Food for thought: Nitrogen too much of a vital resource?

Jan Willem Erisman

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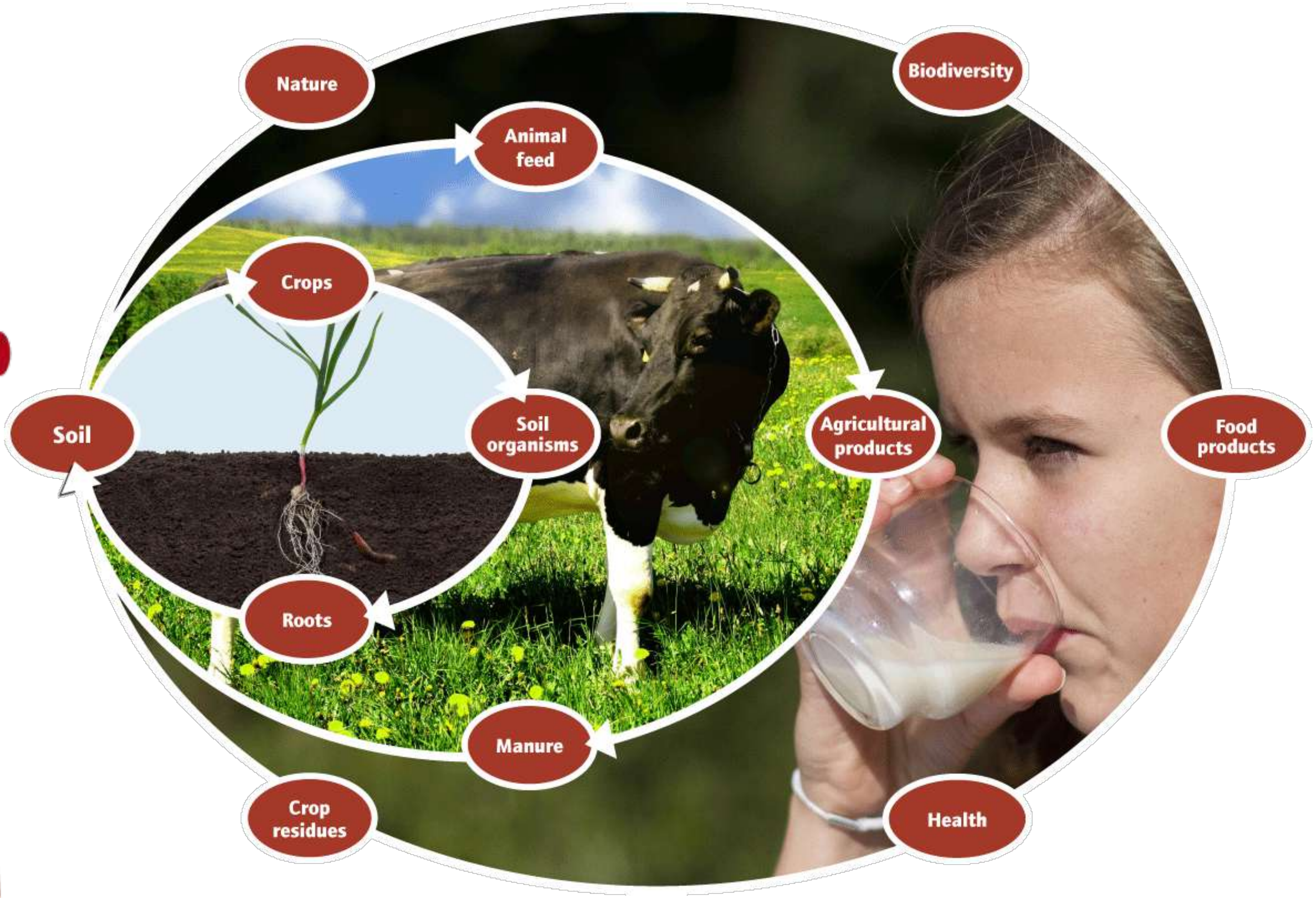
LOOKING FURTHER

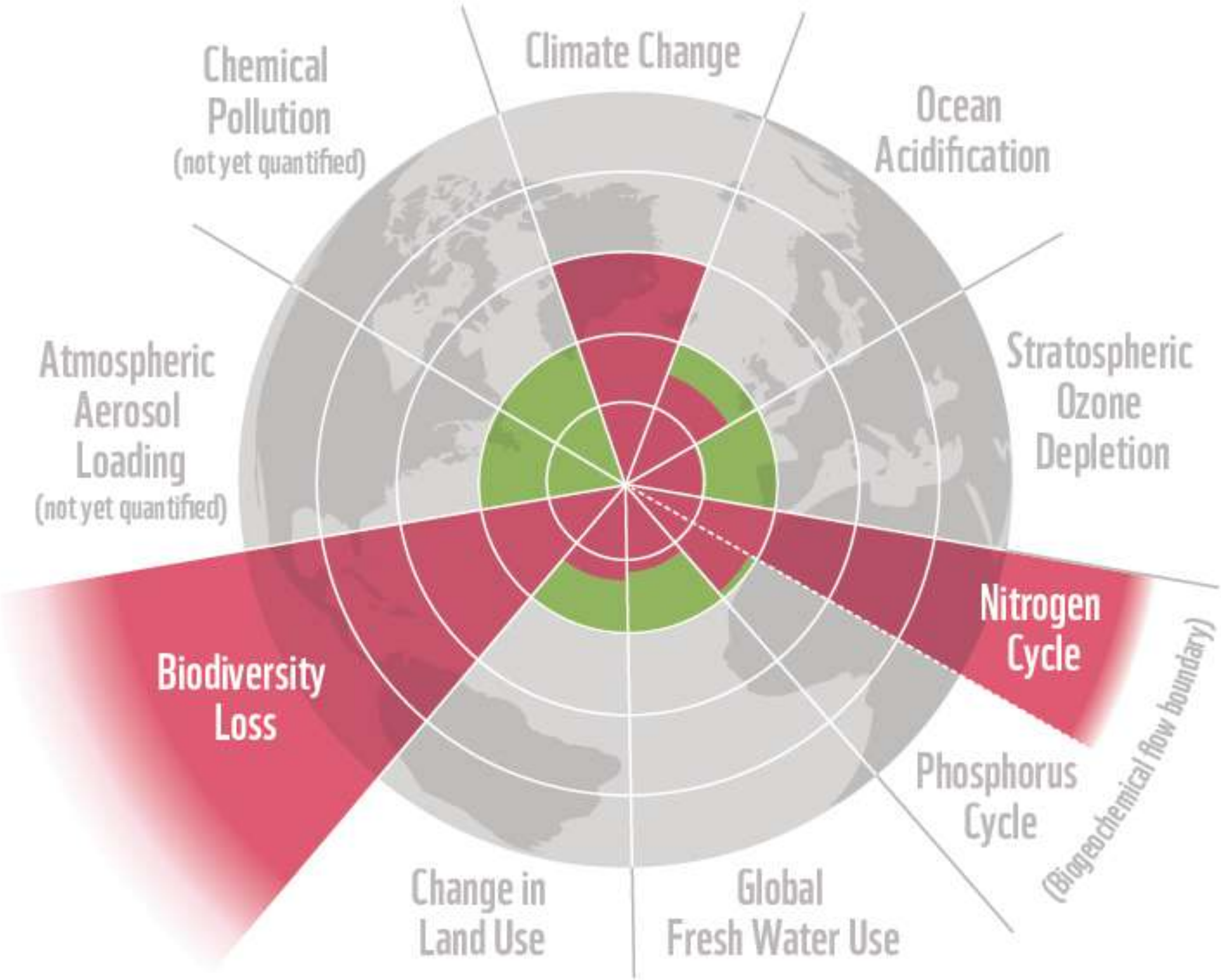
Louis Bolk Institute: for sustainable agriculture, nutrition and health



Outline of my presentation

- Why Nitrogen
- Sources of reactive nitrogen
- Efficiency of Nitrogen use
- Effects of Nitrogen
- Nitrogen and Diets
- Your personal Nitrogen Footprint
- What can be done to solve the N issue?

