Imagine the next 50 years…

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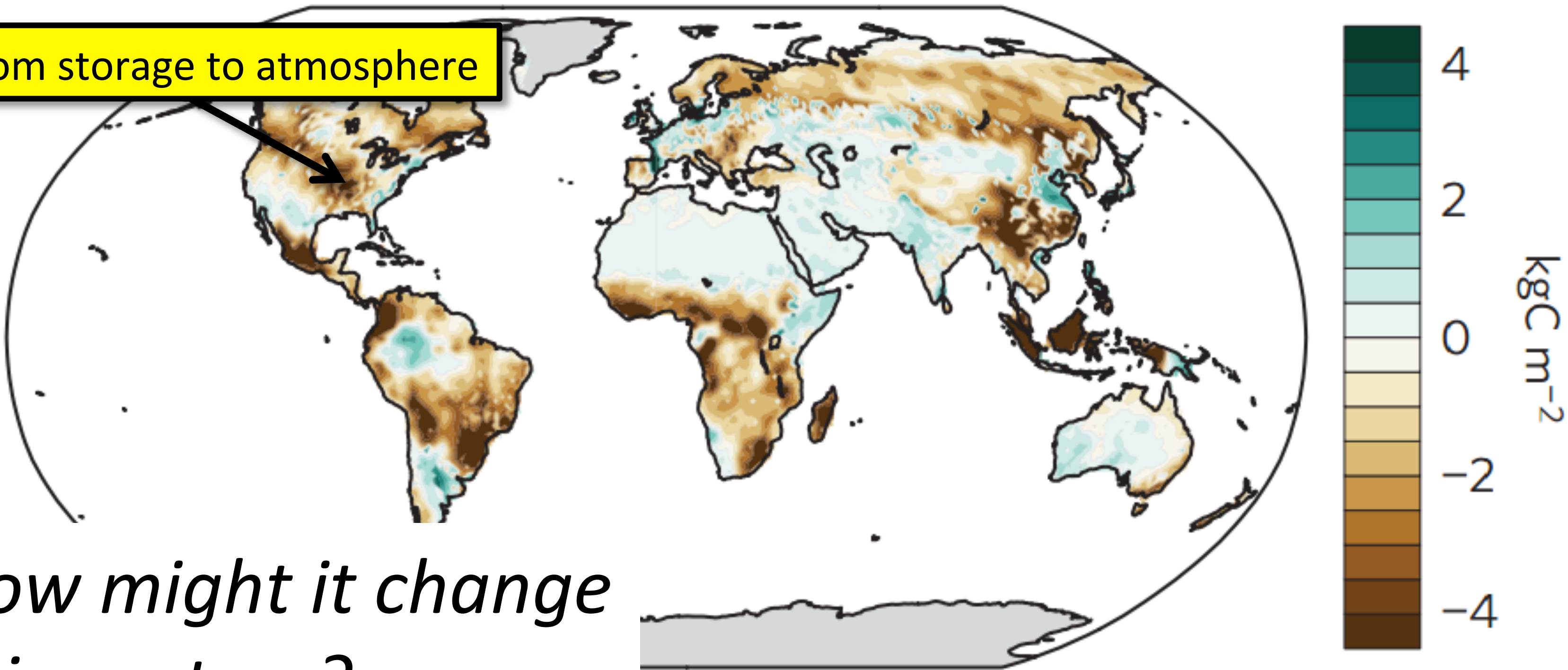
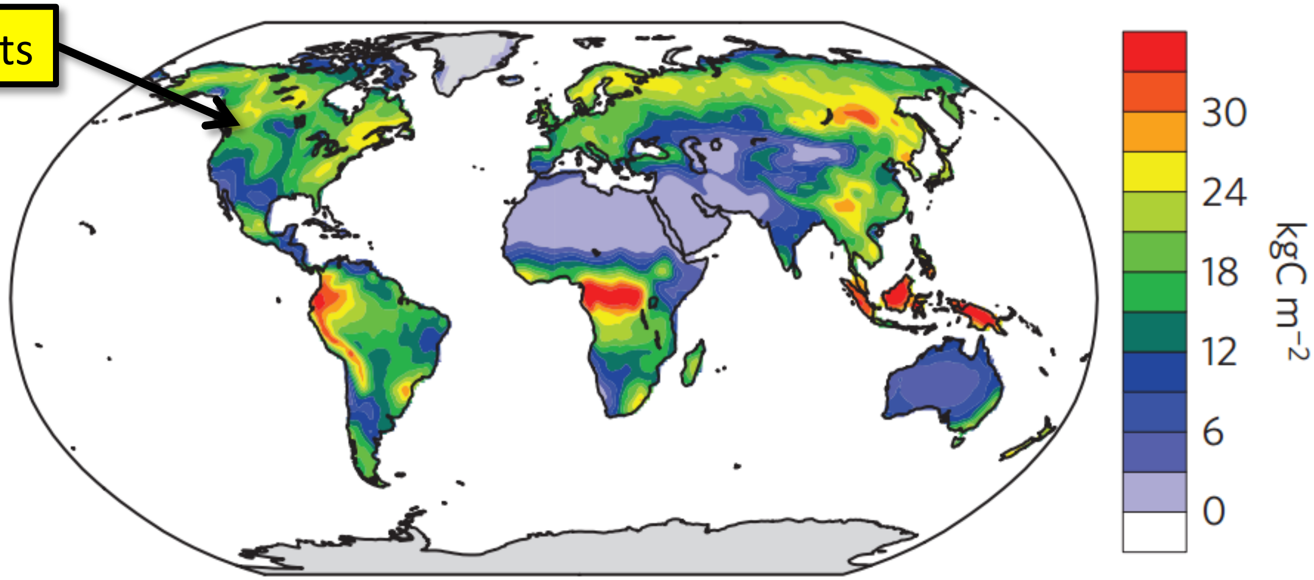
A: From storage to atmosphere



