Nutrients and agriculture

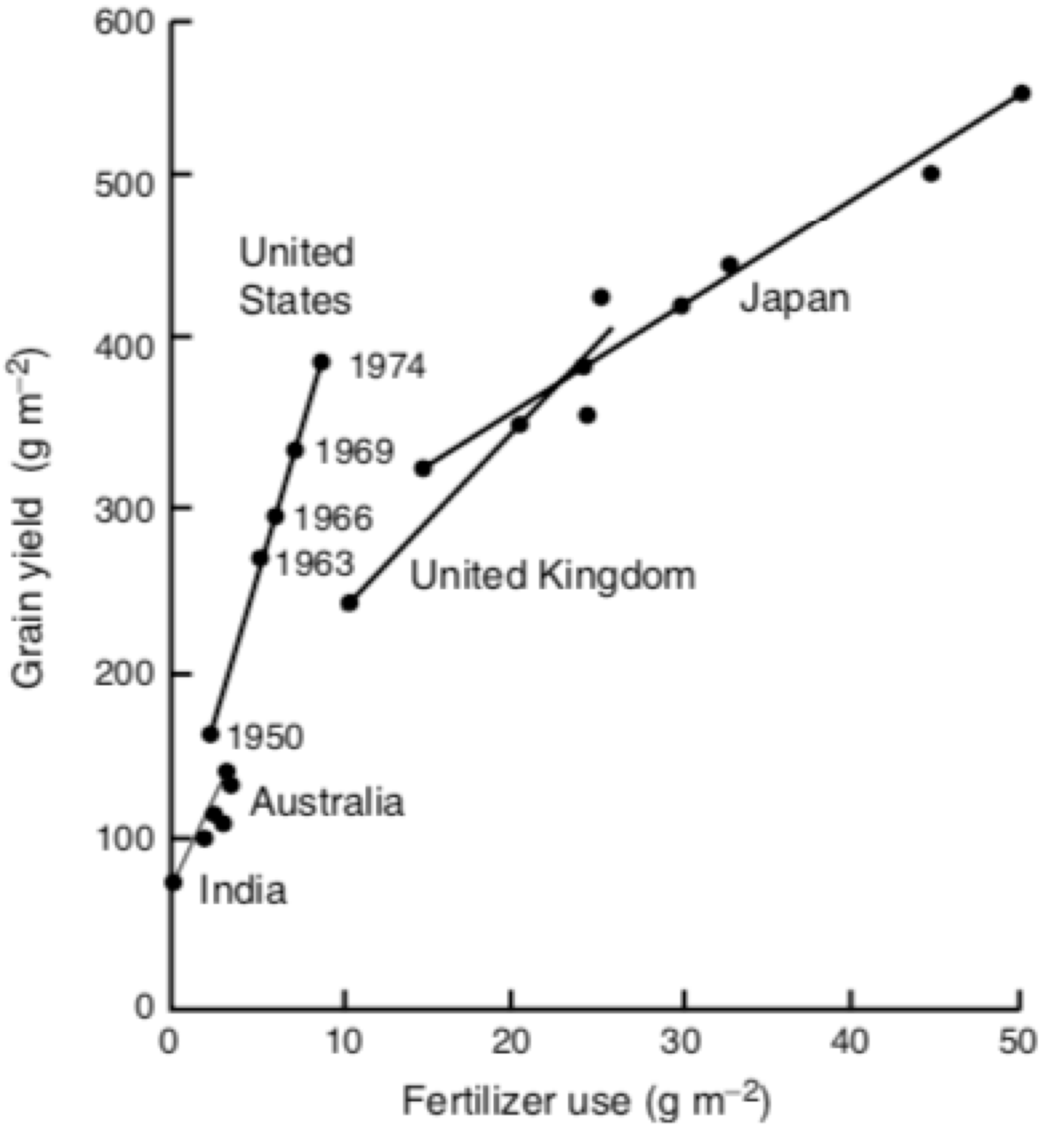
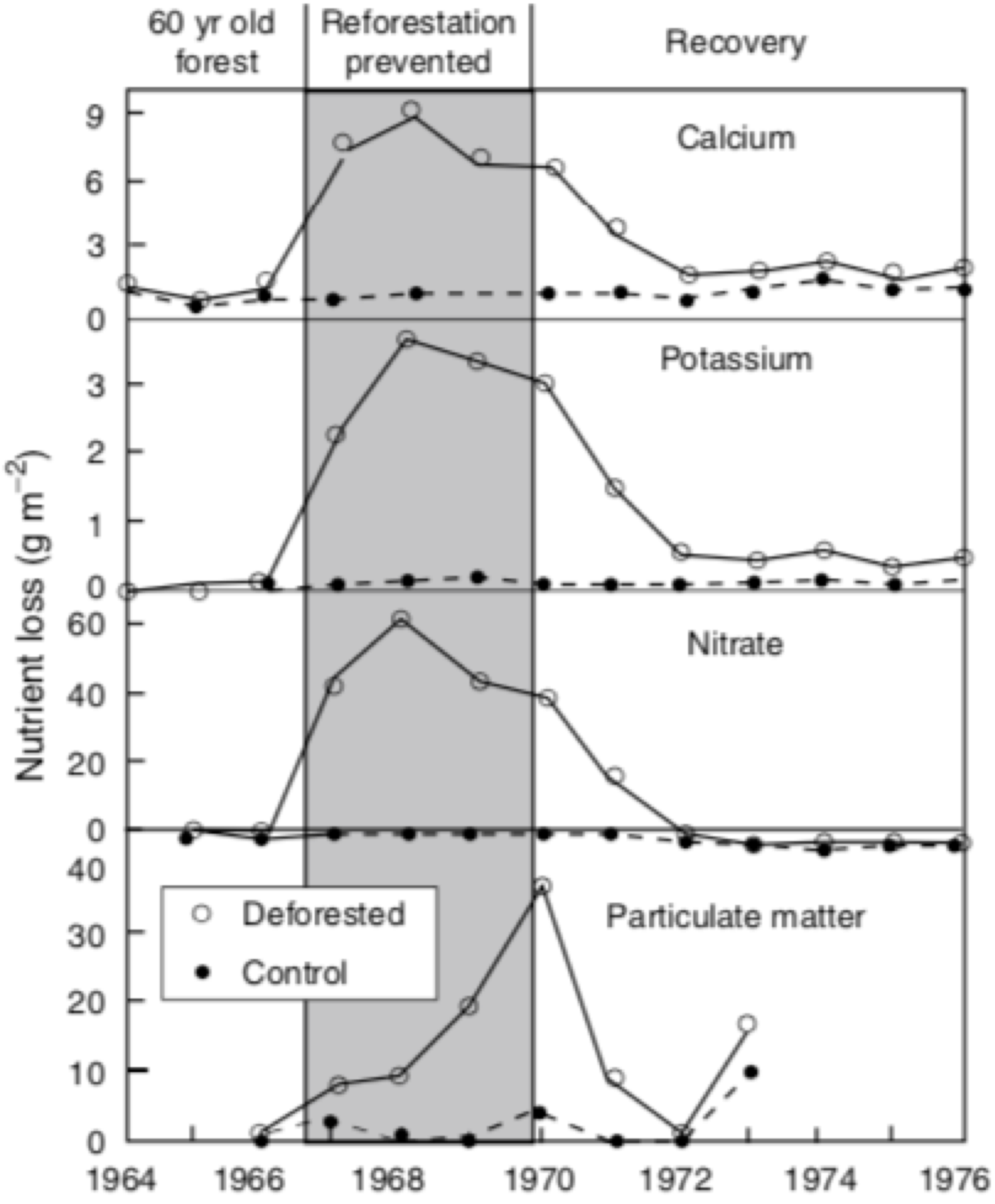