Why care about nitrogen?



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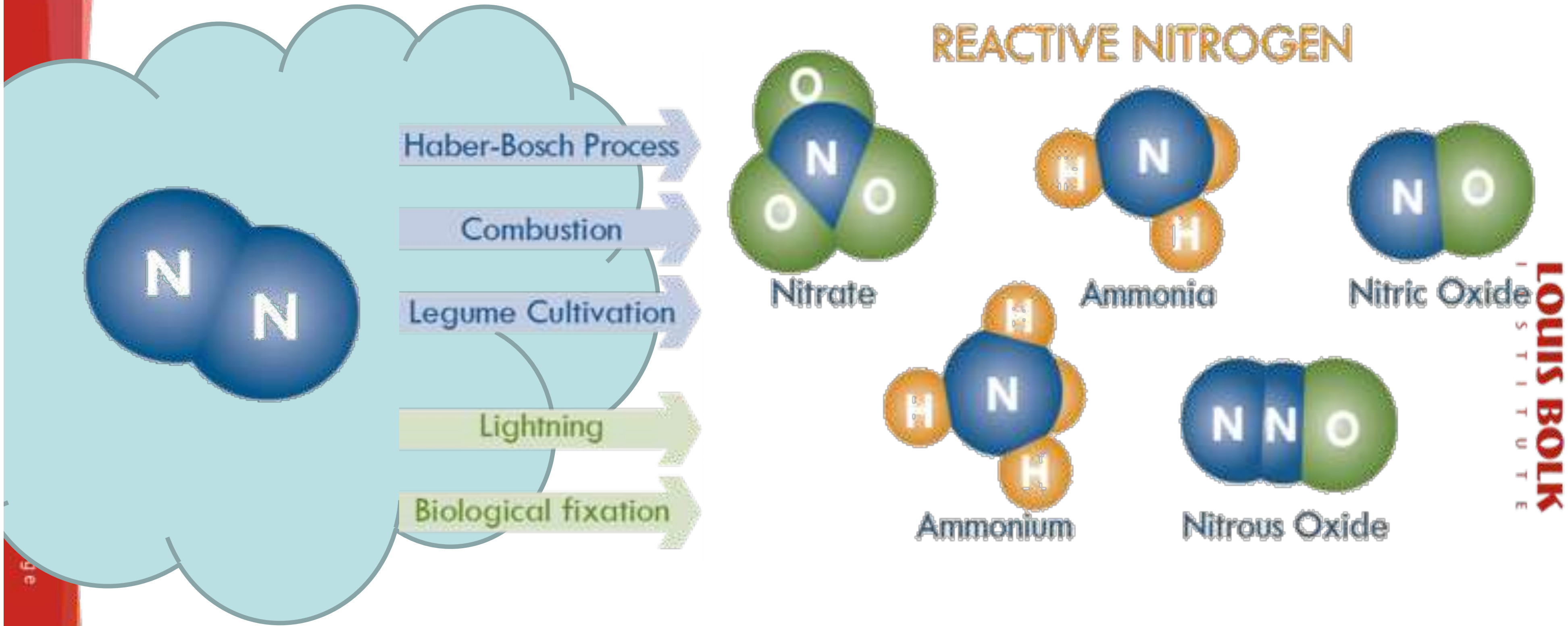
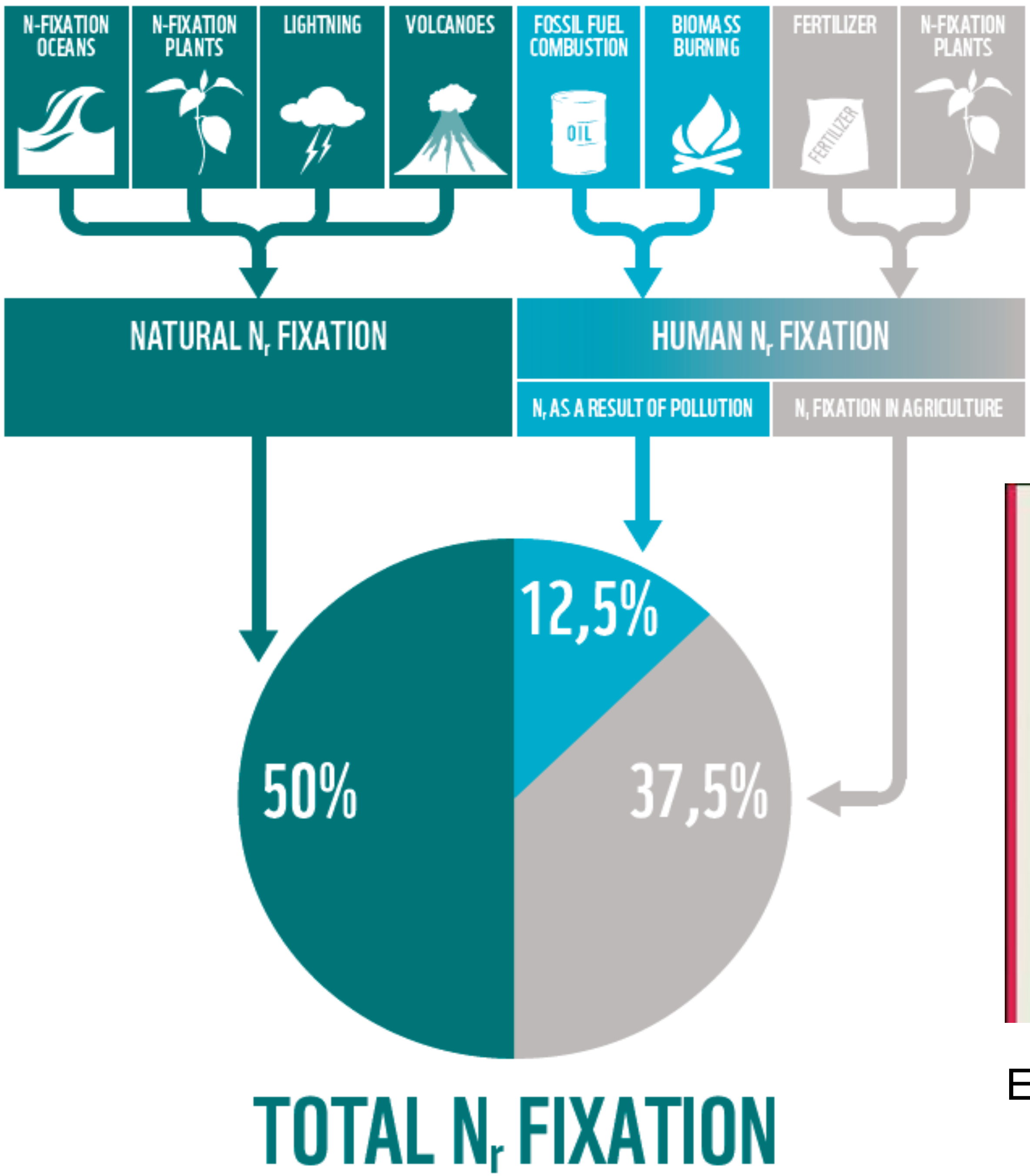
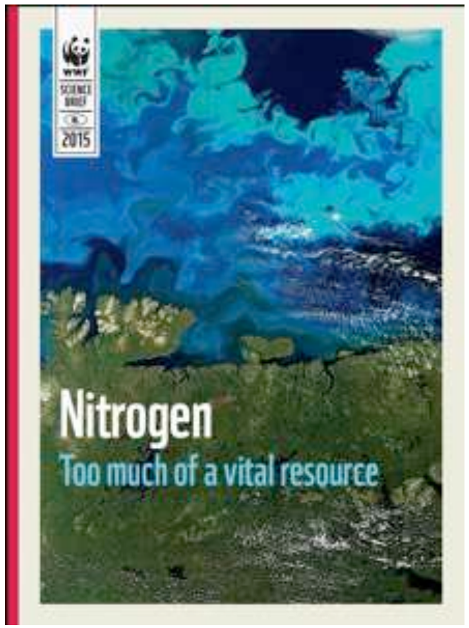
Anthropogenic and natural processes create reactive nitrogen