How might it change this century?

A: Peat and lake sediments



Where is the carbon now?

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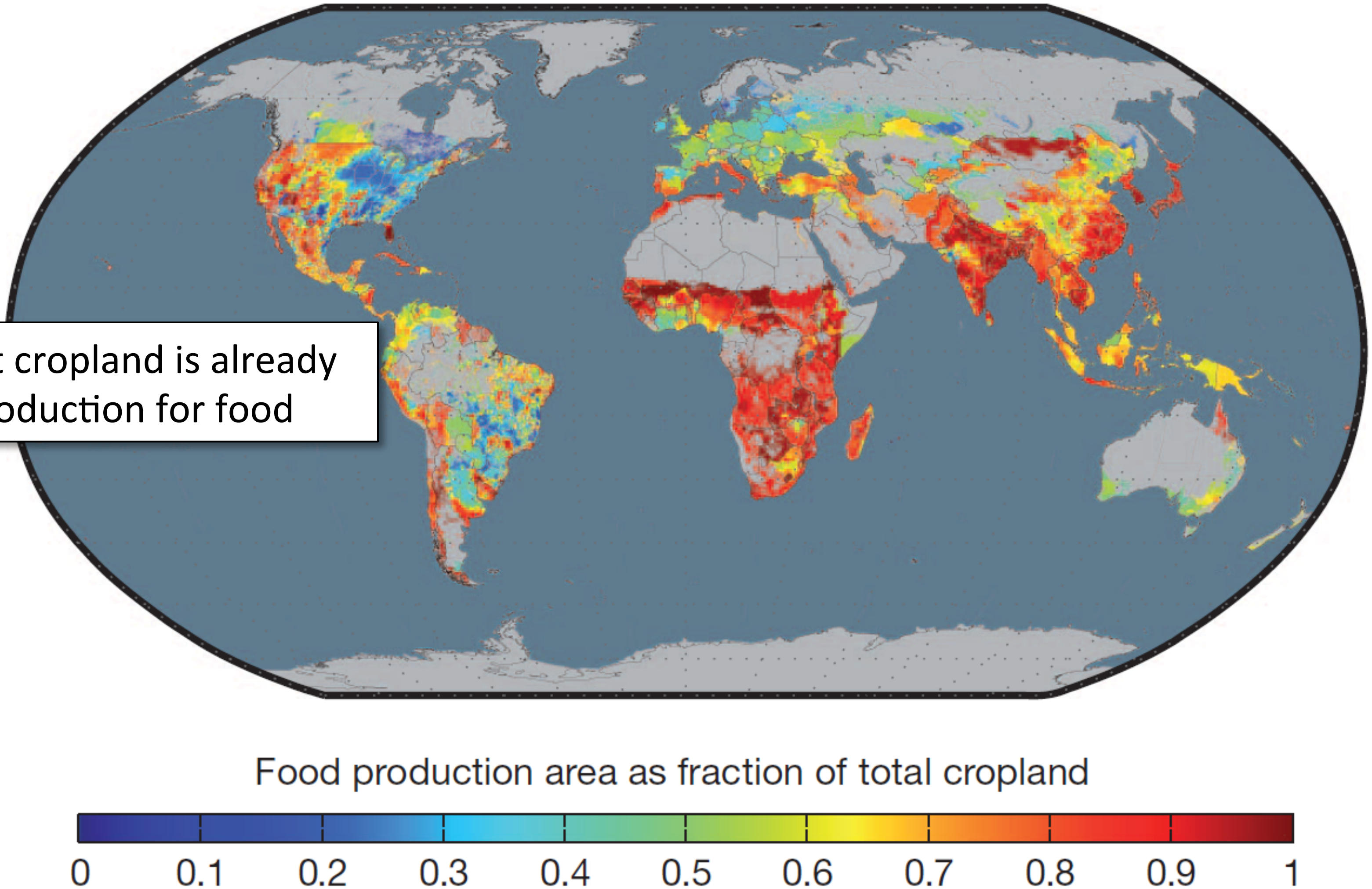
Future productivity and carbon storage limited by terrestrial nutrient availability

