



International Nitrogen Initiative

Global nutrient cycles and Livestock

Building a Global Agenda of Action in support of
responsible livestock sector development



Contributions:

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Global nutrient cycles and Livestock

Outline

- (i) State of knowledge;
- (ii) emerging issues and identification of priorities / focus;
- (iii) suggestions on how to address these issues.

Livestock

- Livestock have long provided valuable food, fiber, fertilizer, fuel, traction, and transport to humans and have had significant impacts on the evolution of human species.
- Traditionally, livestock have been an integral part of agricultural systems, distributed among many owners and raised close to their feed source.

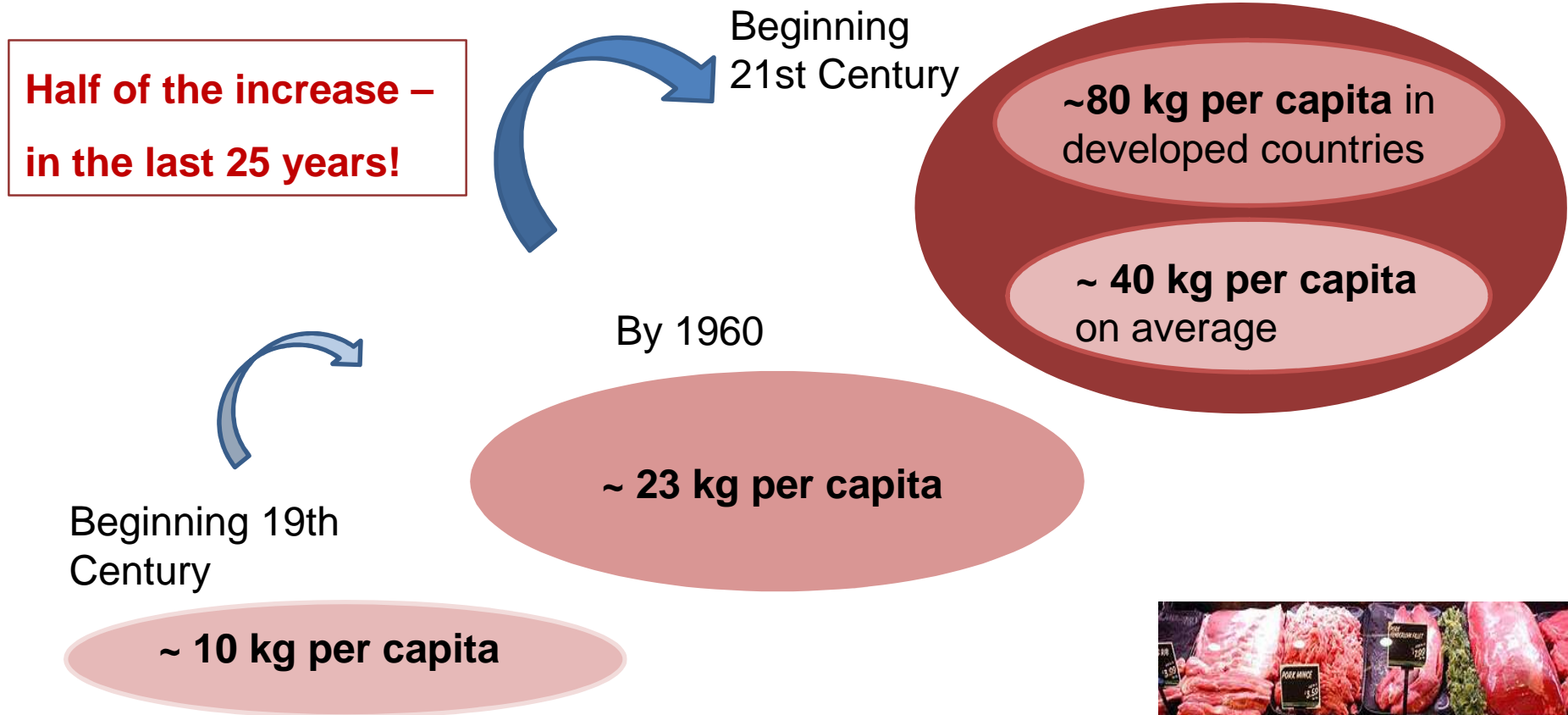


Changes in meat production

- However....
- the nature of global meat production is changing, with potentially serious consequences for the environment.



Changes in annual global meat consumption



Changes in meat production

Urbanizing population
+
explosive growth in global demand for meat products =
changes in animal production systems

From a system once closely linked to
local feed inputs and nutrient
cycles



to one in which different stages of
the production process are
becoming increasingly separated in
space.



Expansion of livestock sector x natural resources

- Industrialized systems = diets containing large amounts of cereal grains and oil meals

x

- Traditional systems = use larger amounts of by-products and waste products (for ruminants, crop residues and forages)

- As the most industrialized systems, pork and poultry production = account for over 75% of cereal- and oilseed-based concentrate feeds



Expansion of livestock sector x natural resources

- Intensifying pressures on production systems and the natural resources to which they are linked....



