Supporting Information

Table S1: Modeled regression coefficients with standard errors, standardized coefficients, and *P* values for our regression model when including phosphorus input.

Variable	Unstandardized Coefficients	Standardized Coefficients	*P* value
Intercept	-2.38 ± 1.91	5.61 ± 0.21	0.21
SOC	1.77 ± 0.68	1.47 ± 0.34	0.009
SOC^2	-0.41 ± 0.21	-0.60 ± 0.30	0.047
N input	0.020 ± 0.0017	2.52 ± 0.19	< 0.00001
N $input^2$	-0.000047 ± 0.0000047	-1.99 ± 0.20	< 0.00001
P input	0.0041 ± 0.0021	0.41 ± 0.21	0.045
Irrigation	0.61 ± 0.38	0.60 ± 0.38	0.11
pH	0.12 ± 0.20	0.29 ± 0.47	0.53
Aridity	0.050 ± 0.55	0.040 ± 0.43	0.93
Crop Type	1.57 ± 0.16	1.56 ± 0.16	< 0.00001
Clay (%)	0.020 ± 0.016	0.44 ± 0.36	0.22
Latitude	0.056 ± 0.019	1.43 ± 0.49	0.0044
SOC*N input	0.0033 ± 0.0011	0.83 ± 0.27	0.0024

Not all of our included studies contained specific rates of phosphorus input (n=723); however, we did carry out a regression that included P input. Standardized coefficients did not change significantly from our original model and so we chose not to include P input in our final model because not doing so increased our number of observations.