William R. Wieder[1,2]*, Cory C. Cleveland[3], W. Kolby Smith[3,4] and Katherine Todd-Brown[5,6]



Most cropland is already in production for food

Solutions for a cultivated planet

Jonathan A. Foley[1], Navin Ramankutty[2], Kate A. Brauman[1], Emily S. Cassidy[1], James S. Gerber[1], Matt Johnston[1], Nathaniel D. Mueller[1], Christine O'Connell[1], Deepak K. Ray[1], Paul C. West[1], Christian Balzer[3], Elena M. Bennett[4], Stephen R. Carpenter[5], Jason Hill[1,6], Chad Monfreda[7], Stephen Polasky[1,8], Johan Rockström[9], John Sheehan[1], Stefan Siebert[10], David Tilman[1,11] & David P. M. Zaks[12]

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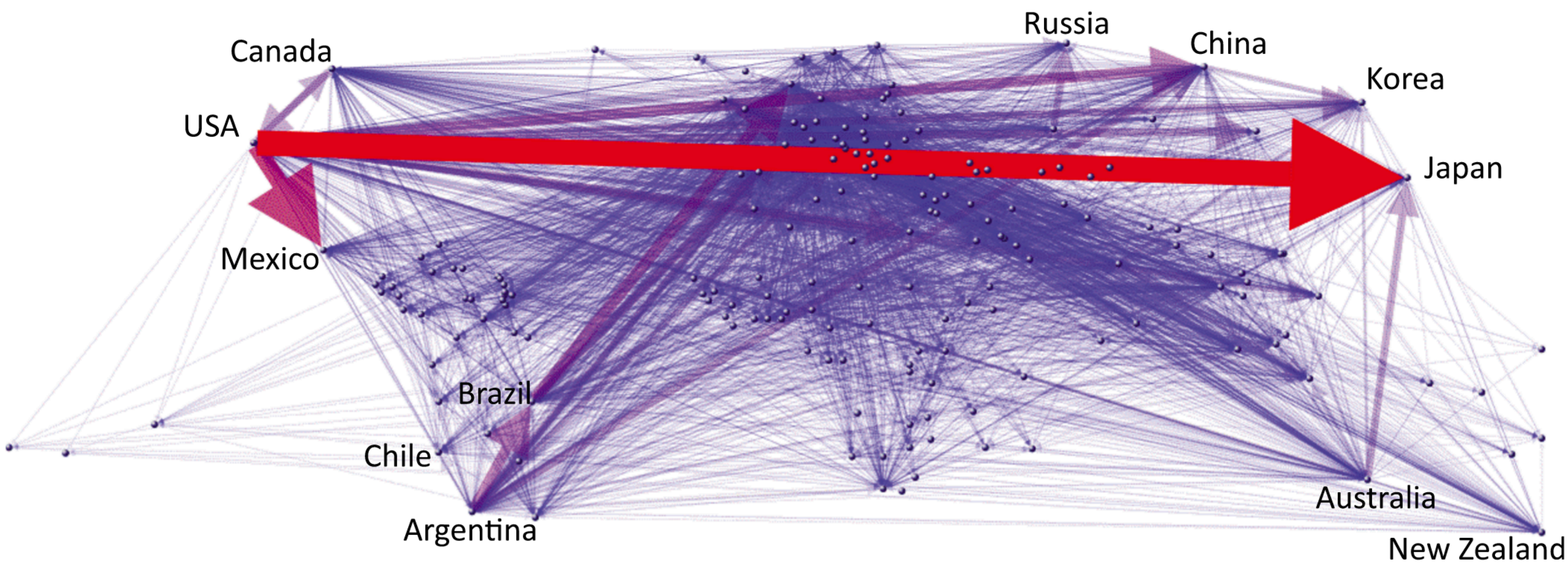