Expansion of livestock sector x natural resources

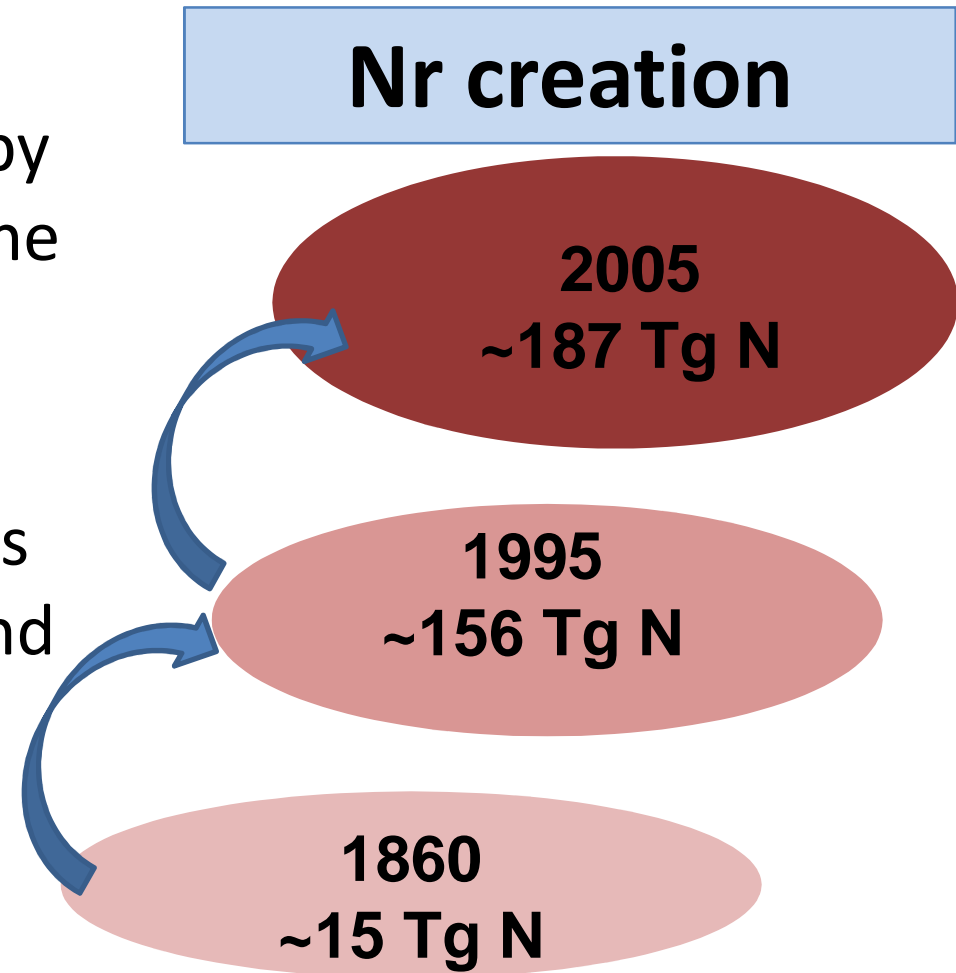
Increasing demand for arable land and the water and nutrients associated with its use.



- Ruminants consume 69% of animal feed overall,
but...
- Nonruminants consume 72% of all animal feed that is grown on arable land.

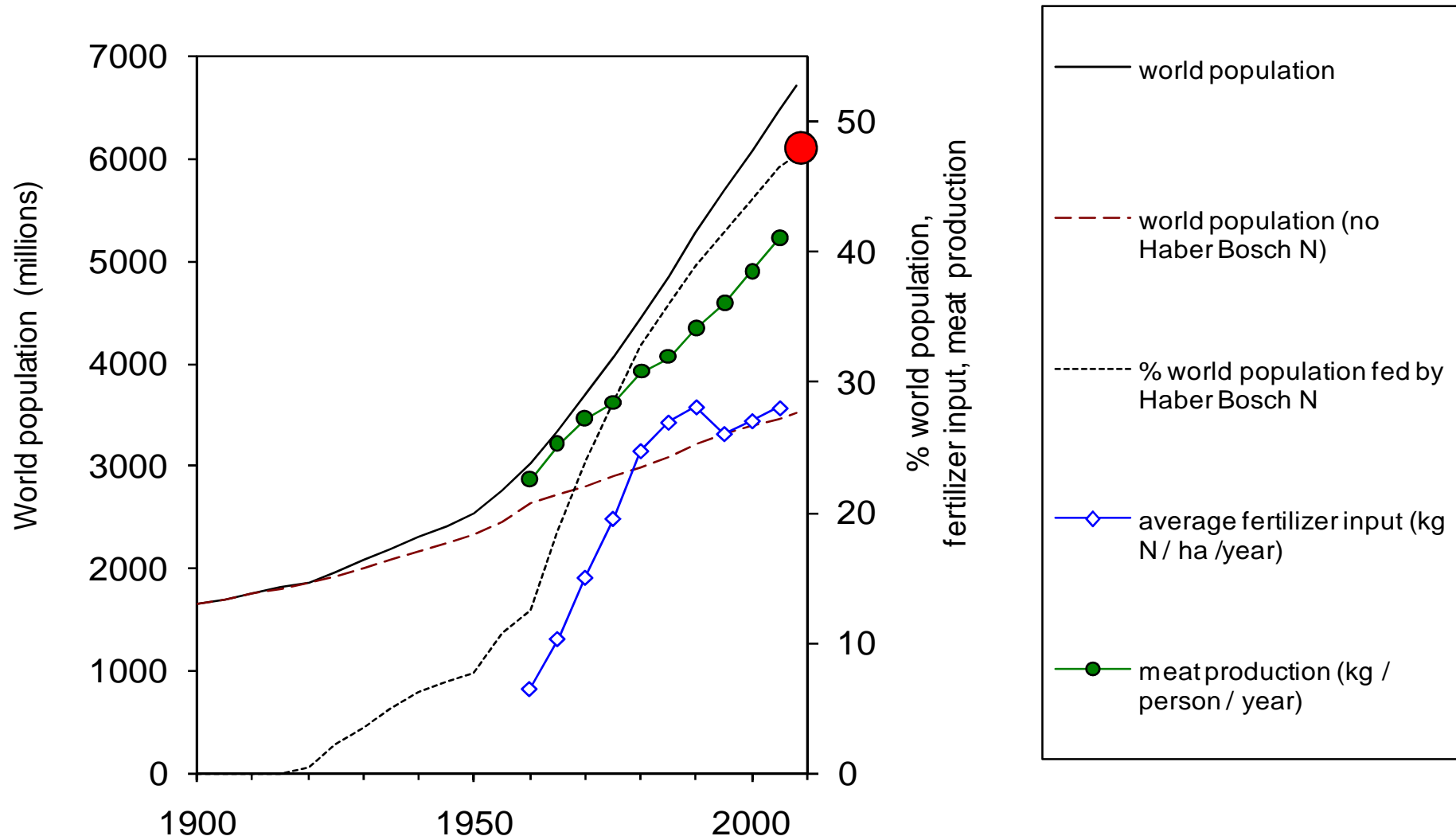
Agricultural production and reactive Nitrogen (Nr)