- Only a limited amount of Nr is created in nature: 99.97% resides in the atmosphere in a relatively inert form
- Ecosystems (biodiversity) are based on low availability

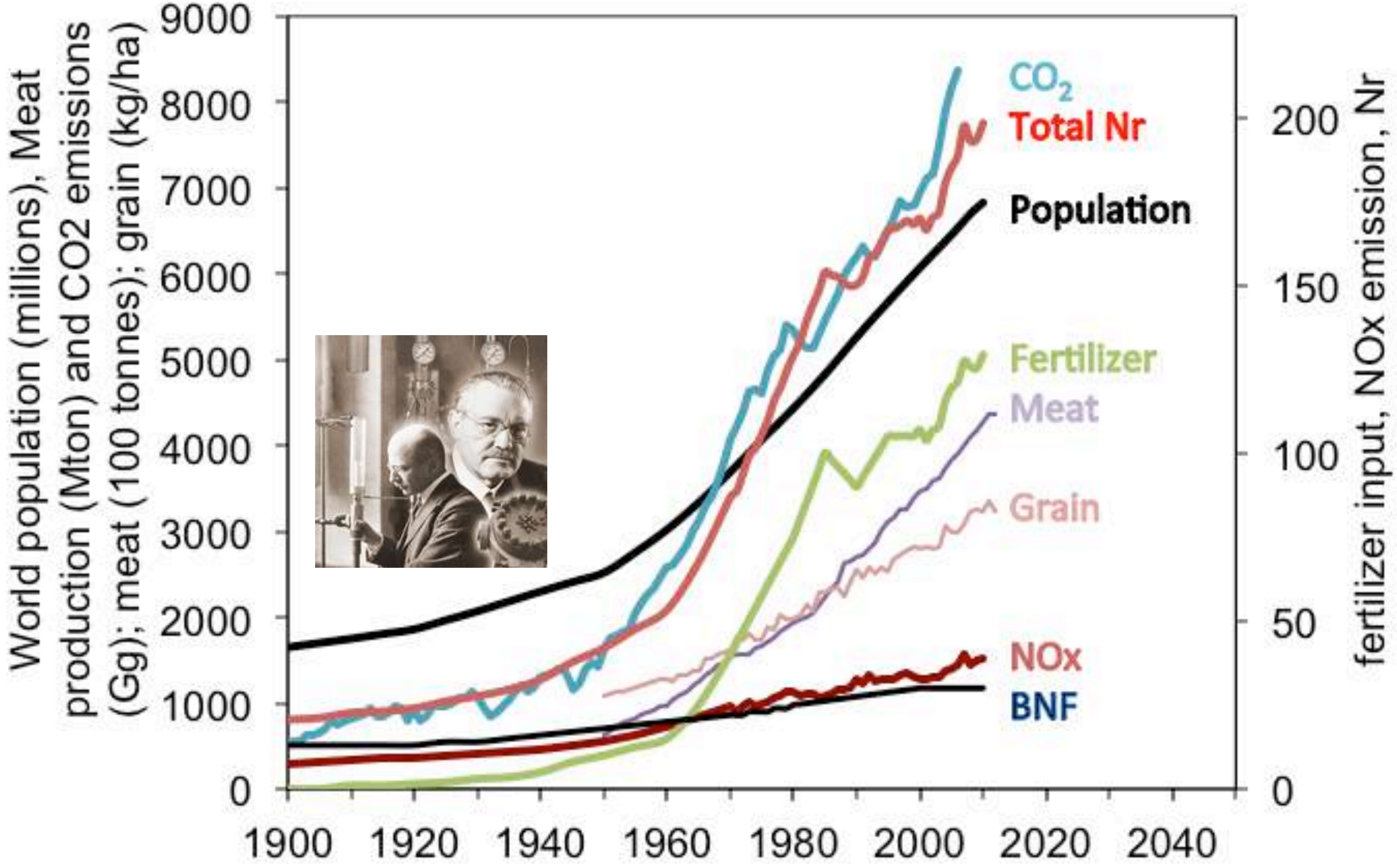
CREATION OF REACTIVE NITROGEN





Erisman et al. (2015)

Global trends in human population, N_r, CO_2 and grain and meat production



48% of the global population eat because of fertilizers

Erisman et al. 2008

Uneven distribution

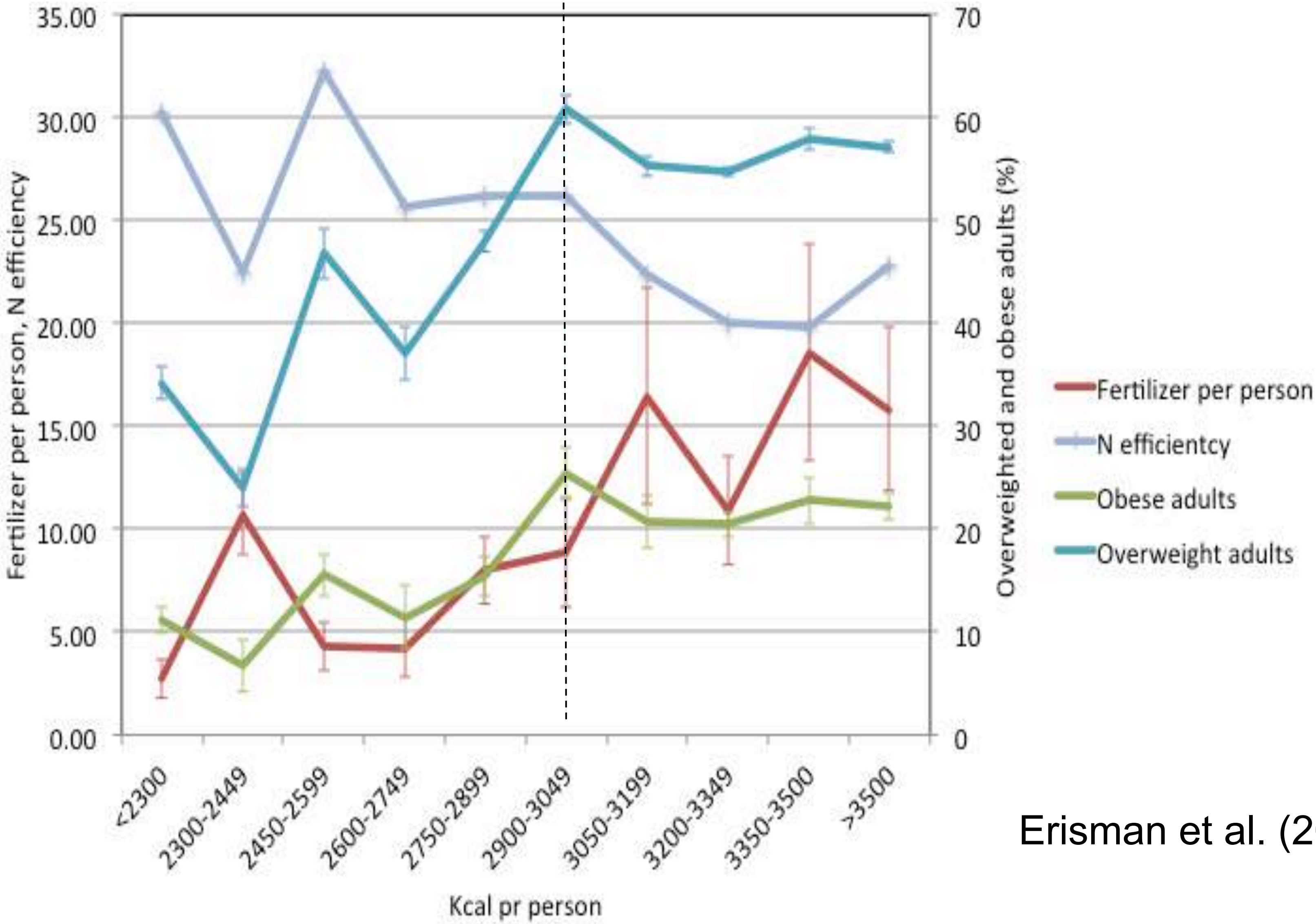
- More than 2 billion people in the world suffer from (micro) **nutrient deficiency**, especially in developing countries. Most critical are **protein-nitrogen**, phosphorus, calcium, zinc, iron, iodine
- An increasing number of people is **obese**
- Probably 20% of the population **'eats' 80% of the fertilizer**