Figure 2. Map of the weighted and directed global virtual water trade network. Each point indicates anode, or nation, in the network. Total volume ~10^{10} m^3 y^{-1}

Water for food: The global virtual water trade networkM. Konar,1C. Dalin,1S. Suweis,1,2N. Hanasaki,3A. Rinaldo,2,4and I. Rodriguez-Iturbe1Received 6 December 2010; revised 15 February 2011; accepted 24 February 2011; published 17 May 2011.

WATER RESOURCES RESEARCH, VOL. 47, W05520,doi:10.1029/2010WR010307, 2011

A global network

These two issues derive from global economies that include global food networks. Understanding how fresh waters might respond to these pressures and formulating smart strategies in response requires:

(a) an understanding of the current state of Earth's fresh waters,
(b) knowledge about how the diversity of freshwaters respond to proximal drivers of change, and
(c) the capacity to predict how fresh waters might change under a diversity of climate change and land-use change scenarios.

Q1. To what extent are big data and cloud-scale computation needed in e-science (based on your own experience with one or more application domains)?

Global data: We do not know the state of the world's lakes.

Cycles and space: Integration of aquatic systems into the broader landscape requires lots of data and lots of compute cycles. Estimating broad-scale ecosystem fluxes, and the influence of the global economy and goods and services based on water require large volumes of very diverse data from multiple countries.

Human component: We need experts in big data and cloud-scale computing to help us re-think current scientific practice and even scientific paradigm.

Q2. How can cloud computing and emerging big-data tools help and what challenges exist in their adoption?

- Workflows: Ecologists need to embrace an alternative approach to their science, which includes re-using other people's workflows, accepting the constraints that come along with those workflows, and contributing back by conforming to a certain level of standardization.
- Cycles and space: Using process-based models at broad scales requires lots of cycles and generates lots of data. Using simpler, more statistical models (think Google and the corpus of the English language), requires huge data sets.
- Training: Sometimes understanding what's possible reshapes how we approach a problem. Ecologists, for the most part, do not know what technologies are available and how they might help.

Q3. How can interdisciplinary collaborations (application experts and computer scientists) help address challenges and seize opportunities in e-Science advancement?

- Global data: Each country has its own repository of information about lakes and reservoirs; harmonizing these data is a huge issue
- Cycles and storage: Making access to computational resources nearly transparent; example, DropBox as the current norm, **GRAPLEr as a working model**
- Human component: Help us re-think the problems – simple models with lots of data; bringing models together with data in efficient and effective ways

Q4. How can international cooperation help accelerate adoption or demonstration of big data and cloud computing solutions in e-science?