600
500
400
300
200
100
0
Grain yield (g m⁻²)
0
10
20
30
40
50
Fertilizer use (g m⁻²)
United States
1974
1969
1966
1963
1950
Australia
India
Japan
United Kingdom

Fig. 9.14 Losses of calcium, potassium, nitrate, and particulate organic matter in stream water before and after deforestation of an experimental watershed at Hubbard Brook in the northeastern U.S. The shaded area shows the time interval during which vegetation was absent due to cutting of trees and herbicide application. Redrawn from Bormann and Likens (1979)



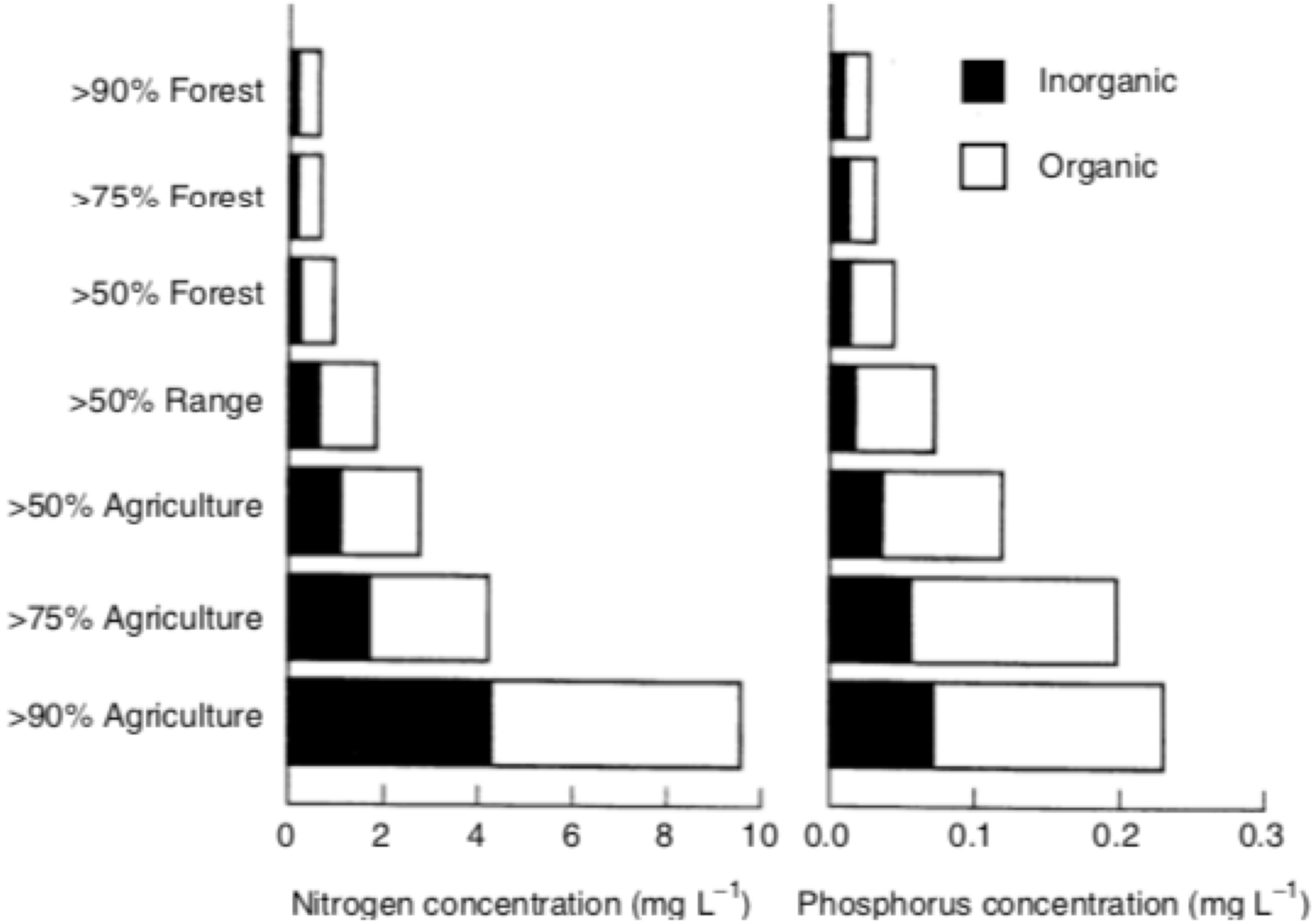


Fig. 9.4 Concentrations of organic and inorganic nitrogen and phosphorus in 928 relatively unpolluted U.S. streams in watersheds with varying degrees of conversion from forest to agriculture. Redrawn from Allan and Castillo (2007)

Yield Gaps

Mueller ND, Gerber JS, Johnston M, Ray DK, Ramankutty N, Foley JA. **2012**. Closing yield gaps through nutrient and water management. *Nature* **490**: 254.