United States, The Revis family
$341.98/week

Chad The Aboubakar family
$1.23

Photo's: Peter Menzel, Faith D'Aluisio

Increase in overweight and obesity with kcal consumption and fertilizer application



Erisman et al. (2017)

Nitrogen stimulates all growth

David,
Michelangelo Buonarroti (1475 - 1564)

Nitrogen use efficiency

Energy Production: NUE = 0%

N

Food Production: NUE = 10 – 50%

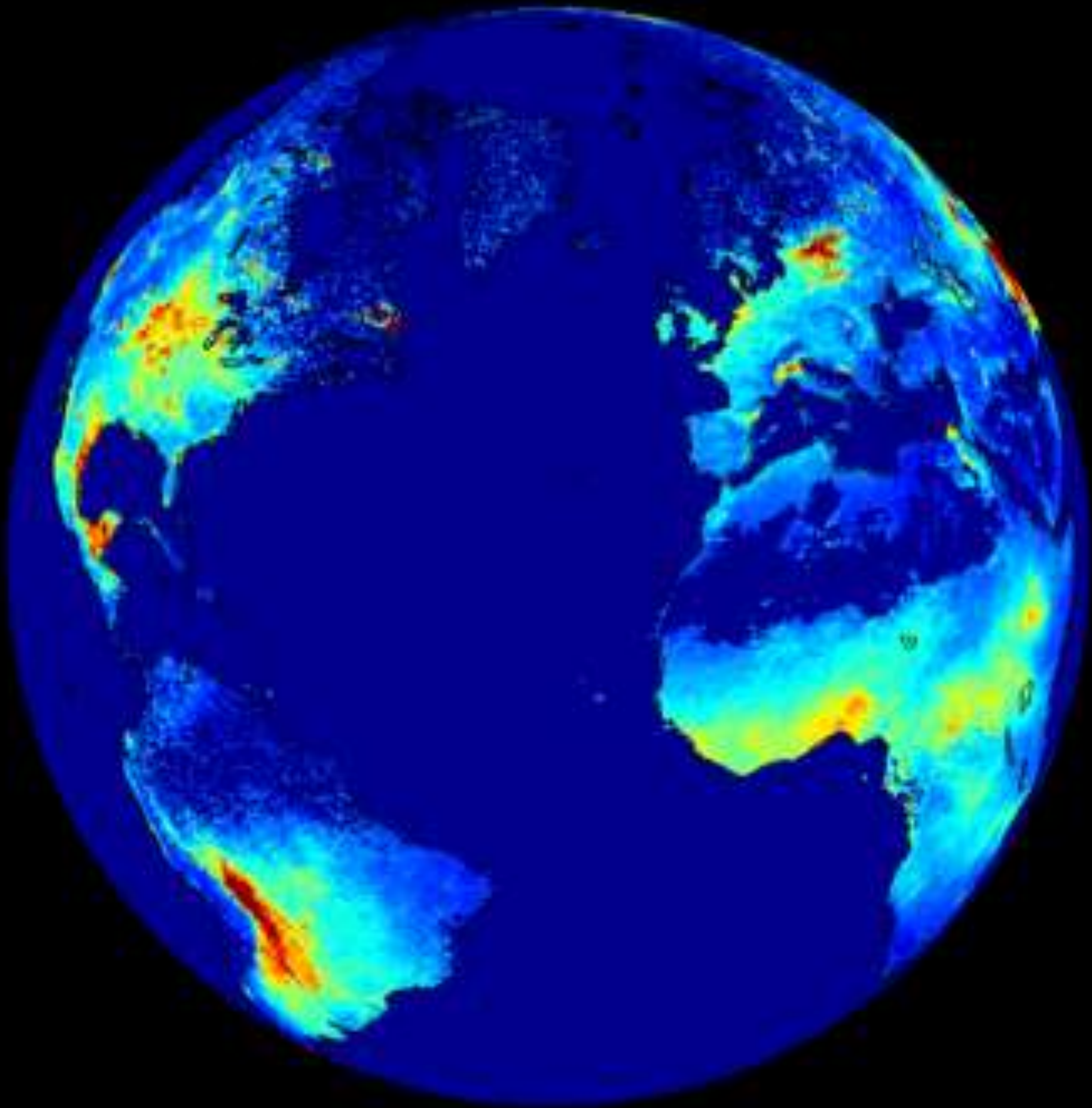
N

ENVIRONMENT

Changes in animal production systems increasing N leakage

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

to one in which the production process are separated from feed production and manure application