- The rising agricultural demands are sustained by a rise in Nr creation by the Haber-Bosch process.
- Reactive N (Nr) continues to increase every year and it is dominated by agricultural activities



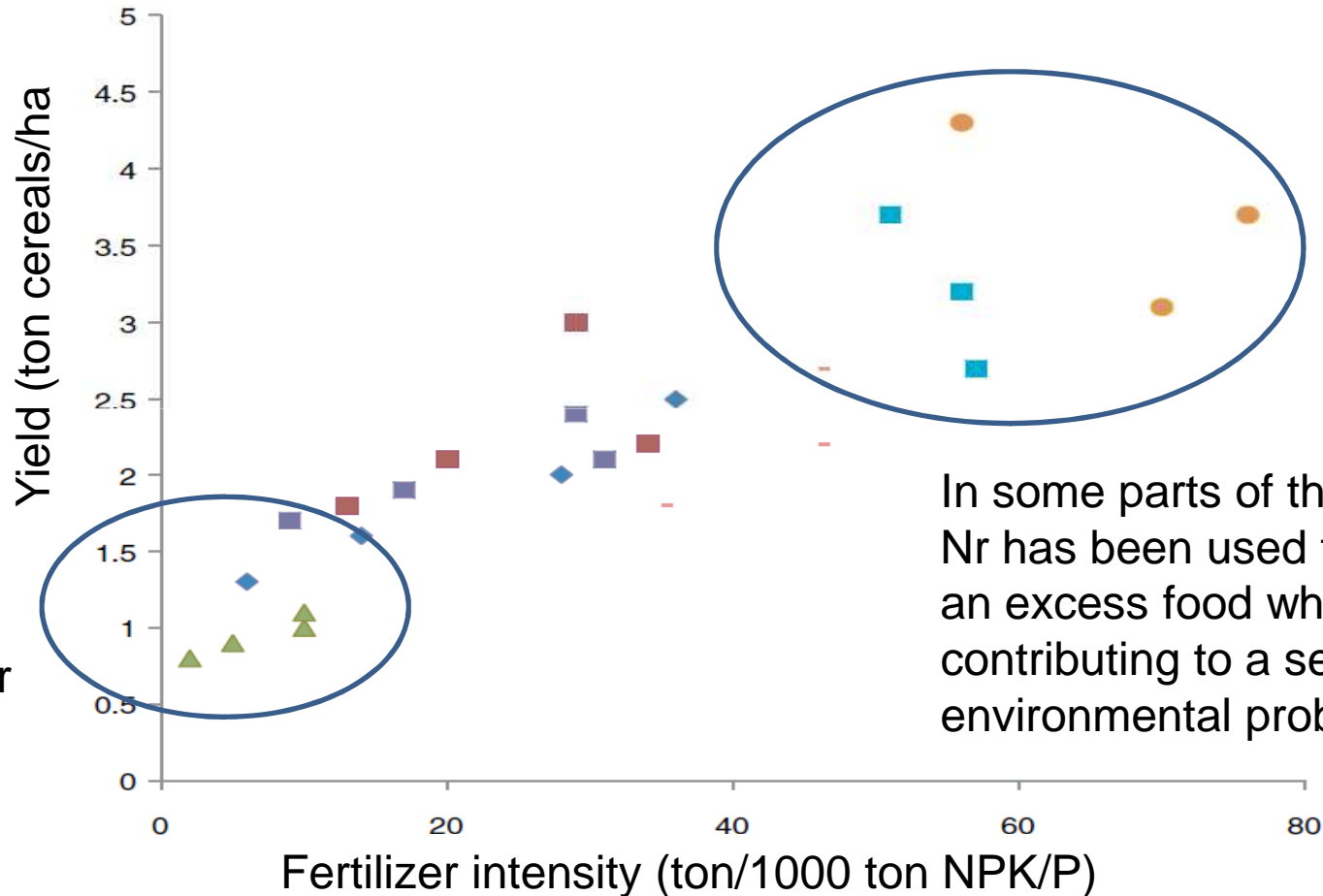
Teragram = 10^{12} g
(Megaton)

World population and reactive nitrogen (Nr)



Reactive N – too much, too little...