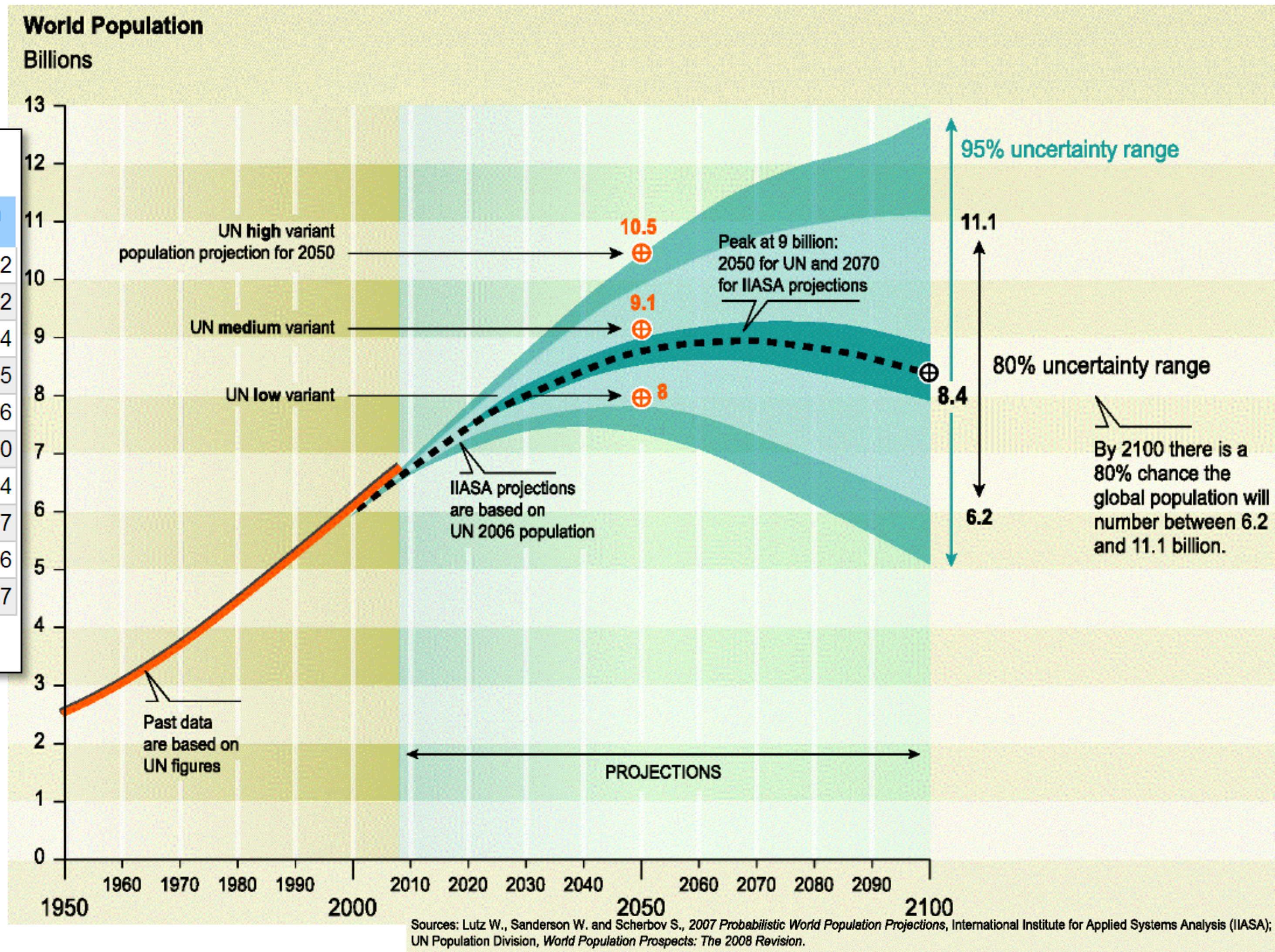
- Solutions to global issues come from the global community.
- Find the data. Data are available in many different repositories scattered all over the world. The global community can help identify where it is and help develop the technologies needed to streamline deeper discovery, access, and use of these data.
- Positive feedbacks: Demonstrable success in, for example a global report card on the state of the world's lakes and reservoirs, would provide a high-profile success story that would catalyze re-use of the data and the infrastructure toward new and creative science.