Van Damme et al. 2014 *2011 NH_3 distribution*

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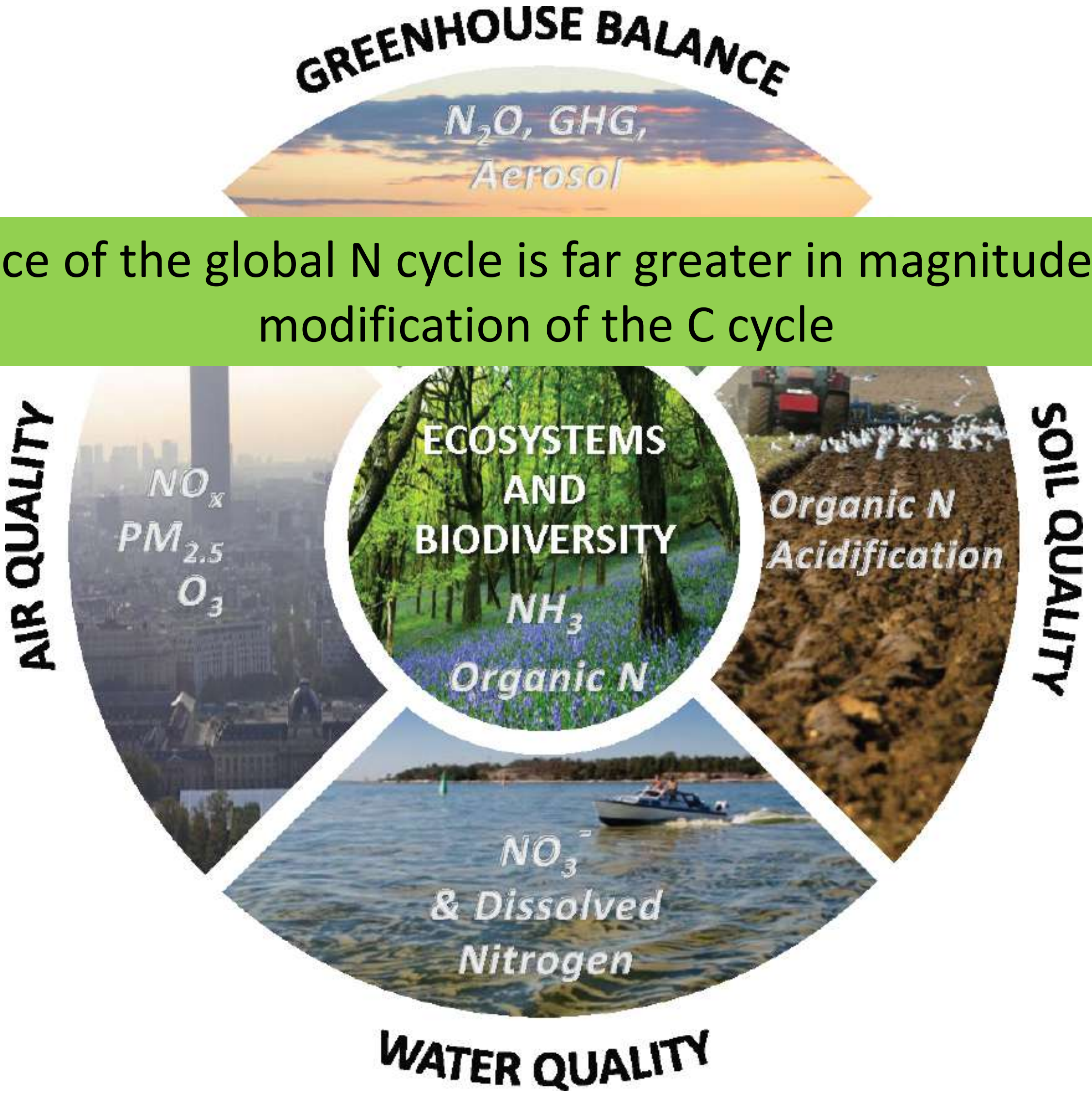
The five key threats of excess N



Disturbance of the global N cycle is far greater in magnitude than our modification of the C cycle

ENA, 2011

Visible impacts of terrestrial N pollution: biodiversity losses

N-poor natural ecosystems

Biodiverse woodland understorey

Lichens sensitive to air pollution

Wildflower biodiversity in meadows

N-enriched ecosystems

Loss of biodiverse understorey

Loss of sensitive lichen species

Biodiversity loss in farmed meadows

Visible impacts of coastal nutrient pollution: implications for coastal communities


Under the microscope


Microcystis bloom, Baltic


Noctiluca tides, New Zld.


Phaeocystis foam, NL


Caulerpa, Florida


Green tides, Brittany


Fish kills, Gulf of Mexico

Shell-fishery closure

Jones, 2015

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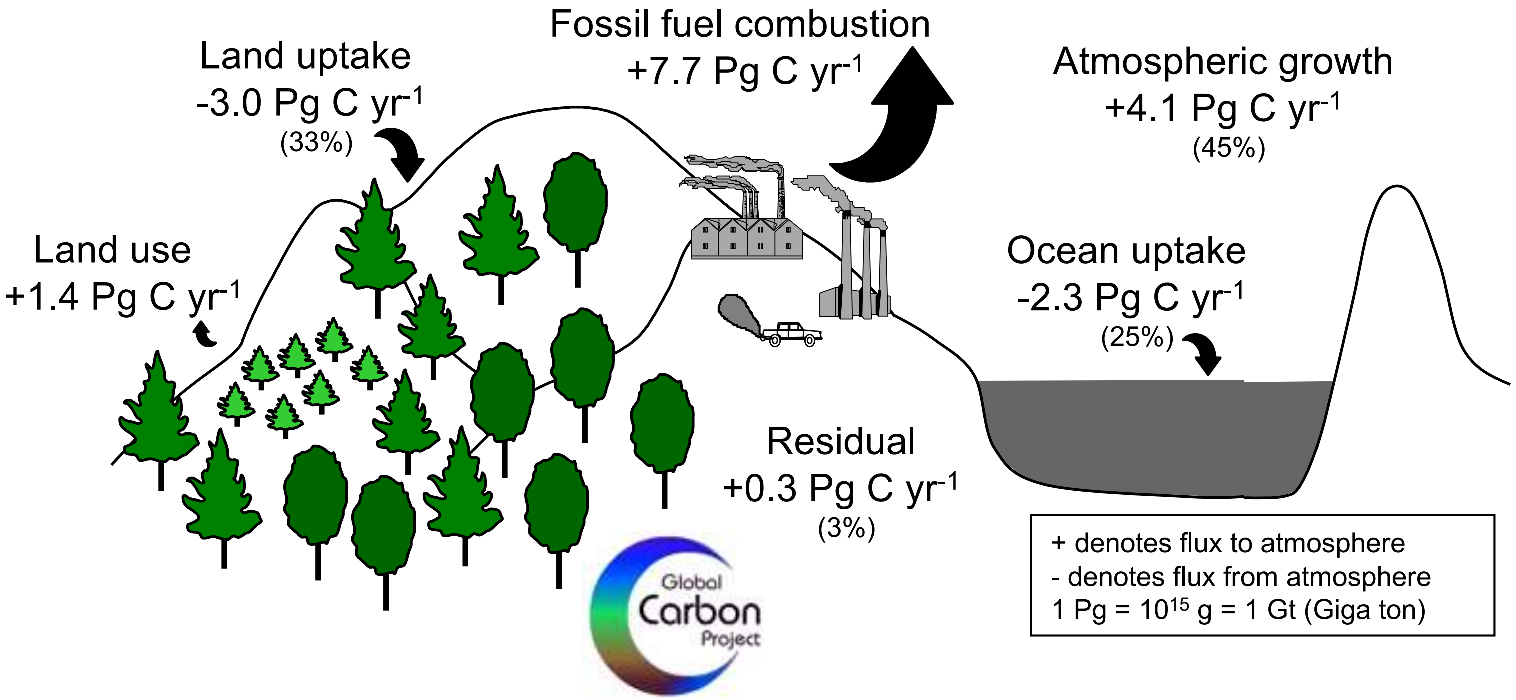
Nitrogen and the carbon cycle

N deposition increased carbon storage by:
~0.3 Pg C yr^{-1} in terrestrial systems
~0.3 Pg C yr^{-1} in marine areas (Blue Carbon)
Limitations of P, other nutrients ..?