In other world regions, lack of sufficient N_r to meet basic nutritional demands

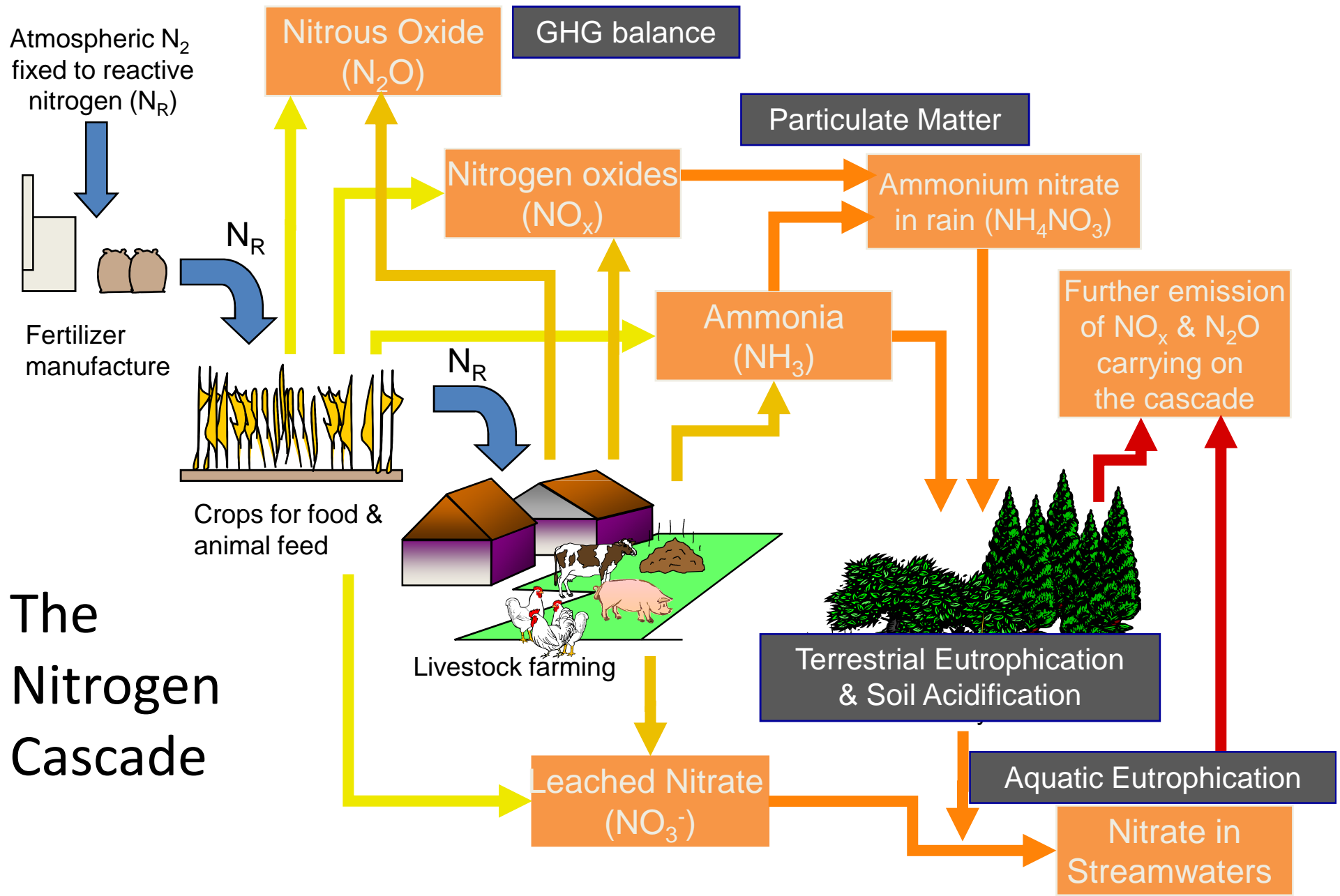


In some parts of the world, N_r has been used to create an excess food while contributing to a set of environmental problems

Nitrogen – Pathways of loss and consequences

- Globally, N fertilizers applied to feed crops represent roughly 40% of the manufactured total (emission of 40Tg CO₂)
- Much of the N not taken up by the crop is lost to the surrounding water and atmosphere





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Impacts of trade

Producers and consumers

- Increase in meat consumption and trades generally indicates
 - Income growth
 - High quality protein
- Growth is changing the relationship between me production and environment

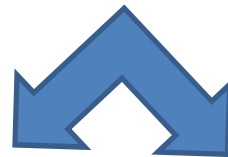


How to quantify?

- Modelling efforts – eg. MEAT model – estimates land, water and nitrogen inputs to feed and meat production using country-specific data (Galloway et al. 2007; Burke et al. 2010)
- Case-study countries (Brazil, Japan, USA, The Netherlands)

How to quantify?

- Three stages in production process:
 1. Feed production
 2. Live-animal production
 3. Meat processing



- **Virtual** = those resources that are used in production but are not physically contained in the final product