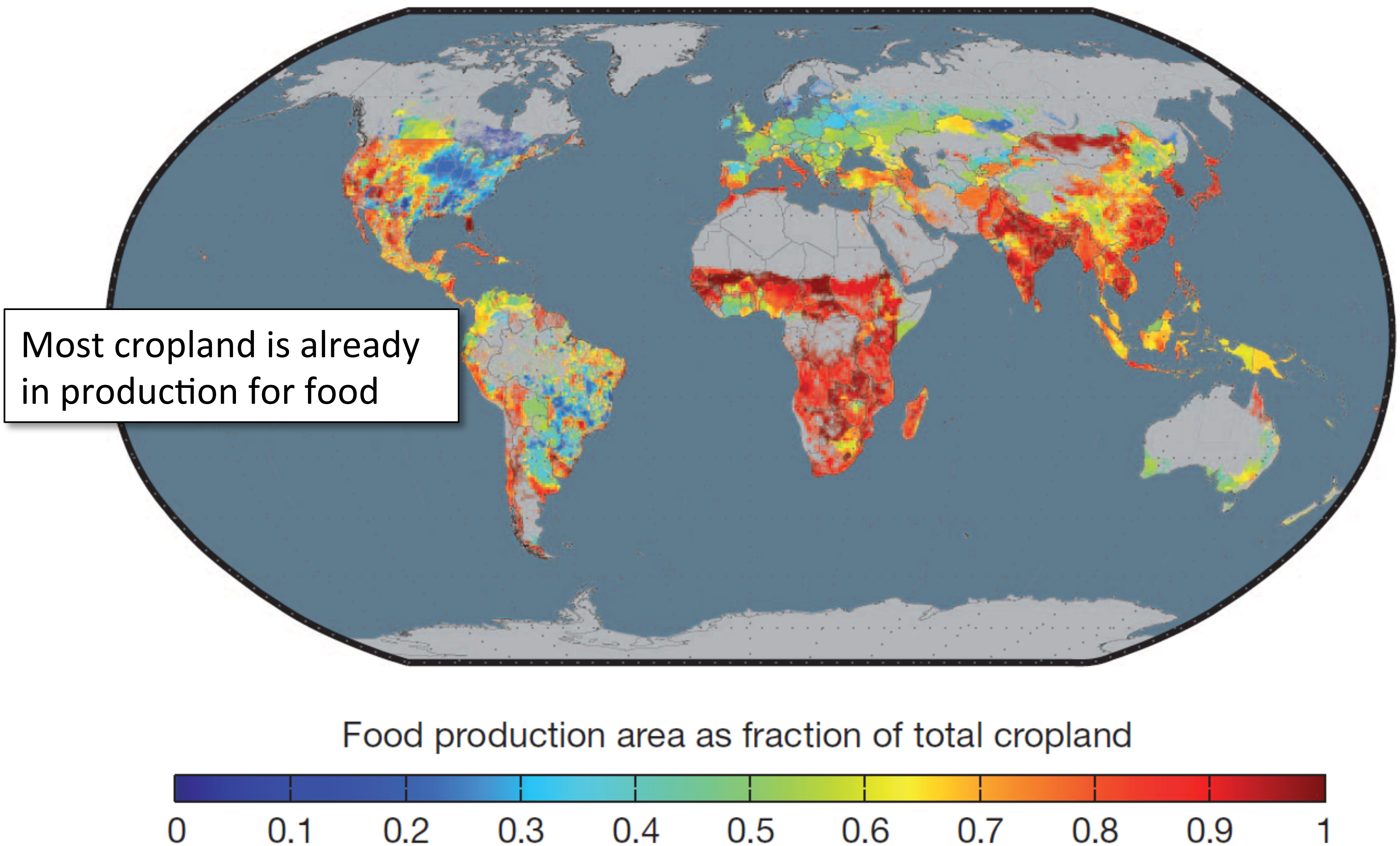
A global economy and infrastructure supports the growing demands of a global population

Countries and Areas Ranked by Population:2050

Rank	Country Or Area	Population
1	India	1,656,553,632
2	China	1,303,723,332
3	United States	422,554,384
4	Nigeria	402,425,535
5	Indonesia	300,183,166
6	Pakistan	290,847,790
7	Bangladesh	250,155,274
8	Brazil	232,304,177
9	Ethiopia	228,066,276
10	Philippines	171,964,187

Source: U.S. Census Bureau, International Data Base.