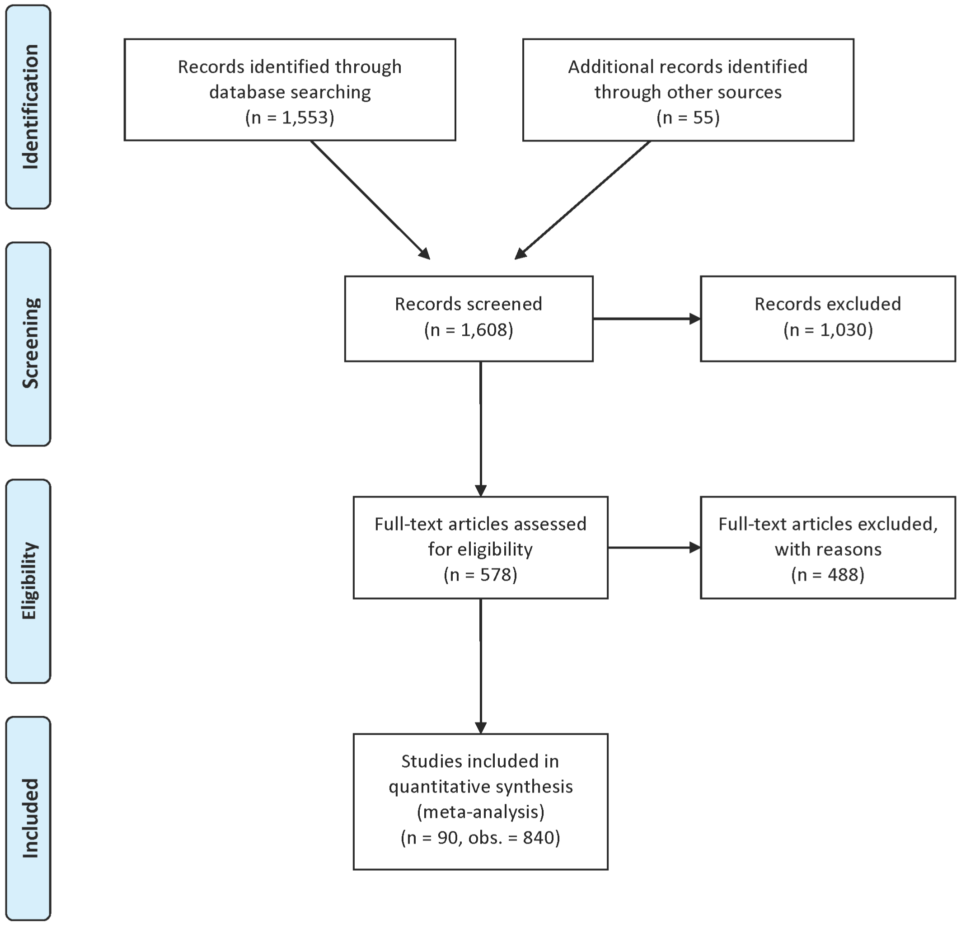

Figure S1: A PRISMA flow chart showing the identification, screening, eligibility, and inclusion process for all articles and observations. Our literature searches from Web of Science and the EviEM database resulted in 1,608 records considered during screening. The 1,030 articles rejected during the Screening stage were rejected because they focused on crops not included in our analysis and/or did not contain yield or SOC data. The 488 articles rejected during the Eligibility stage were rejected for any of the following reasons: They did not include paired experimental (as opposed to baseline) SOC-yield observations, they did not include bulk density data to convert SOC stocks to concentrations, or they did not include N fertilization rates. See Methods for further explanation.

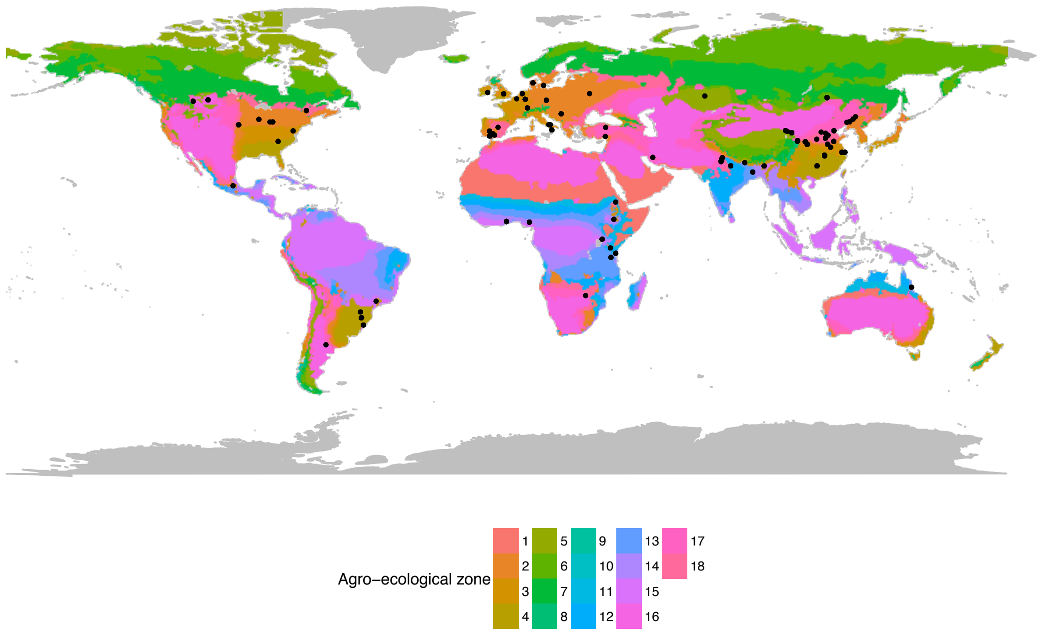

Figure S2: Global map of sites used to establish meta-data set within their respective agro-ecological zone (AEZ). Climate classifications for each AEZ are as follows: 1, tropical arid; 2, tropical-dry semi-arid; 3, tropical-moist, semi-arid; 4, tropical sub-humid; 5, tropical humid; 6, tropical-humid (year round); 7, temperate arid; 8, temperate-dry semi-arid; 9, temperate-moist semi-arid; 10, temperate sub-humid; 11, temperate humid; 12, temperate humid (year round); 13, boreal arid; 14, boreal-dry semi-arid; 15, boreal-moist semi-arid; 16, boreal sub-humid; 17, boreal-humid; 18, boreal humid (year round). Future research should prioritize research in the more arid AEZs, particularly AEZ 2 (tropical-dry semi-arid) and AEZ 3 (tropical-moist semi-arid).