- **Embedded** = are the resources contained in the final product

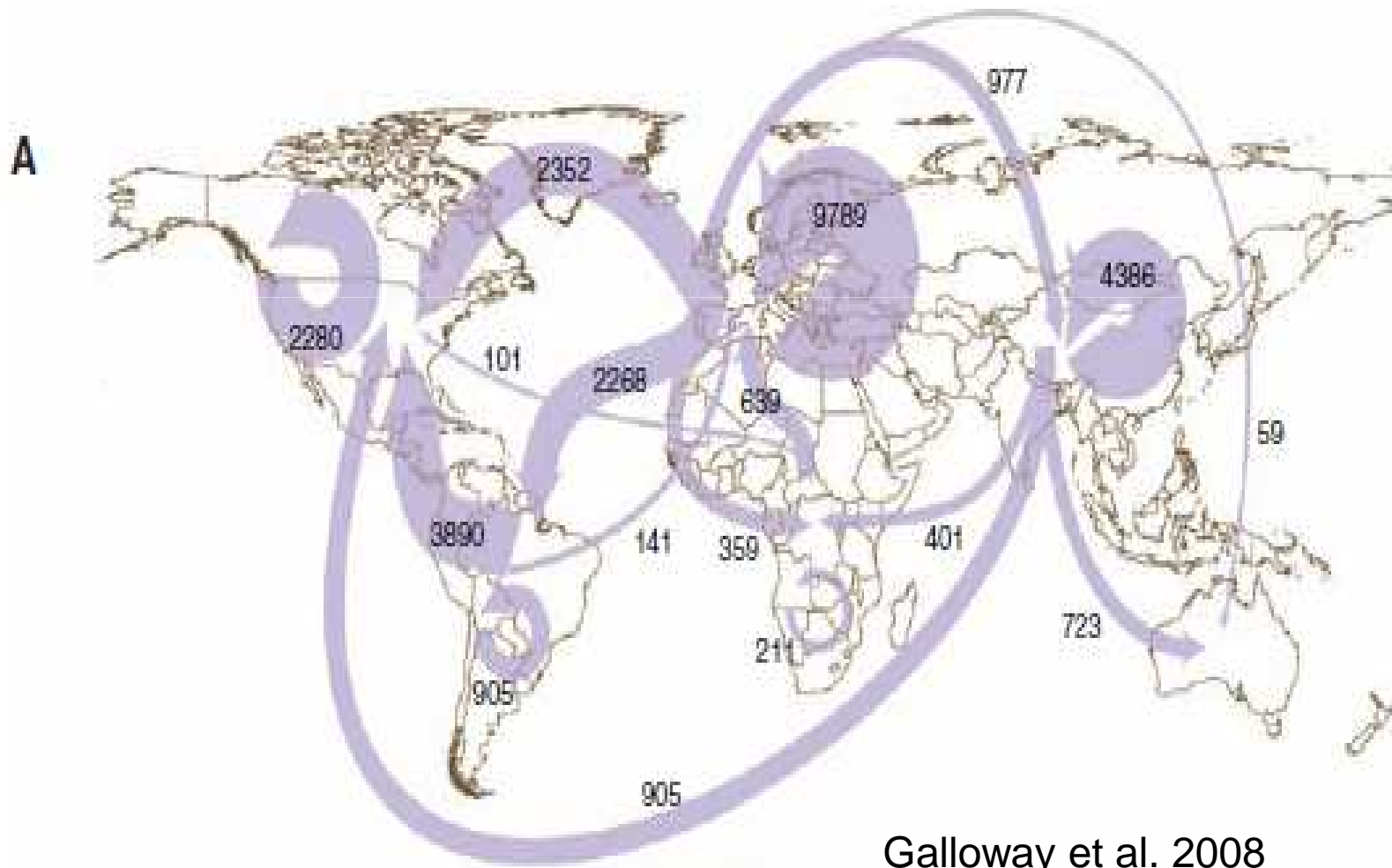
Main results

- Feed production swamps meat production in terms of both virtual N and embedded N =70% of the totals each
 - More difficult to regulate non-point N pollution (field crops) than point N pollution (animal production)
- N associated with trade is significant relative to that associated with domestic consumption
 - Brazil and USA – are receiving large amounts of N to support animal production in other countries
 - Brazil -over 40% of N lost to the environment is due to meat consumption in other countries

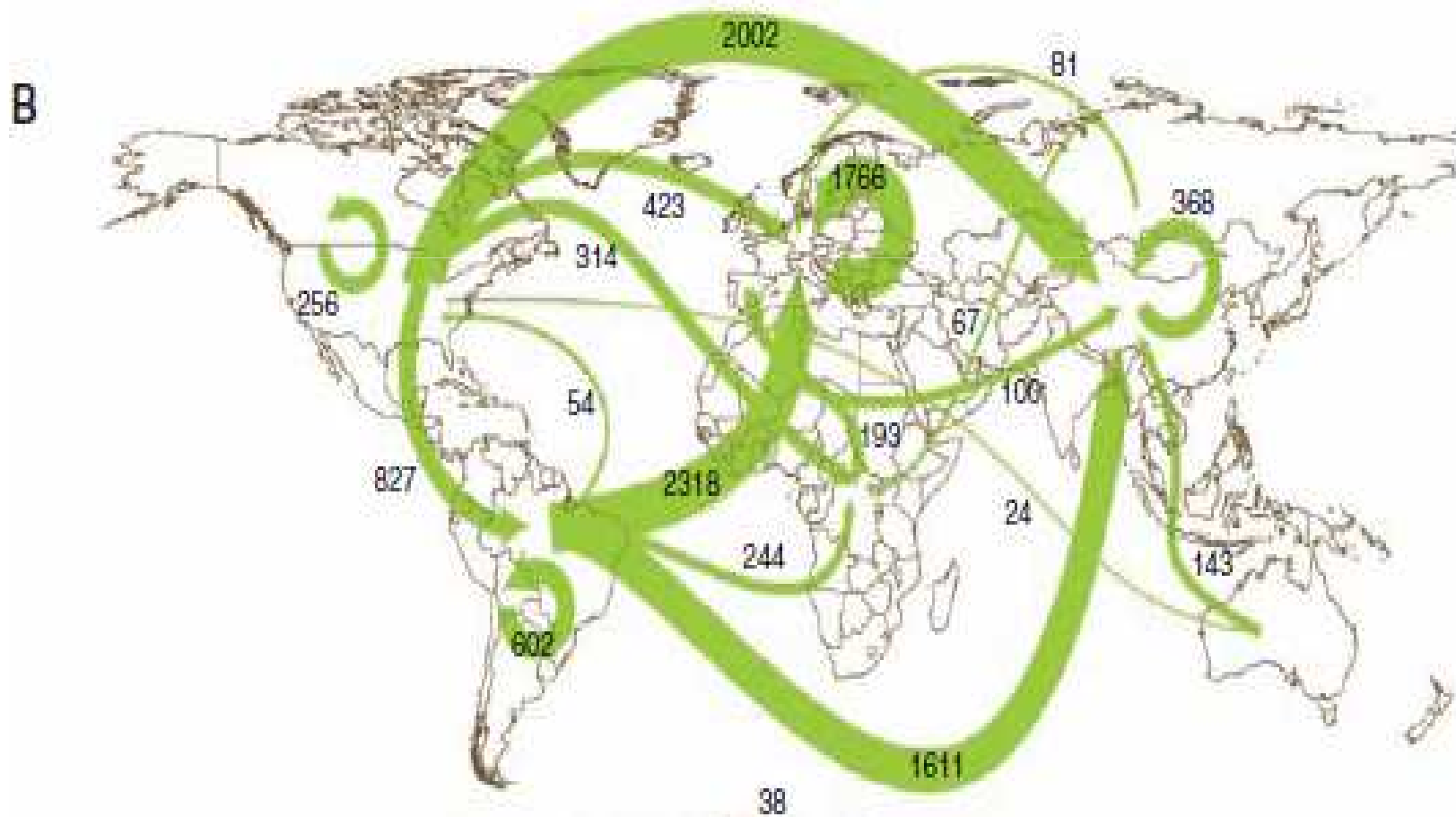
Main results

- Ne totals are generally larger than Nv totals.
 - Importance of legumes in the diet of pigs and chickens – exporting soil fertility
 - In spite of that, Nv is important – importing country, N is lost in the form of human waste after consumption – such waste is much better regulated than N lost from fields
- Model –country-level determinants of meat-related resource use
 - Analysis relinks consumption and production
 - For example, 16% of Nv left behind in Brazil is related to trade with China