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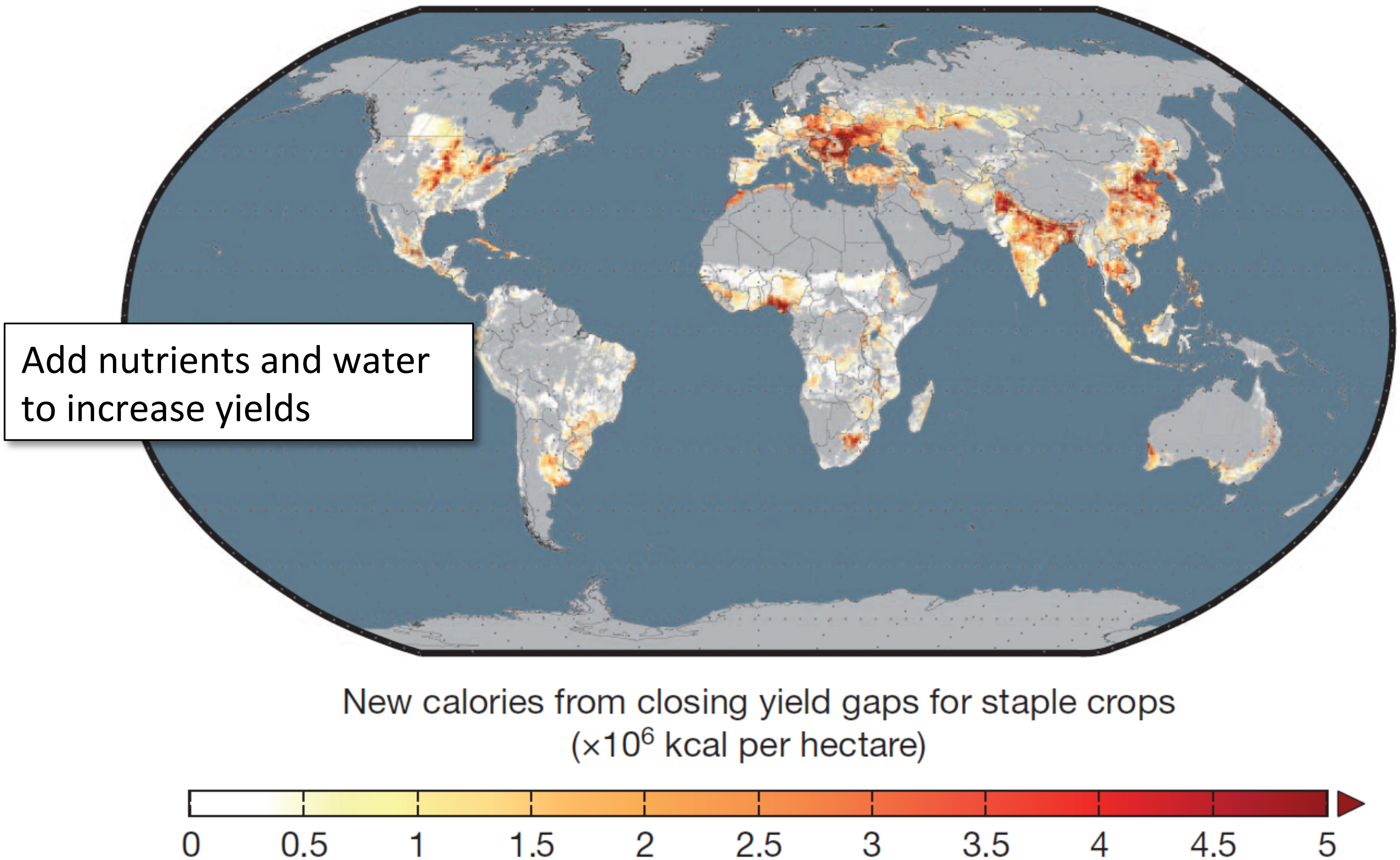

Figure 3 | Closing global yield gaps. Many agricultural lands do not attain their full yield potential. The figure shows the new calories that would be made available to the world from closing the yield gaps for 16 major crops: barley, cassava, groundnut, maize, millet, potato, oil palm, rapeseed, rice, rye, sorghum, soybean, sugarbeet, sugarcane, sunflower and wheat. This analysis shows that bringing the world's yields to within 95% of their potential for these 16 important food and feed crops could add 2.3 billion tonnes (5×10^{15} kilocalories) of new crop production, representing a 58% increase. These improvements in yield can be largely accomplished by improving the nutrient and water supplies to crops in low-yielding regions; further enhancement of global food production could be achieved through improved crop genetics. The methods used to calculate yield gaps and limiting factors are described in the Supplementary Information.

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Switch from mix-use crop to 100% food.