Only some areas obtain max yield

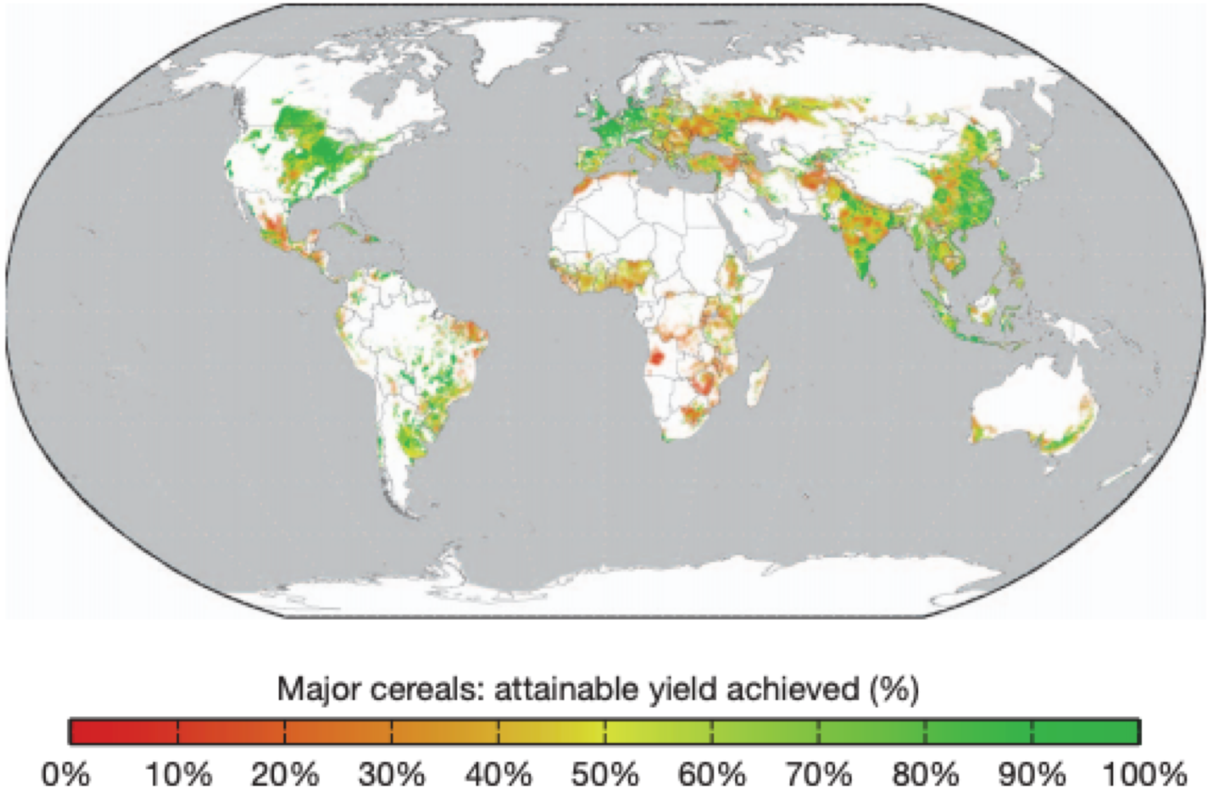


Figure 1 | Average yield gaps for maize, wheat and rice. These were measured as a percentage of the attainable yield achieved circa the year 2000. Yield gap in each grid cell is calculated as an area-weighted average across the crops and is displayed on the top 98% of growing area.

