Letter to the Editor

Ecosystem service models are indeed being validated: A response to Pereira et al. (2025)

In their recent paper Pereira et al. (2025) claim that validation is overlooked in mapping and modelling of ecosystem services (ES). They state that *"many studies lack critical evaluation of the results and no validation is provided"* and that *"the validation step is largely overlooked"*. This assertion may have been true several years ago, for example, when Ochoa and Urbina-Cardona (2017) made a similar observation. However, there has been much work on ES model validation over the last decade.

To evidence our point, we carried out a search on Web of Science (WoS) for papers published between the start of 2015 and 14th August 2025 using the search term: model* (Title) and "ecosystem services" AND valid* (Topic). Papers comparing model outputs with independent data may not always use the term 'validation', as multiple alternative terms with less clear definitions might be used: 'evaluation', 'exploration', 'testing', etc. So, our search should be seen as a conservative test. This search gave 330 papers overall, showing a steady increase in numbers over the years, with a peak of 39 in 2023. Running the search again without the 'valid*' term gave us 2,676 papers: so those mentioning validation form 12 % of this total. From the 330 papers mentioning validation, we selected the 25 that WoS deemed most relevant. Of these, 12, roughly half, presented some form of validation of their modelling approach. So, the research literature shows numerous examples of ES model validation, suggesting an increasing robustness over recent years. This is likely in part due to the earlier calls for model validation, such as by Ochoa and Urbina-Cardona (2017), and a widespread recognition of the importance of validation amongst peer reviewers and journals. Hence, we show that validation is commonplace, although an understanding of the exact extent would require a full systematic review.

Some of our own papers illustrate the advances in ES model validation over the last decade. Redhead et al. (2016)—the most cited paper of the WoS search—broke new ground by validating the InVEST water yield model at a national scale. Willcock et al. (2019) validated multiple models of five different ES at a continental scale— across sub-Saharan Africa. Finally, Willcock et al. (2023) modelled multiple versions of models for three different ES globally, using validation methods to show that model ensembles are more accurate. In many cases, validation has resulted in improvements to the original model and the publication of the validated parameter values, allowing future use of the model in similar contexts potentially without the need for further validation.

Pereira et al. (2025) do make the valid point that cultural services are harder to validate than biophysical services. However, it is worth pointing out that validation has also been carried out for cultural service models, especially for those representing recreation services (e.g., Willcock et al., 2023).

A further point is that, while it is important to validate models to ensure they can be applied generally, it is not essential to validate their every use, and it certainly should not be *"mandatory"* as suggested by Pereira et al. (2025). Modelling is used generally because empirical ES data are not available or are spatially sparse. This facility is especially important for less well studied parts of the world, for example in the Global South (Willcock et al., 2019). Expecting validation in data-poor regions could lead to erroneous conclusions about model capabilities. Pereira et al. (2025) also state that *"Several mistakes are made in models' validations, such as validating one model with the results of other models that may already have an error"*, but this overlooks the fact that errors and biases may be equally inherent in empirical data. Each empirical dataset has associated uncertainties, and the 'true' value of an ES can never be absolutely determined (Willcock et al., 2023): a risk which is exacerbated in regions where data availability is and will remain poor.

In conclusion, whilst we support calls to collect more empirical data to further understanding and reiterate the importance of model validation efforts, we suggest that Pereira et al.'s claim that validation is overlooked does not reflect recent advances and the state of the art, whilst the assumption that validation should be mandatory is unfeasible and ignores the potential to draw lessons from the existing body of model validation literature.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

James M. Bullock: Writing – original draft, Conceptualization. **Danny A.P. Hooftman:** Writing – review & editing. **John W. Redhead:** Writing – review & editing. **Simon Willcock:** Writing – review & editing.

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