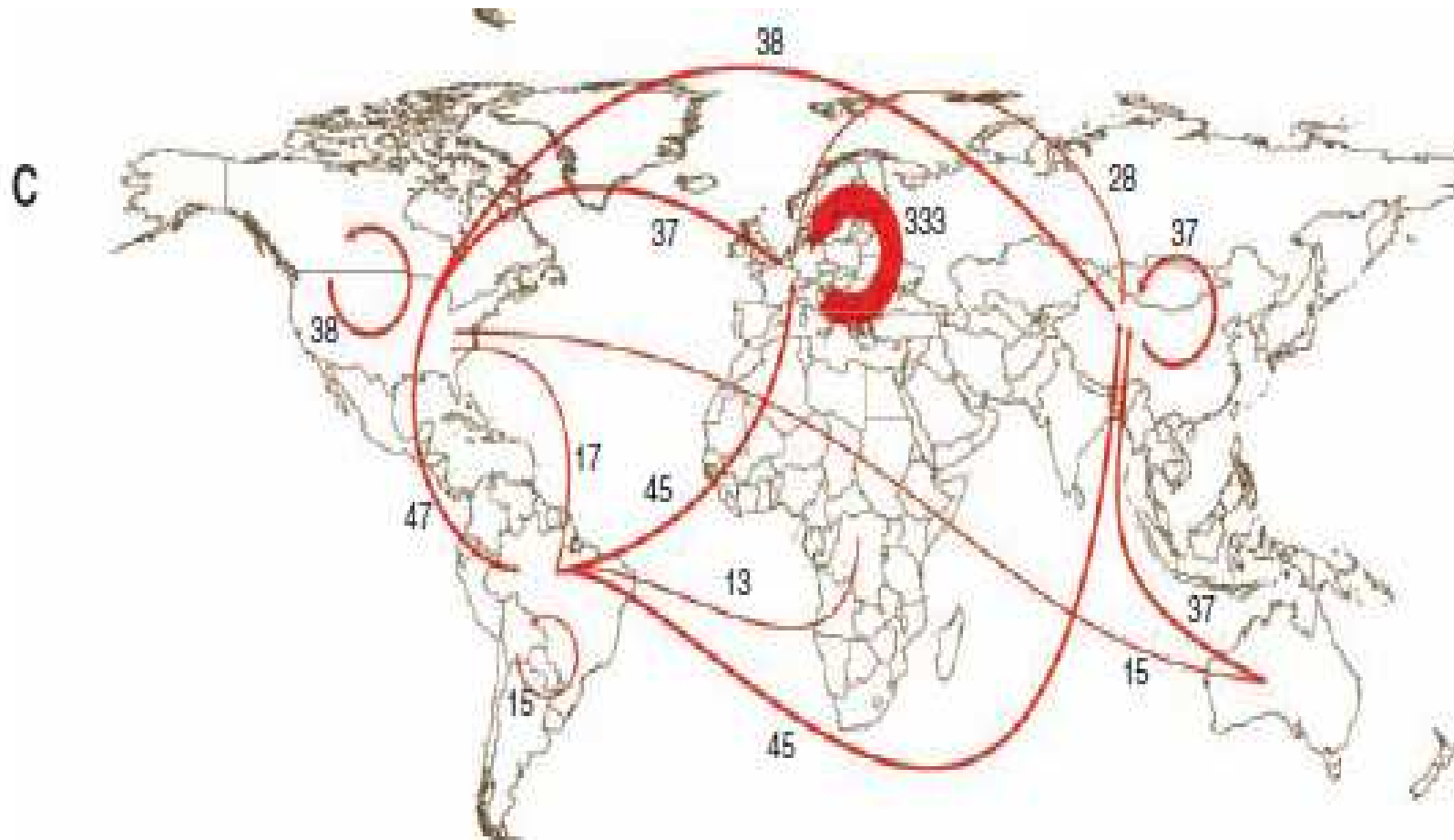
N contained in internationally traded fertilizer (31 Tg N)



N contained in internationally traded grain (12 Tg N)



N contained in internationally traded
meat (0.8 Tg N)



Galloway et al. 2008

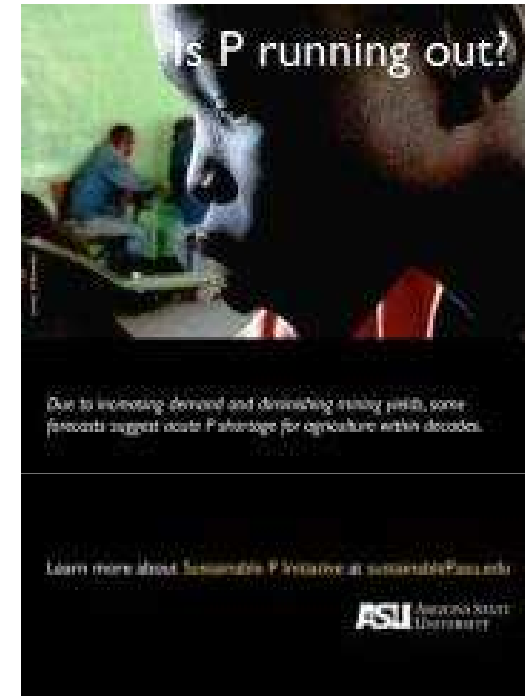
Environmental consequences – Who does pay the bill?

- As trade separates meat consumers and the negative environmental impacts of meat production...