But it takes a lot of resources to get there

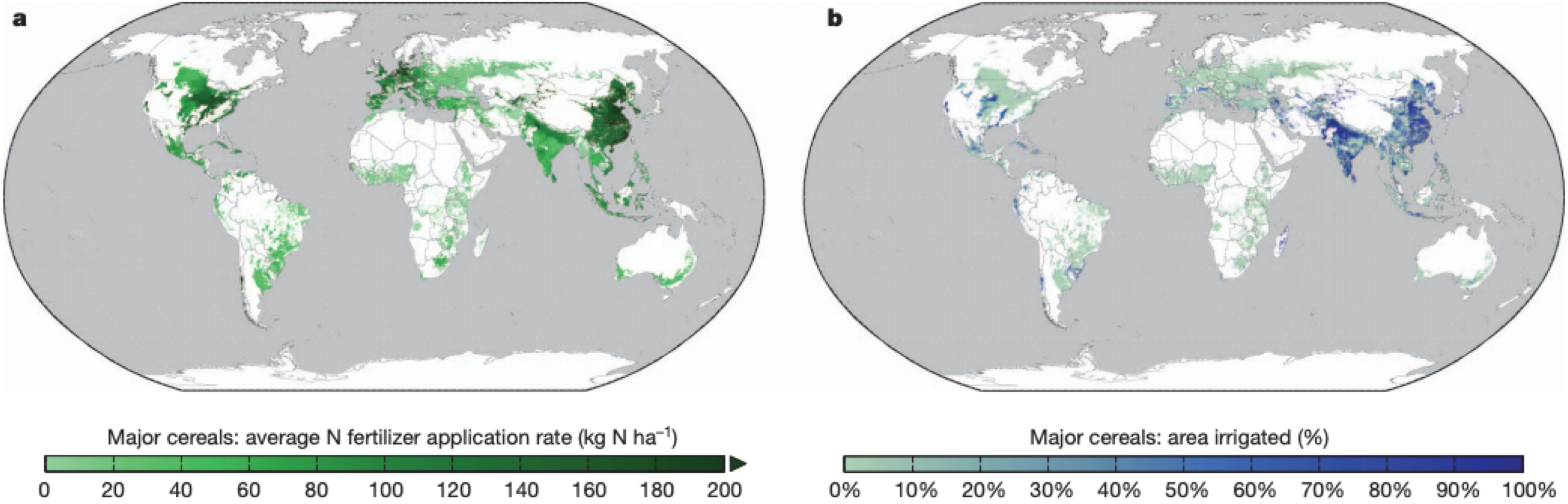


Figure 3 | Management intensity of nitrogen fertilizer and irrigated area[14] varies widely across the world's croplands. **a**, **b**, Fertilizer (**a**) and irrigation (**b**) values are area-weighted averages across major cereals.

(green areas are using more nutrients than necessary)

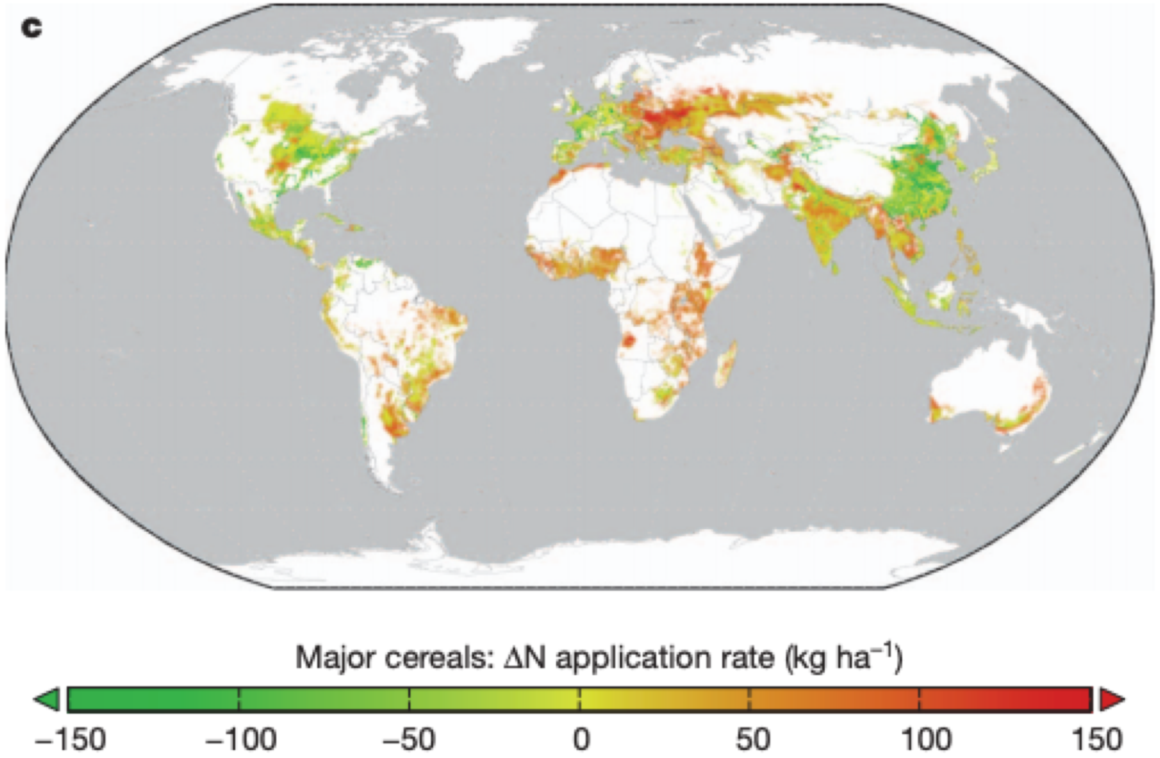
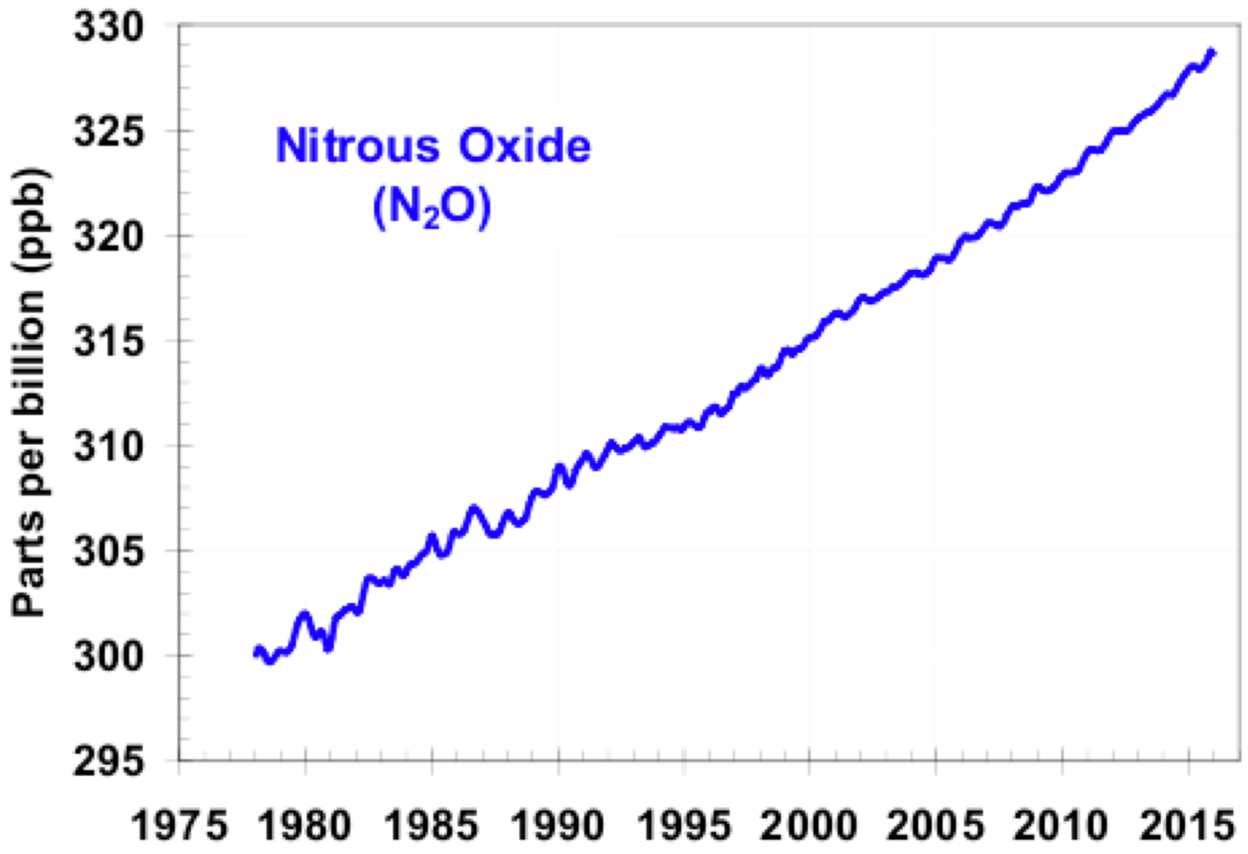


