centralized, transparent and well-documented procedures for data processing, provenance and metadata. Data contributors from outside these infrastructures should receive clear guidelines, and their data should only be accepted when they can prove that they have followed the guidelines.

The community must accept that complex terrain cannot be ignored in integration studies. The basic hypothesis that different influences of terrain balance each other out in big data sets has been falsified here, at least for towers located in terrain with TDA higher than 300 m. Sites in terrain with lower TDA have also been shown to be affected by terrain[7], but with the relatively simple approach used here this cannot be proved statistically. More effort must be invested here, and until the problem of complex terrain has been solved, infrastructures and integration networks should clearly communicate possible terrain influences to data users.

Finally, it is important to consider all important factors and additional information when deriving general ecological hypotheses. In the present case, fertilization experiments (for example on clearcuts) could support the various ideas.

Overall, the re-analysis shows that the ecological conclusions drawn by Fernández-Martínez *et al.*[1] are not justified. Nevertheless, the re-analysis also shows that the eddy covariance method as such, although not applicable in all terrains, allows important insights into the ecology of forest ecosystems. The most important result is the strong correlation between GPP and ecosystem respiration. A CUEe between 0 and 0.3 with an average around 0.15 may be a reasonable result from this data set for modellers. An ensemble of other factors is likely to influence CUEe within this range. Nutrient availability is certainly one of them[8], but not as unequivocally as claimed. ❐

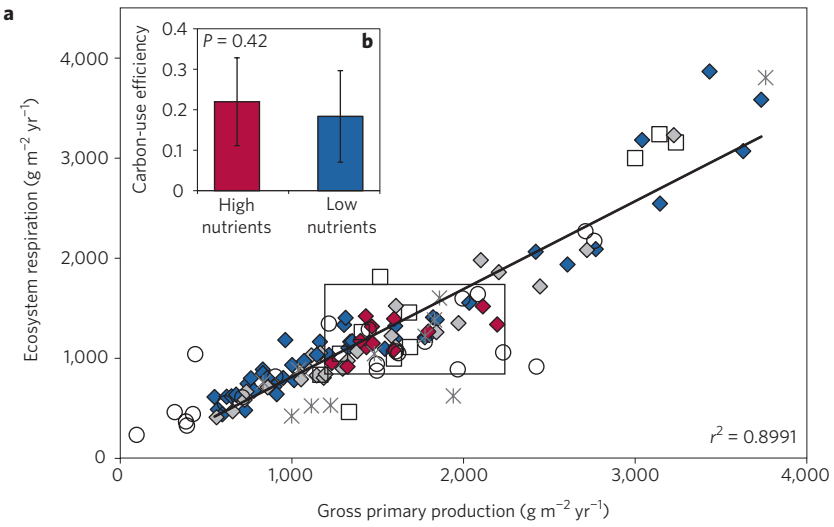

Figure 2 | Ecosystem respiration (Re) plotted against GPP for the remaining 82 sites. **a**, Red: sites with high nutrient availability. Blue: sites with low nutrient availability. Grey: sites with medium nutrient availability. Open squares: sites removed owing to bad data quality and unclosed carbon balance that could not be fixed. Open circles: removed sites younger than 15 years. Grey stars: removed sites with complex terrain. **b**, Average CUEe for sites with low and high nutrient availability with a GPP between 1,200 and 2,300 gC m^{-2} yr^{-1}.

References

1. Fernández-Martínez, M. *et al. Nature Clim. Change* **4,** 471–476 (2014).
2. Luyssaert, S. *et al. Glob. Change Biol.* **13,** 2509–2537 (2007).
3. Grant, R. F. *et al. Tellus Ser. B* **62,** 475–496 (2010).
4. Poeplau, C. & Don, A. *Geoderma* **192,** 189–201 (2013).
5. Belcher, S. E., Harman, I. N. & Finnigan, J. J. *Annu. Rev. Fluid Mech.* **44,** 479–504 (2012).
6. Feigenwinter, C. *et al. Agric. Forest Meteorol.* **148,** 12–24 (2008).
7. Kutsch, W. L. *et al. Ecol. Applic.* **18,** 1391–1405 (2008).
8. Vicca, S. *et al. Ecol. Lett.* **15,** 520–526 (2012).

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Additional information

Supplementary information is available in the online version of the paper.