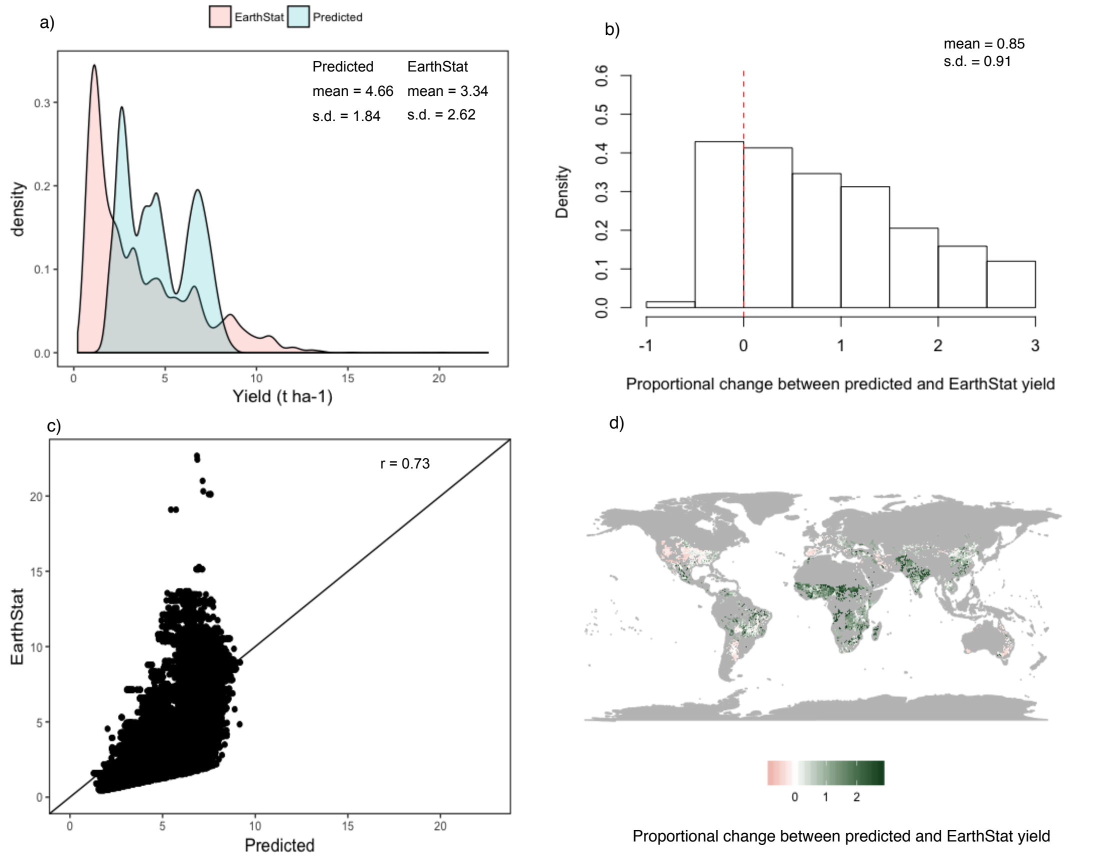

Figure S3: Data quality analysis for EarthStat and modeled maize yields. To ensure global extrapolations based on our regression model were adequate, we performed a number of data checks. (a) Mapped distributions of both predicted global maize yields, calculated by our regression model, and EarthStat global maize yields. (b) Histogram of the proportional change between predicted maize yields and EarthStat yields. (c) A 1:1 plot of predicted maize yields versus EarthStat maize yields. (d) A global map of the proportional change between predicted and EarthStat maize yields. We dropped all cells for which the proportional difference between predicted and gridded data was >3-times. This threshold represents the mean ± half the standard deviation for the distribution of the proportional difference between predicted and EarthStat yield data. Overall, 86% of maize values fall within this range, and there was a relatively strong correlation (r=0.73) between EarthStat and predicted yields, lending credence to our global extrapolations.