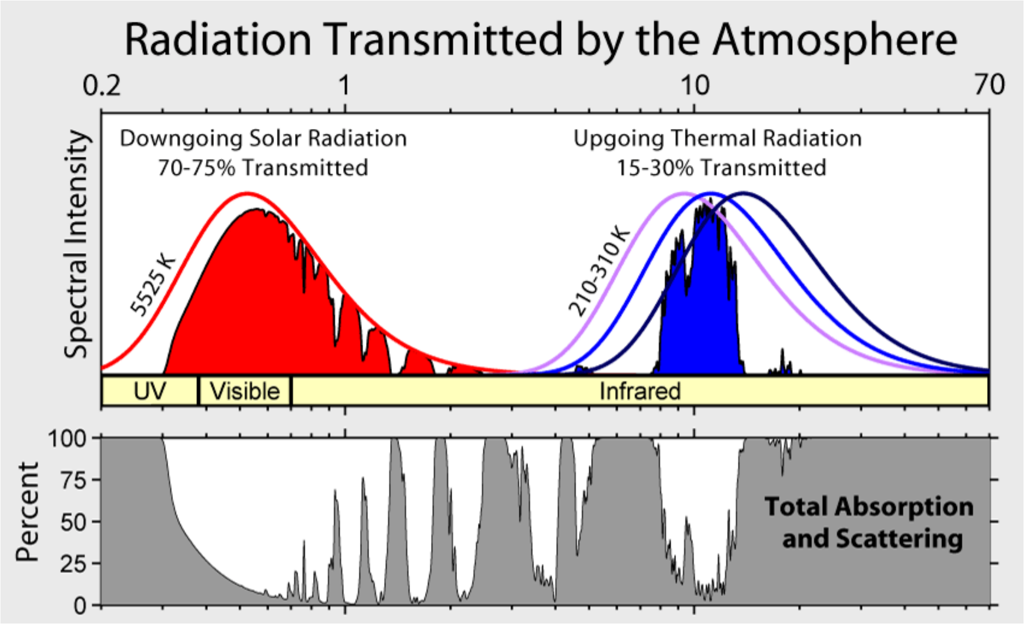
Figure 5 | Closing yield gaps through changes in agricultural management. **a**, **b**, Projected increases in nitrogen application rates (**a**) and irrigated areas (**b**) necessary to close maize, wheat and rice yield gaps to 75% of attainable yields. **c**, Projected net changes in nitrogen application rates when closing yield gaps and eliminating input imbalances and inefficiencies.

What might be the ecosystem impacts of fertilizer use?

