the default of leaving decisions to the market. Furthermore, we feel that advances in research will, within the present decade, yield integrated analyses which capture most major ES processes in an acceptable manner and that, through the use of high-speed computing processes, optimal (either cost minimising or, more challengingly, value maximising) solutions for land use change can be identified even for highly heterogeneous and densely populated countries such as the UK.

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