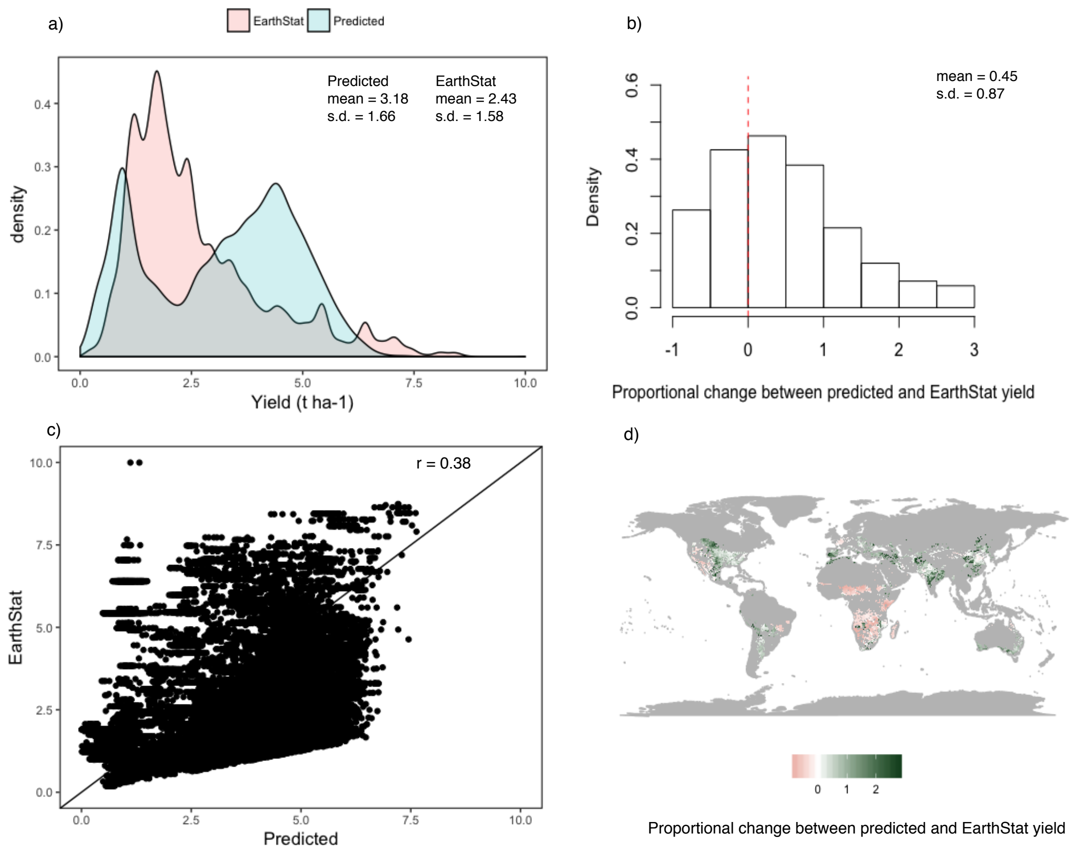

Figure S4: Data quality analysis for EarthStat and modeled wheat yields. The same data checks were applied to predicted and EarthStat wheat yields as in S2 Fig. (a) Mapped distributions of both predicted global wheat yields, calculated by our regression model, and EarthStat global wheat yields. (b) Histogram of the proportional change between predicted wheat yields and EarthStat yields. (c) A 1:1 plot of predicted wheat yields versus EarthStat wheat yields. (d) A global map of the proportional change between predicted and EarthStat wheat yields. For wheat data quality, 93% of model-predicted wheat yields fell within the mean ± half the standard deviation for the distribution of the proportional difference between predicted and EarthStat yield data (i.e. the proportional difference between predicted and gridded data was <3-times) and the correlation coefficient was 0.38.