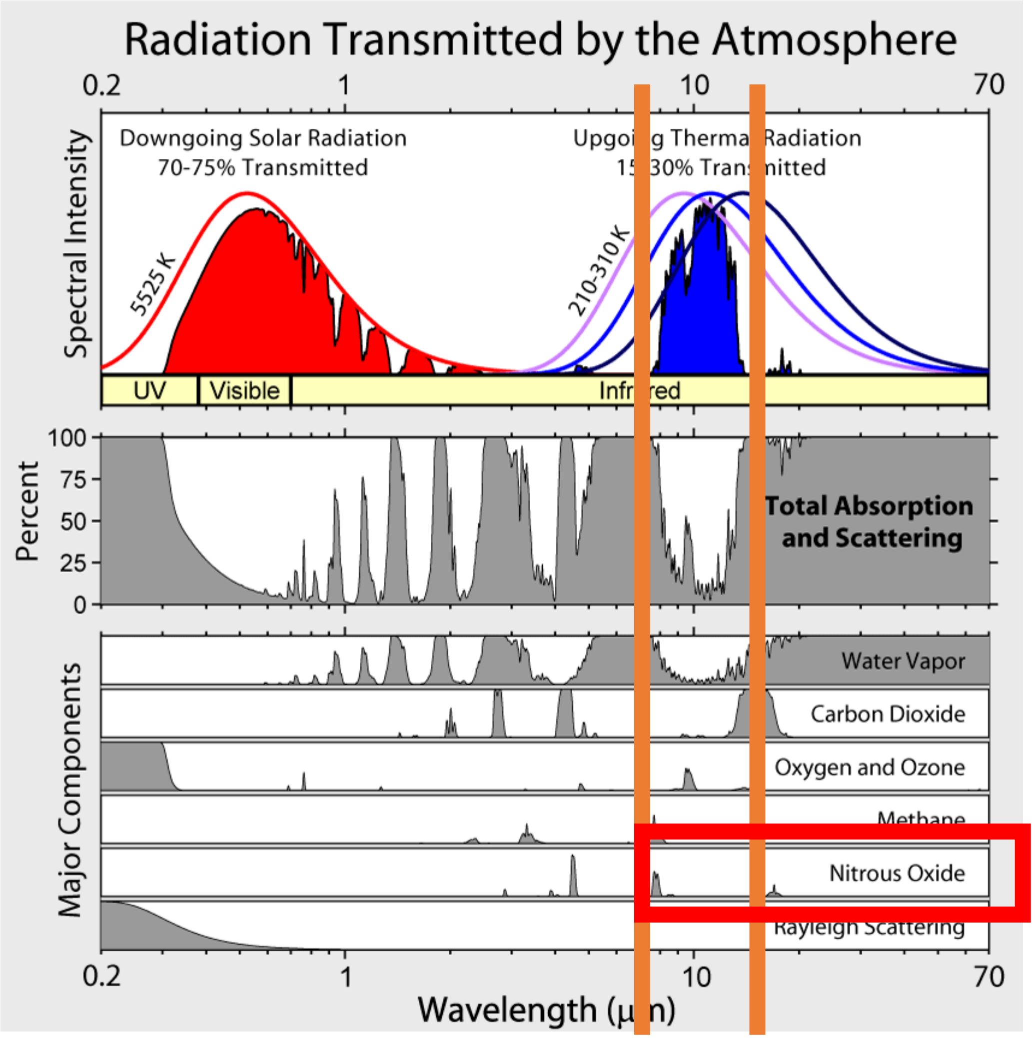


From agriculture and fossil fuel burning

NOAA



Radiation Transmitted by the Atmosphere
0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption
and Scattering



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15-30% Transmitted
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
Wavelength (μm)