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Reply to 'Uncertain effects of nutrient availability on global forest carbon balance' and 'Data quality and the role of nutrients in forest carbon-use efficiency'

Fernández-Martínez *et al.* reply — Du suggested in his Correspondence[1] that our analysis[2] was flawed for several reasons and offered a new hypothesis. Our analyses and conclusions were not based on the simple regression presented in Fig. 1 of our paper[2]. The figure was merely meant for visualization purposes, showing the data and the differences between fertile and infertile sites. We relied instead on generalized linear models (GLMs; see Supplementary Information in ref. 2). Our study showed that NEP was affected not only by fertility and GPP, but also by stand age, mean annual temperature, water deficit and management (Table 1 of ref. 2). Conclusions therefore cannot be based on linear regressions restricted to a partial set of predictor variables. Stand age in our models in fact interacted with GPP and therefore presented a nonlinear relationship with NEP, precisely as Du suggests in his conceptual model. The Correspondence further claims that three young forests with the highest carbon-use efficiency (CUEe) confounded our analysis. This claim is incorrect. Our analyses were supported by leverage tests[3], which showed that these sites did not affect our results. Nonetheless, as shown in the Supplementary Information of ref. 2, we repeated all analyses using only data from the eddy covariance towers (excluding these three sites with the highest CUEe), and yet the patterns remained unchanged. Similarly, the comment suggested the use of different GPP ranges, but all analyses in the original paper also excluded all high-GPP

forests and thus used similar GPP ranges for fertile and infertile sites (see Supplementary Information of ref. 2), and the models again revealed a strong nutrient effect on CUEe. Even when excluding the 'uneven sampling effect' (only considering forests with GPPs ranging from ~1,000 to 2,200 gC m^{-2} yr^{-1}) and the conjectured 'outliers' (the three very young forests), nutrient availability remains significant for NEP and CUEe ($P = 0.0064$ and $P = 0.0008$, respectively) in a GLM model also including MAT and GPP (only for NEP) as significant factors.

Werner L. Kutsch and Pasi Kolari[4] also suggested that our analysis was flawed for various reasons. After removing 47 forests from our study (~35% of the data set) for questionable reasons, they suggested that nutrient availability had no significant effect on forest carbon balance and that the results in ref. 2 were driven by a few outliers. Their statement, however, is incorrect. When we analyse the much restricted data set of Kutsch and Kolari using the same GLM as in ref. 2, in contrast to their simple linear model, the effect of nutrient availability on forest NEP remains unequivocal. The GLM model reveals a statistically significant interaction between GPP and nutrient availability on NEP and on Re ($P = 0.026$), and a marginally significant effect of nutrient availability on CUEe ($P = 0.073$).

Kutsch and Kolari's reasons for deleting forests from the analysis were: (1) data quality, (2) history of the young forests, and (3) complex terrain affecting C flux measurements. Regarding these points:

(1) Important in the discussion about unavoidable uncertainties in the GPP, Re and NEP estimates is that inaccuracies (for example typesetting, errors on site-level calculations) were not responsible for our results (that is, there was no bias towards any category of nutrient availability, ANOVA, $P = 0.32$). Moreover, the equation of the carbon balance is not GPP – Re – NEP = 0, as Kutsch and Kolari assumed, but the sum of the variables with their associated errors: GPP $\pm E_{GPP}$ – Re $\pm E_{Re}$ – NEP $\pm E_{nep} = 0 \pm E$. Including these uncertainty terms in the equation is relevant because several sites also provided chamber-based estimates. In this sense, only one of the 129 sites used in our study presented a carbon imbalance larger than the uncertainty. The one site (La Mandria), with many zero values, was included in our visual presentation (Fig. 1 in ref. 2) but not in the statistical analyses upon which we based our conclusions (because stand age was unknown). Therefore this site did not affect our conclusion.

(2) We see no reason to remove forests under 15 years old, as Kutsch and Kolari suggested, because we included stand age as a covariate in our models interacting with GPP. Furthermore, the effect of nutrient availability on CUEe was not driven by young forests (Supplementary Fig. S4 in ref. 2).

(3) The criterion that Kutsch and Kolari suggested of removing sites in complex terrains is questionable, subjective and not generally accepted, in contrast to ustar filtering applied to all sites, which is the most accepted method to address the advection problem. Also, in their Correspondence, differences in CUEe for forests with contrasting TDA cannot be statistically assessed, because they did not present the significance of the test nor the description of the error bars in their Fig. 1.

We agree with Kutsch and Kolari on the general statement of the importance of high standards of data quality in multi-site statistical analyses. However, they failed to demonstrate in their specific comments why data quality, site history or complex terrain should cause a bias in favour of our main hypothesis. We continue to insist on our strong factual base that these 47 forests should not be removed from the original data set. In fact, all the additional analyses performed with subsets of the original data set for points (1), (2) and (3) and with Kutsch and Kolari's data set strengthen our finding that nutrient availability plays a key role in forest carbon balance. ❐

References
1. Du, E. *Nature Clim. Change* **5,** 958–959 (2014).
2. Fernández-Martínez, M. *et al. Nature Clim. Change* **4,** 471–476 (2014).
3. Fox, J. *Regression Diagnostics: An Introduction* (Sage, 1991).
4. Kutsch, W. L. & Kolari, P. *Nature Clim. Change* **5,** 959–960 (2014).

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CORRESPONDENCE:

Clarity of meaning in IPCC press conference

To the Editor — In a recent Letter[1], Hollin and Pearce suggest that the panel at the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report Working Group 1 (ref. 2) press conference fell into a "certainty trap" by presenting an "incoherent" message. We argue that this conclusion is incorrect because the authors misunderstand key points of the panel's message and misrepresent some of the press conference statements.