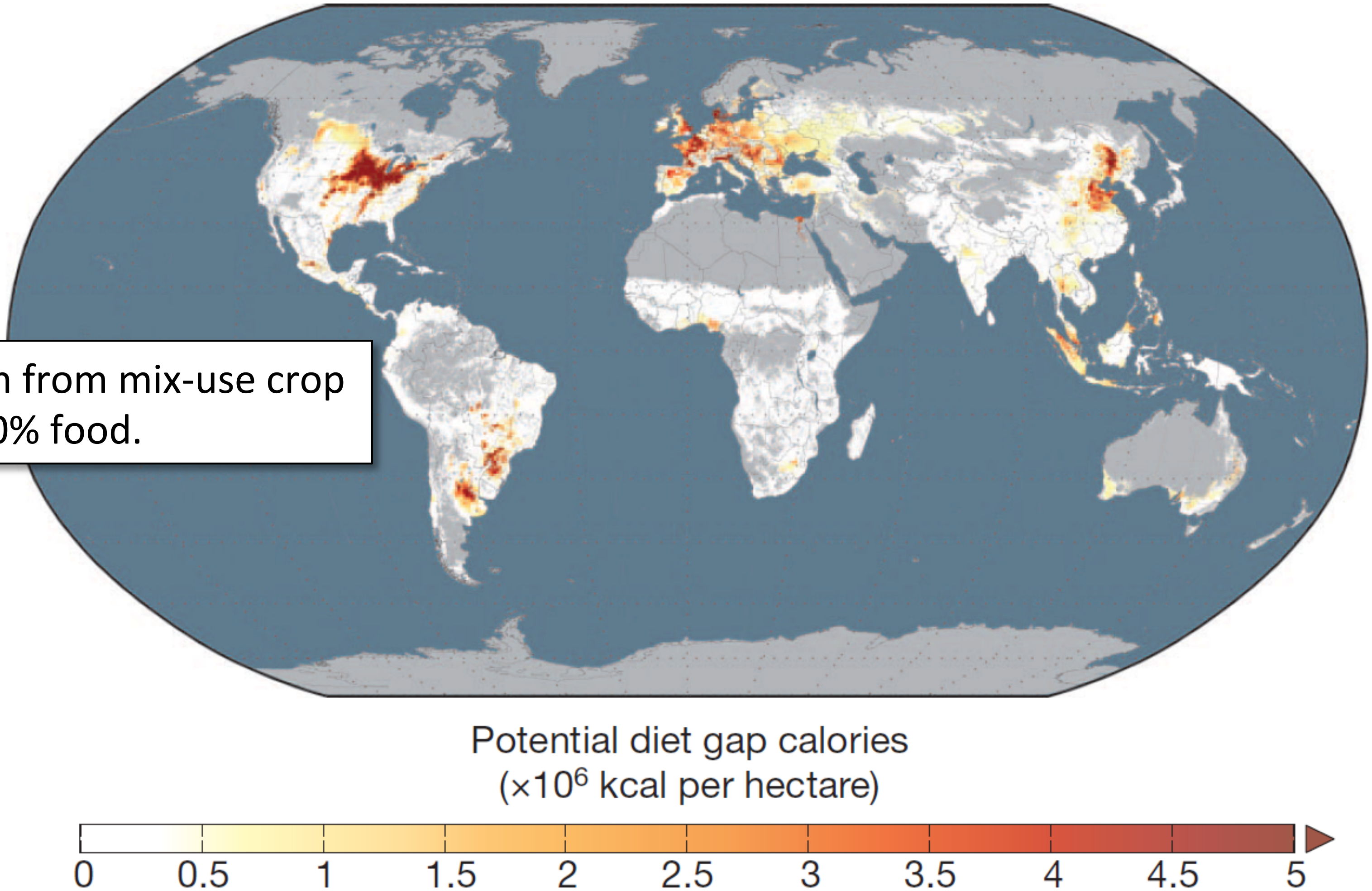

Figure 4 | Closing the diet gap. We estimate the potential to increase food supplies by closing the 'diet gap': shifting 16 major crops to 100% human food and away from the current mix of uses (see Fig. 1) could add over a billion tonnes to global food production (a 28% increase for those 16 crops), the equivalent of $\sim 3 \times 10^{15}$ kilocalories more food to the global diet (a 49% increase in food calories delivered).

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