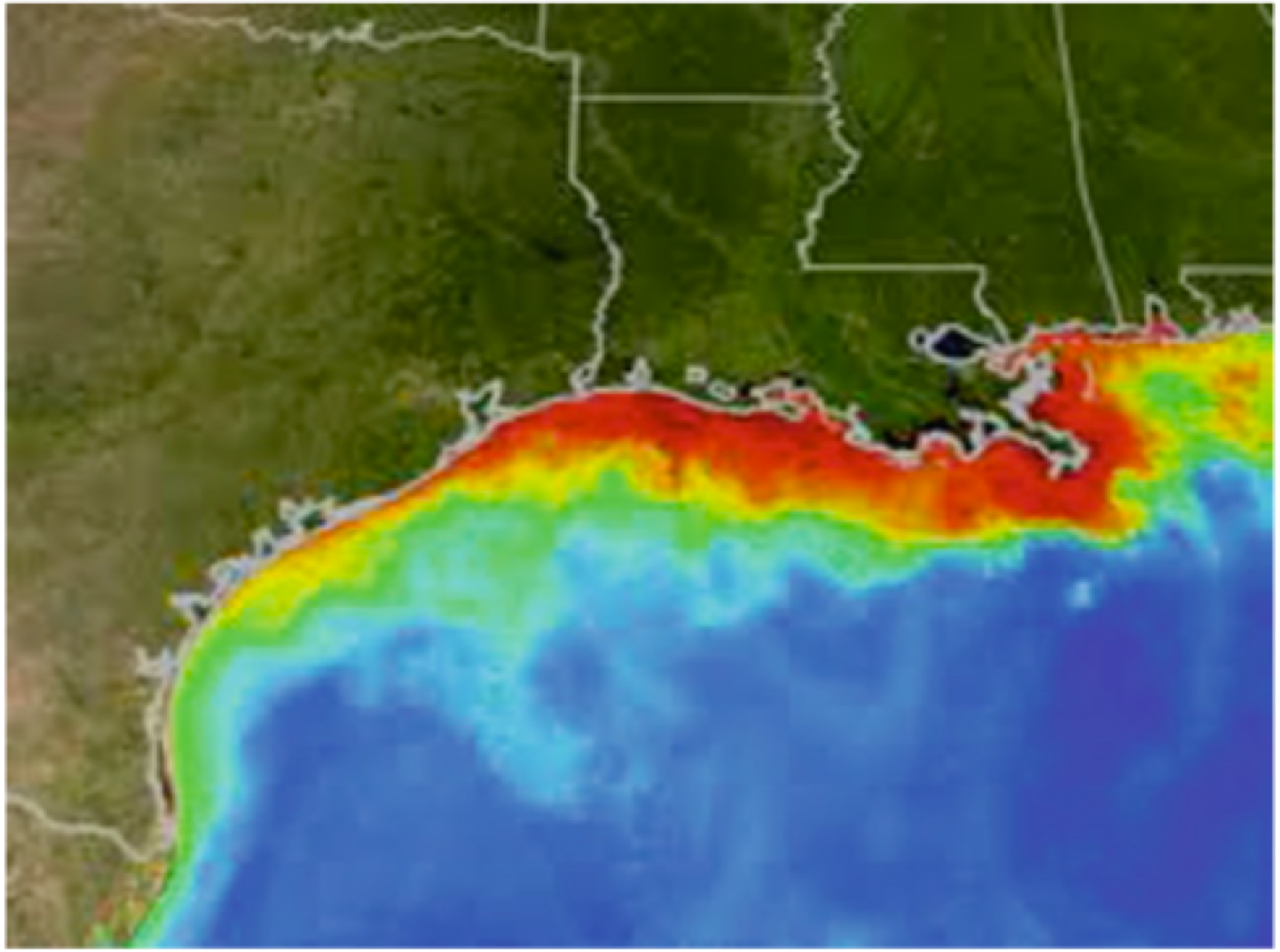
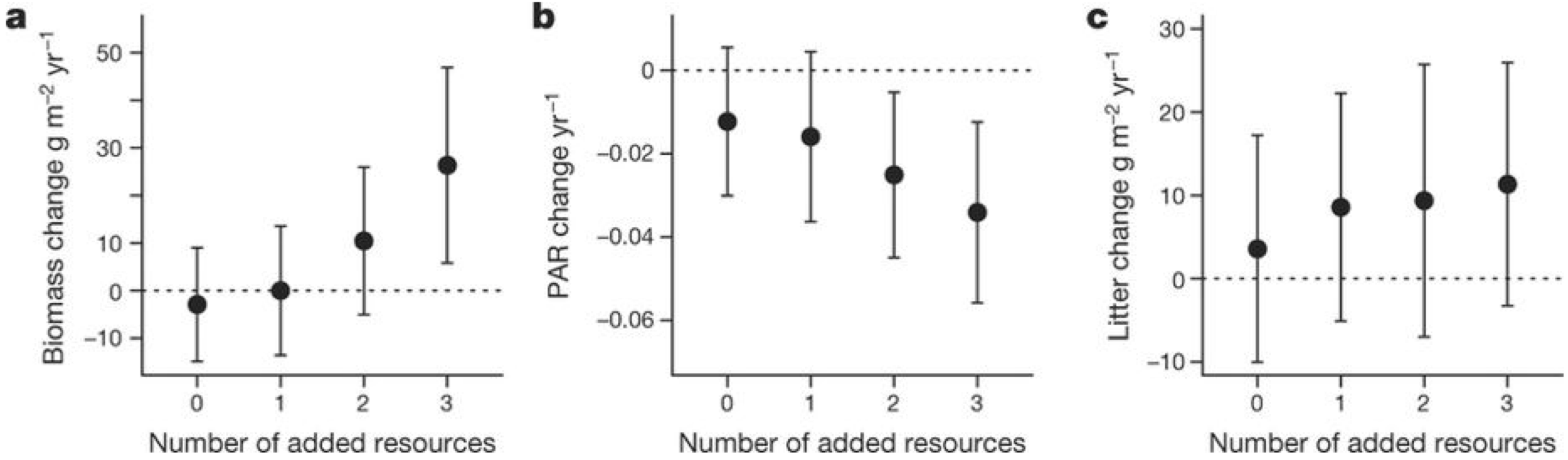
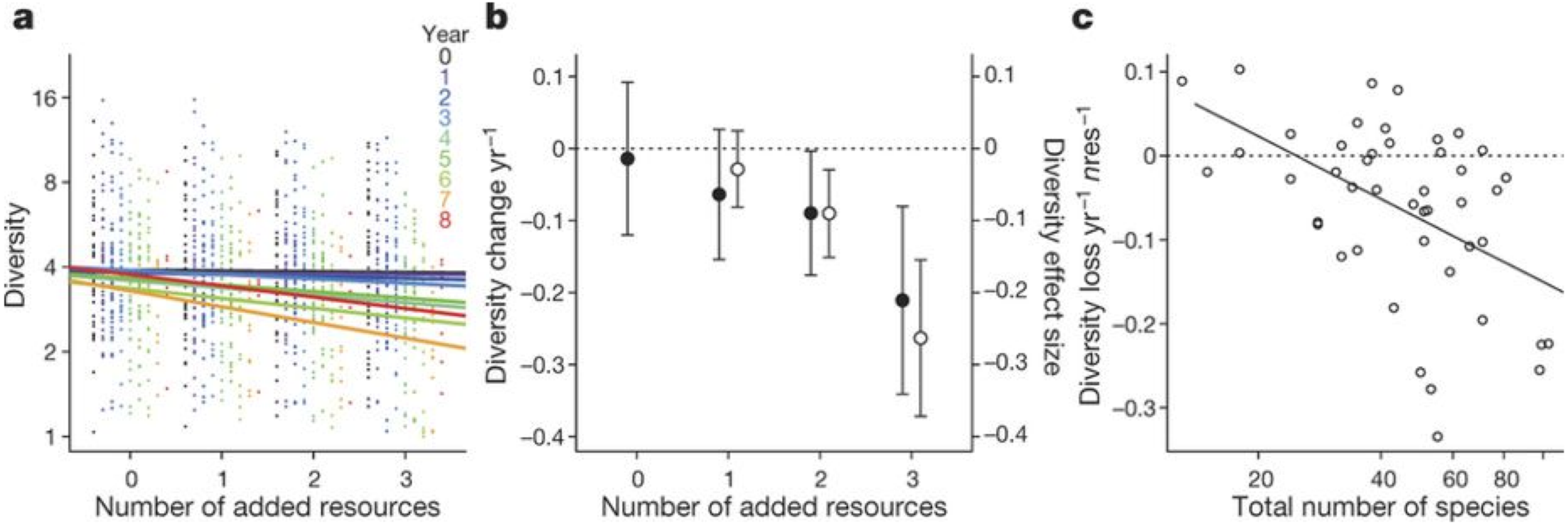


Fig. 9.1 Dead zone in the Gulf of Mexico, magnified by nutrient inputs from agricultural runoff from the Mississippi river drainage. Reds and oranges represent high concentrations of phytoplankton and sediments (http://www.nasa.gov/vision/earth/environment/dead_zone.html)



Harpole et al. (2016)



Harpole et al. (2016)

How do we avoid these?