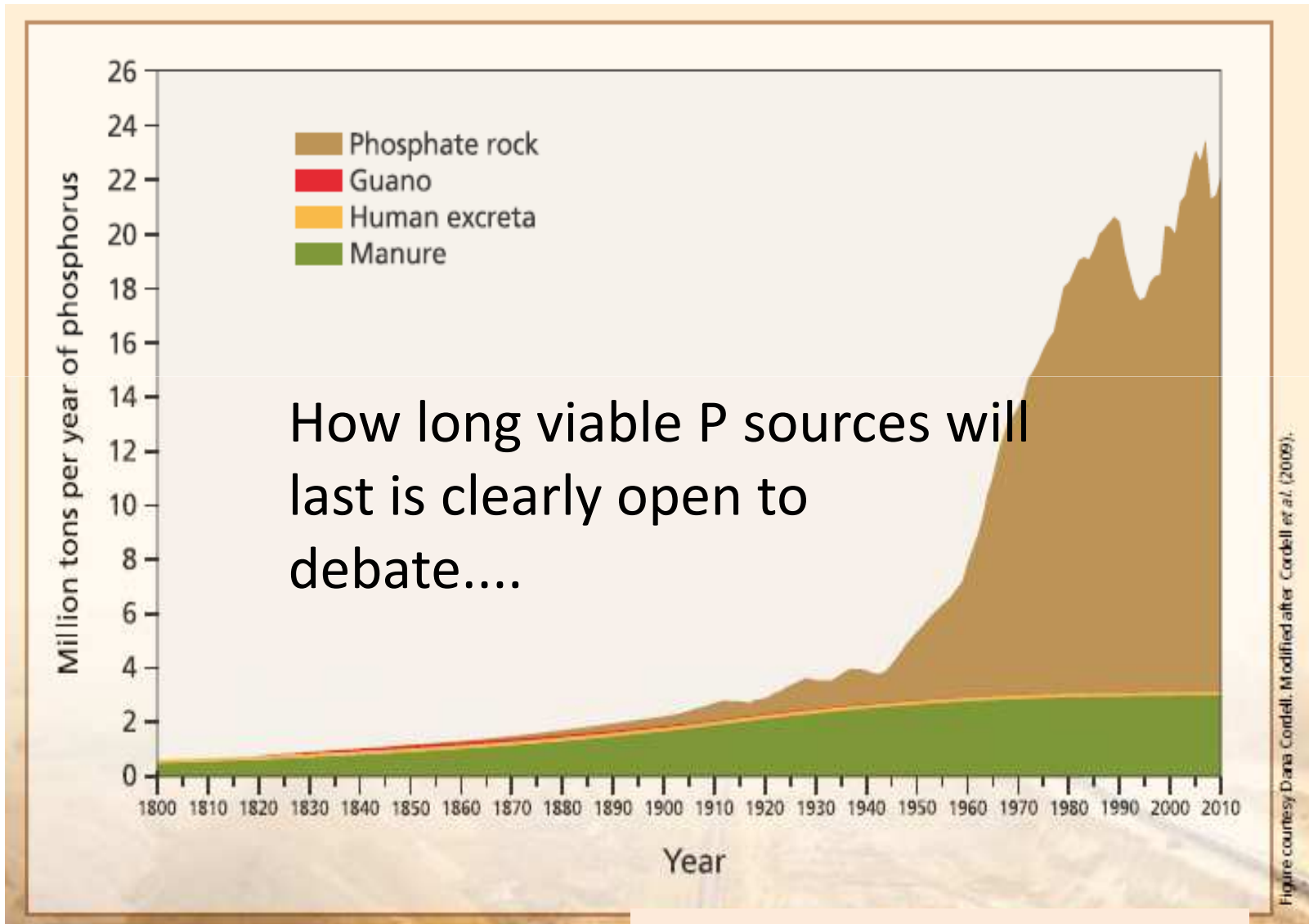
meat importers are neither made to feel nor pay for the impacts of their consumption decisions.

And what about Phosphorus?

- Producing N fertilisers is not a problem – it is abundant in the atmosphere and we know how to artificially “fix” it.
- Phosphate-rich rocks formed slowly over geologic time and are not renewable on human timescales.



P fertiliser



(Modified from Cordell et al.2009)

P - Global demand and supply

- Global demand for P will likely increase, but how much depends on the path that society chooses to follow during the coming decades.

• For example, the continued increase in meat consumption will trigger increase P demand.



Environmental consequences

- The majority of mined P is wasted throughout the production and supply chain, from fertiliser production to crop harvest to food retailing.

Some of this makes its way to water bodies, causing **eutrophication** = has been flagged as a **serious global environmental problem**



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How to reduce environmental impacts?

- Among various production factors - **improvements in crop yields and animal feed conversion efficiencies** result in the most significant reductions in environmental harm.
- Scenario analysis of feed production parameters suggests that **small changes in crop production** parameters have a **large effect on environmental outcomes.**