Increased efficiency could reduce N and P use by 28% and 38% globally

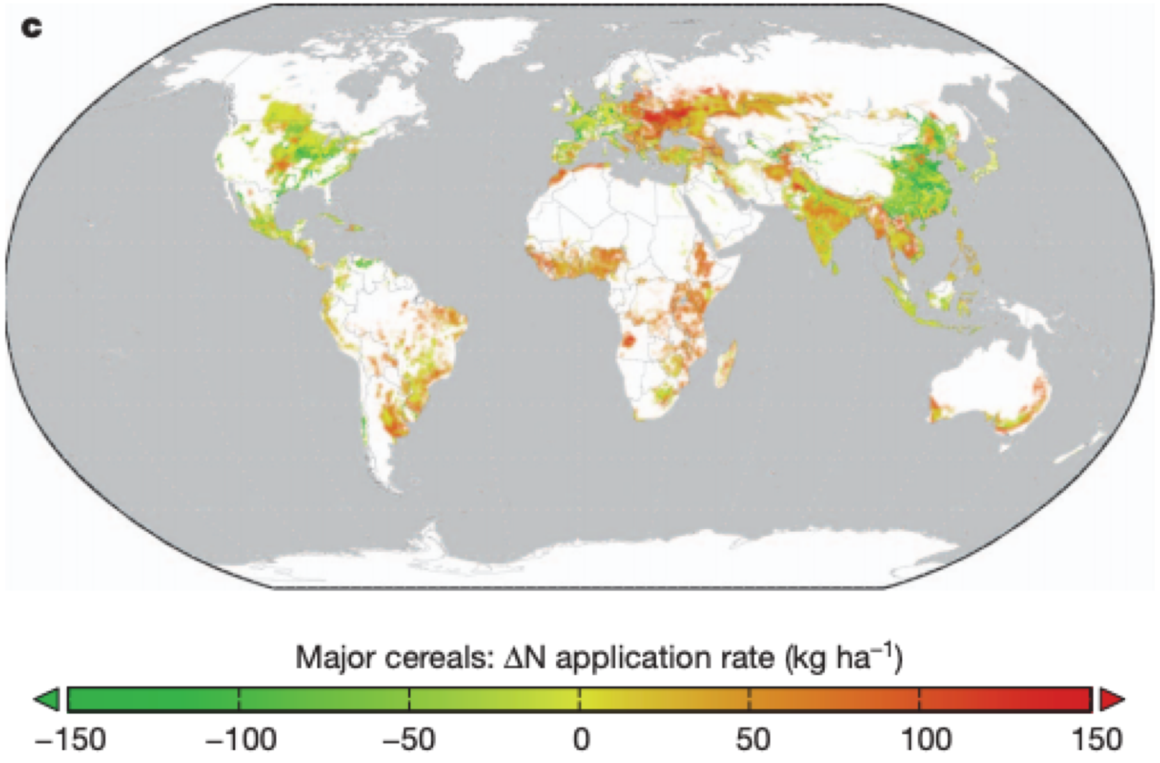


Figure 5 | Closing yield gaps through changes in agricultural management. **a**, **b**, Projected increases in nitrogen application rates (**a**) and irrigated areas (**b**) necessary to close maize, wheat and rice yield gaps to 75% of attainable yields. **c**, Projected net changes in nitrogen application rates when closing yield gaps and eliminating input imbalances and inefficiencies.

Closing yield gap requires more input (in some place), but mostly better management

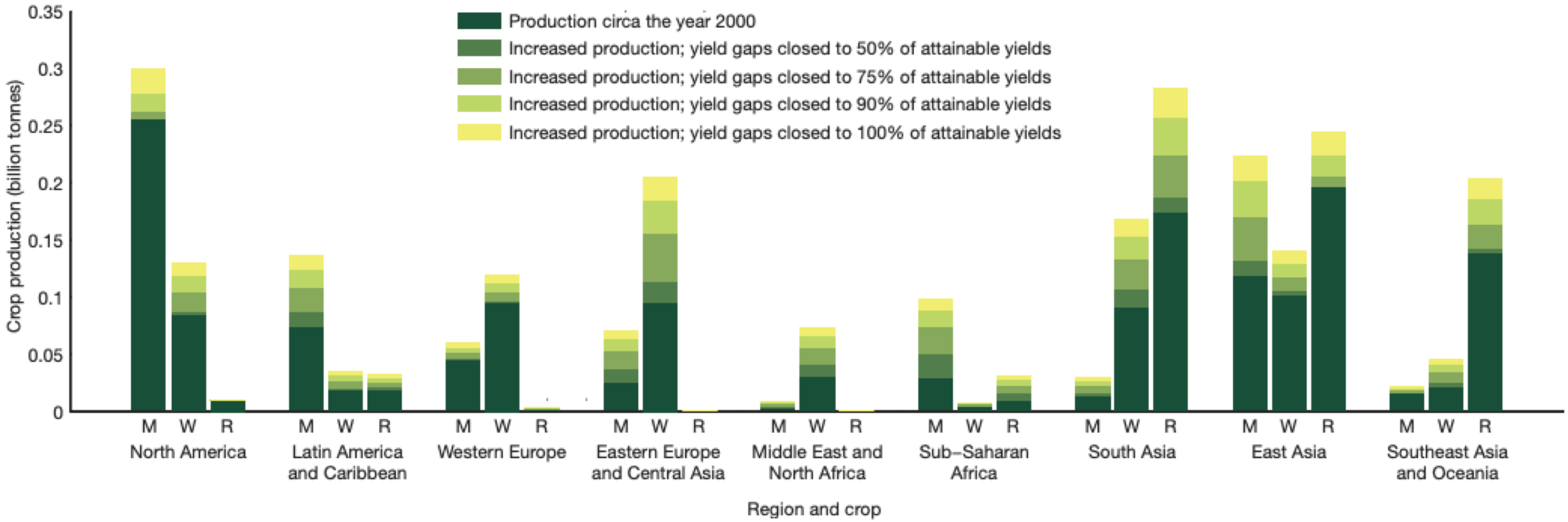


Figure 2 | Global production increases for maize, wheat and rice from closing yield gaps to 50%, 75%, 90% and 100% of attainable yields. The greatest opportunities for increases in absolute production (from closing yield gaps to 100% of estimated attainable yields) are wheat (W) in Eastern Europe and Central Asia, rice (R) in South Asia and maize (M) in East Asia. Absolute production increases for individual crops in Sub-Saharan Africa are smaller owing to lower attainable yields and diverse cropping systems (that is, less area devoted to any one crop). The region could still achieve large production increases in cassava, maize and sugarcane.