Where to intervene to decrease Nr and associated damages

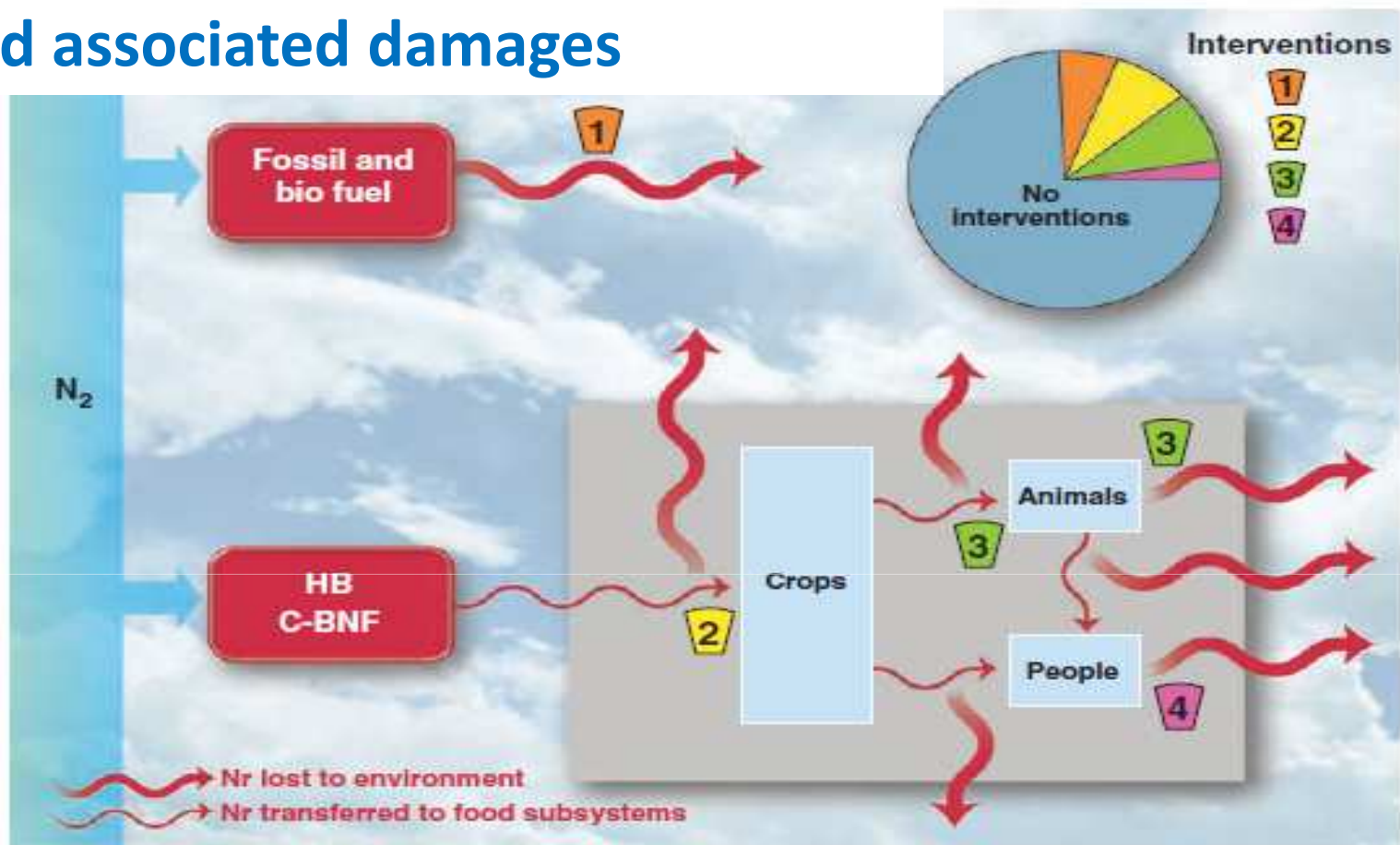


Fig. 3. Conceptual model of where interventions in the N cycle can be used to decrease the amount of Nr created or the amount of Nr lost to the environment. The red boxes represent subsystems where Nr is created. The sky-background space represents the environment. Arrows leaving the red boxes either result in Nr lost to environment (fossil fuel and biofuel combustion) or inputs to the food production system (gray box). The light blue boxes within the gray box represent subsystems within the food production system where Nr is used. Nr can either enter these subsystems (thin red lines), or be lost to the environment (thick red lines). The numbers represent intervention points for N management. The pie chart shows the magnitude of Nr managed by the four interventions relative to the total amount created (187 Tg N) in 2005.

Seven key actions for better nitrogen management in Europe

Agriculture

1. Improving nitrogen use efficiency in crop production
2. Improving nitrogen use efficiency in animal production
3. Increasing the fertilizer N equivalence value of animal manure

Transport and Industry

4. Low-emission combustion and energy-efficient systems

Waste water treatment

5. Recycling nitrogen (and phosphorus) from waste water systems

Societal consumption patterns

6. Energy and transport saving
7. Lowering the human consumption of animal protein

European Nitrogen Assessment, Launch April 2011
(Mark Sutton et al.)

Final remarks

- Nitrogen fertilisers support around 48% of world population
- Many +/- effects: e.g. European N has a net cooling effect on climate
- Important effects of nitrogen on water and air quality, human health and biodiversity

Final remarks

- In regions that do not have sufficient Nr or other nutrients – increase food production without nutrient losses and environmental damages
- Smart management of the nitrogen cycle
 - Meet pollution targets with climate co-benefits
 - Our ambition for food & energy consumption

The challenge....

nature

www.nature.com/nature

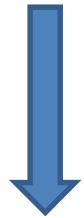
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How to feed a hungry world

Producing enough food for the world's population in 2050 will be easy. But doing it at an acceptable cost to the planet will depend on research into everything from high-tech seeds to low-tech farming practices.

What is needed?

a second green
revolution



“sustainable
intensification of
global agriculture”
(Britain’s Royal Society)



Monitoring world's agriculture

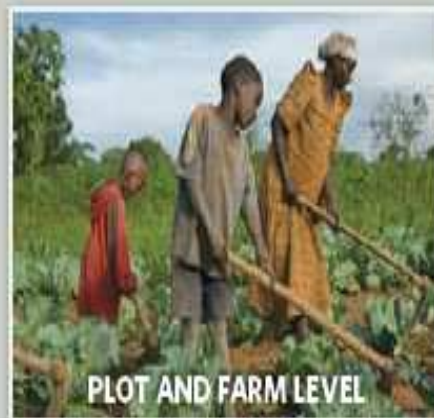
(Jeffrey Sachs et al. Nature 2010)

SUMMARY

- Agriculture is assessed at different scales, using inconsistent methods and narrow criteria
- A common set of metrics must be collected at comparable scales
- The resultant, freely available data should inform farming practices worldwide

A HOLISTIC VIEW

Metrics monitored at the level of a village or watershed (at the landscape scale) can be integrated with data collected from individual farms, as well as regions, nations and continents. This will inform local and global models, help researchers to make cross-site comparisons and lead to evidence-based food policy.



Stronger scientific guidance for management and policy of agricultural systems from the plot to the global level

Thank you!

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