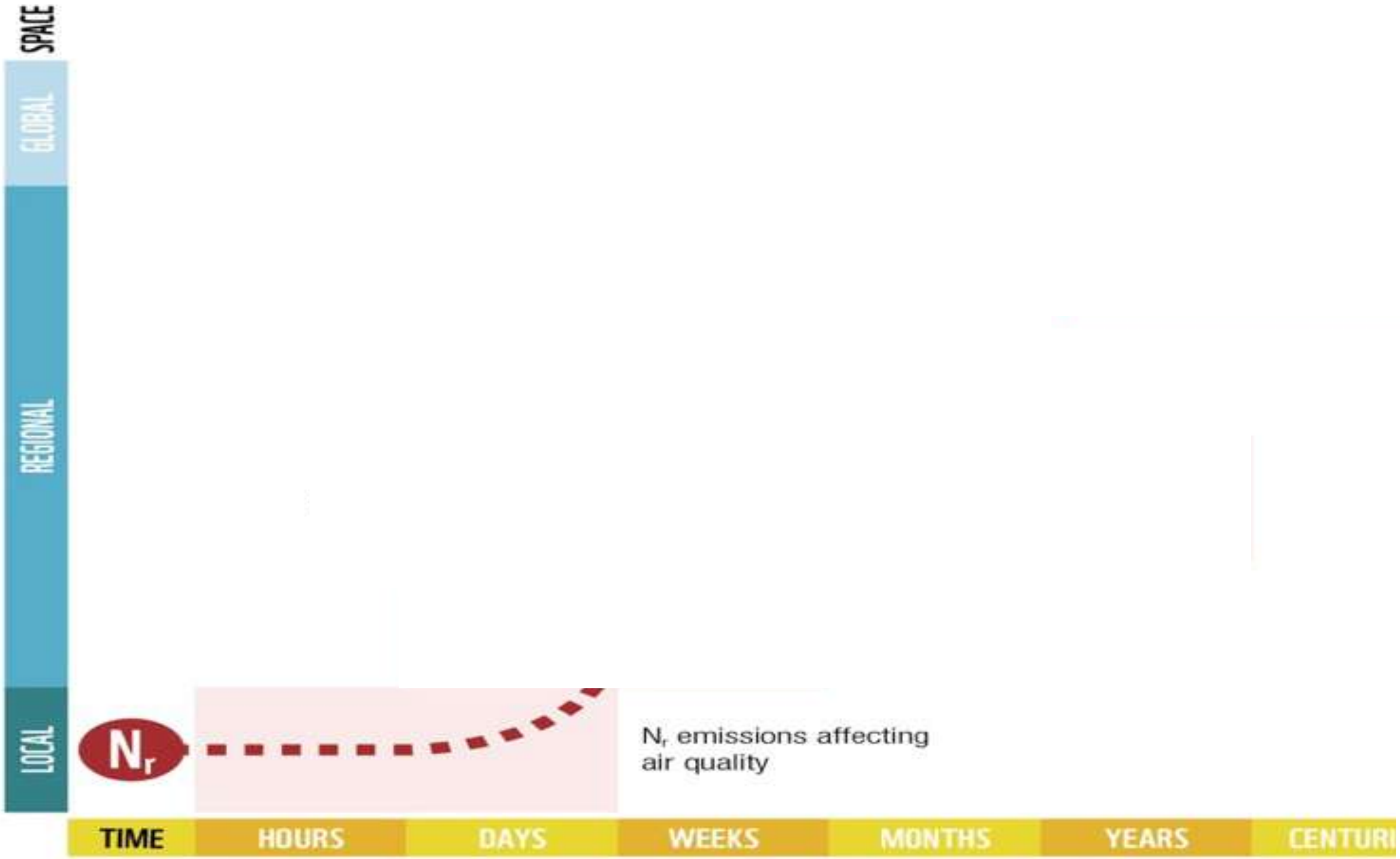
Global carbon cycle, 2000-2008



+ denotes flux to atmosphere
- denotes flux from atmosphere
1 Pg = 10^{15} g = 1 Gt (Giga ton)

Data from
Le Quéré (2010)

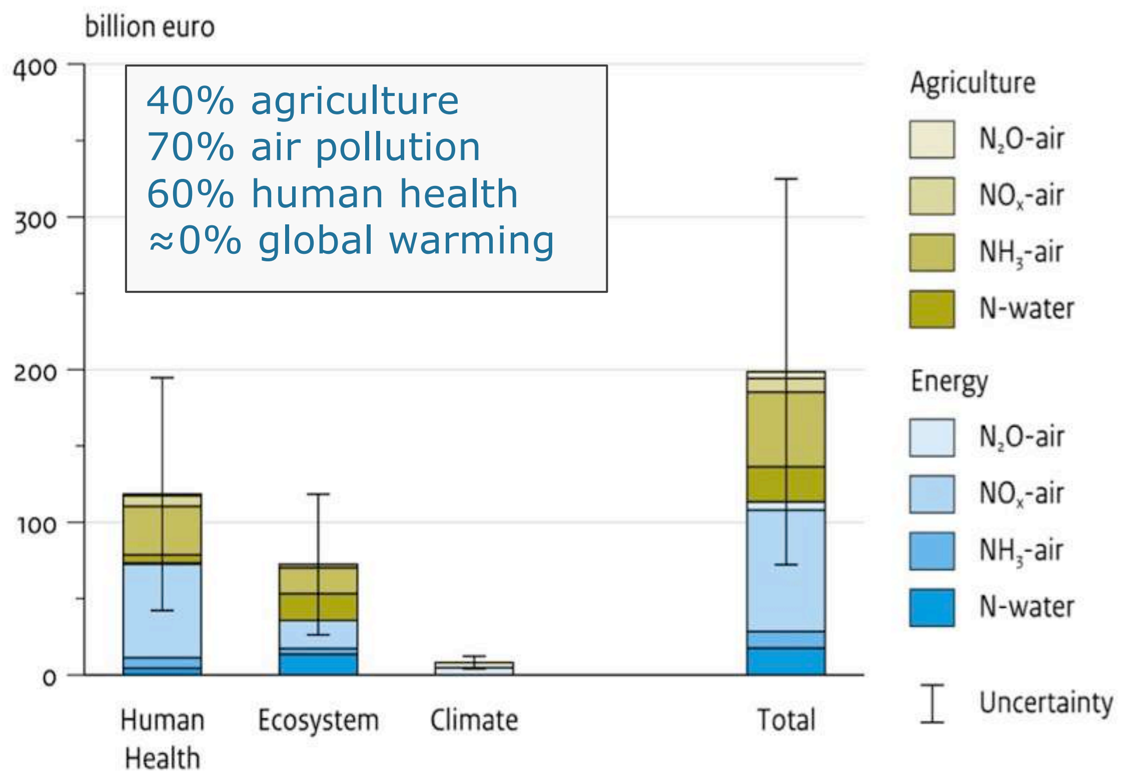
Too much nitrogen: in a cascade



Galloway et al. 2003

The unintended costs of Nitrogen to society

- Willingness To Pay: to prevent N damage 70-320 bln € (EU, 2000)
- Added value for the primary sector (agriculture) similar to external cost
- Global extrapolation: 200 – 2000 bln US $



ENA, 2011

Economic N footprint of foods:

www.n-print.org

Steak

Grocery store cost:	7 Euro
Health/environment cost:	1.9 Euro
Total cost =	8.9 Euro

Chicken Breast

Grocery store cost:	3 Euro
Health/environment cost:	1.1 Euro
Total cost =	4.1 Euro

Broccoli

Grocery store cost:	1.5 Euro
Health/environment cost:	0.2 Euro
Total cost =	1.7 Euro

Milk

Grocery store cost:	1 Euro
Health/environment cost:	0.4 Euro
Total cost =	1.4 Euro

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The Nitrogen Dilemma

Benefits:

- Necessary for life
- Nitrogen fertilizer supports food supply

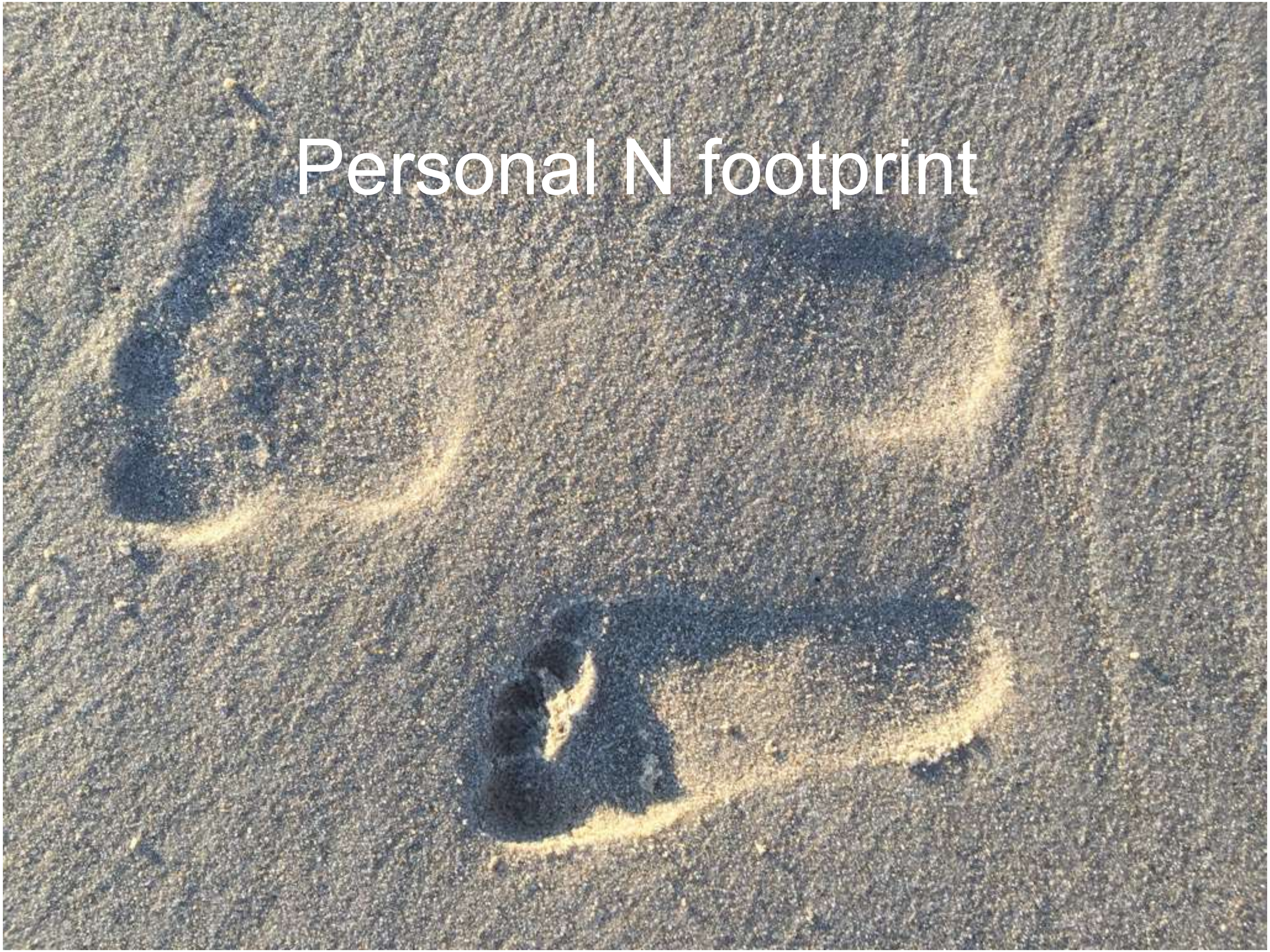

Drawbacks:

- Excess reactive nitrogen negatively affects environmental and human health


Challenge:

Optimizing the use of nitrogen, while minimizing the negative impacts

Personal N footprint



What is a nitrogen footprint?

A **nitrogen footprint** is the amount of **reactive nitrogen** released to the environment as a result of an entity's resource consumption

What major sectors are commonly included in a nitrogen footprint?

Food*	Utilities	Transport
		

*Food consumption and production

Food N footprint: Definitions

Food consumption

= N that enters human mouth

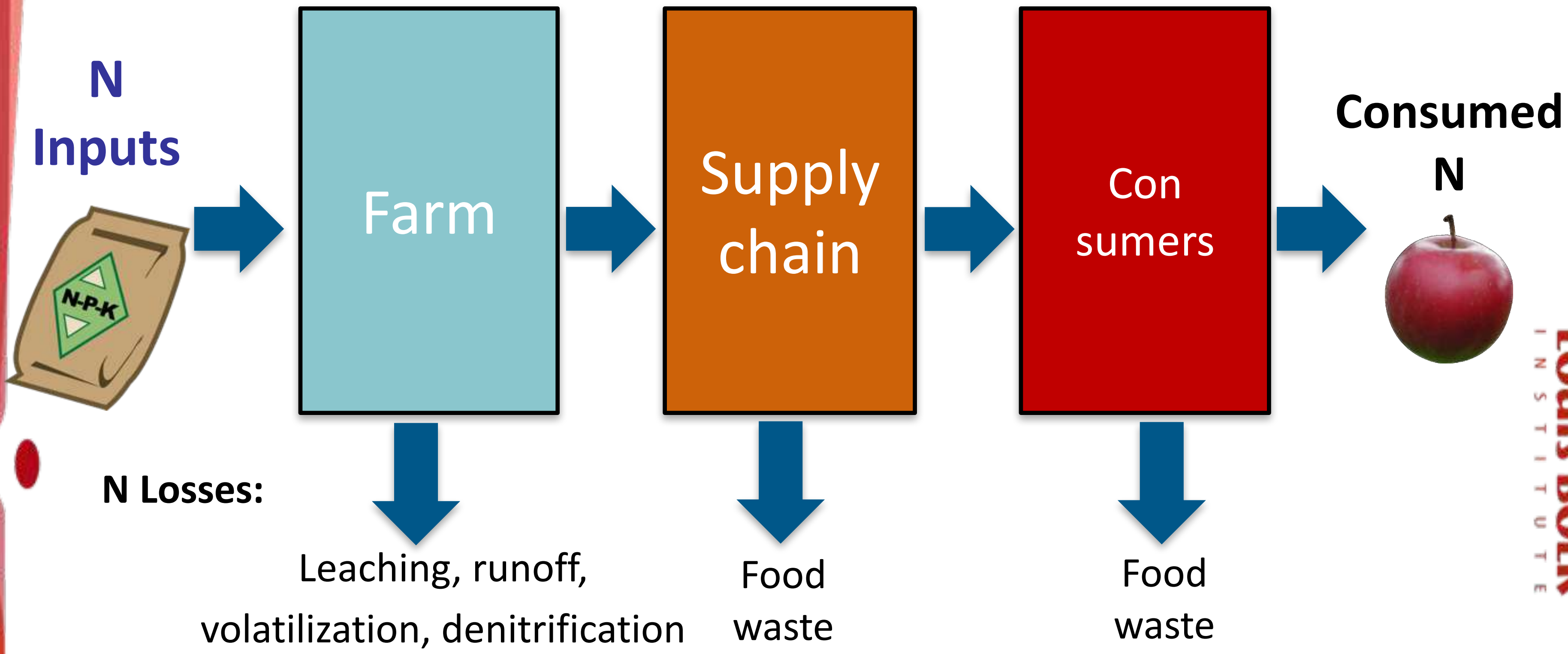



Virtual N

= **Food production N**

= N lost to the environment during the food production process


N efficiency over the food chain



$$\text{Virtual N Factor} = \frac{\sum \text{N Losses}}{\text{Consumed N}}$$

The impact of FOOD CHOICES on a N footprint

ENVIRONMENT

ENVIRONMENT

½ cup beans

15 g protein

3 oz steak

15 g protein

Personal N footprints

Calculate your nitrogen footprint at:

www.N-Print.org

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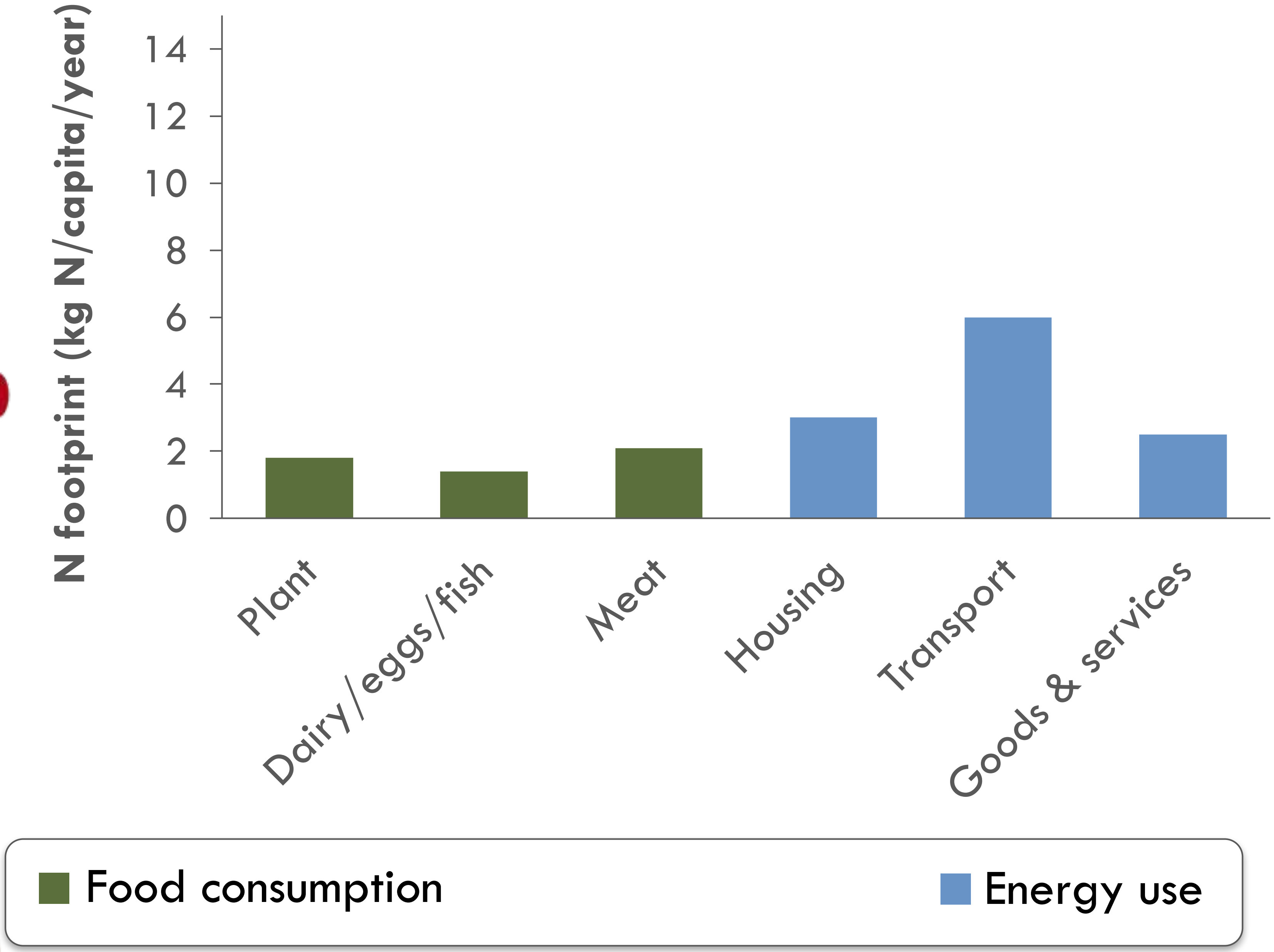
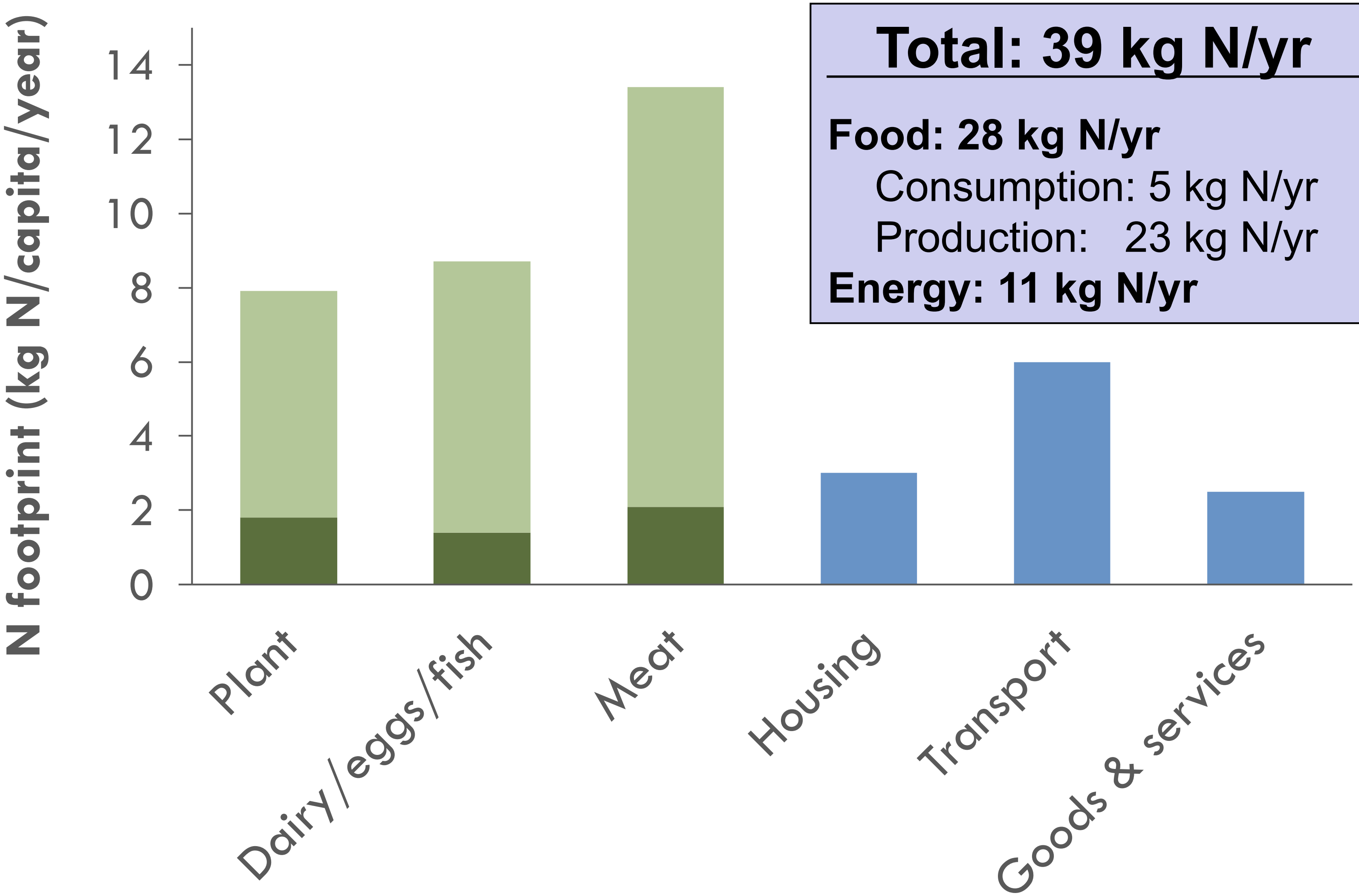
Personal N footprint in the US



Personal N footprint in the US



Total: 39 kg N/yr

Food: 28 kg N/yr
Consumption: 5 kg N/yr
Production: 23 kg N/yr
Energy: 11 kg N/yr

Food consumption   Food production   Energy use

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What the world eats:
Personal N footprints around the world

USA

Japan

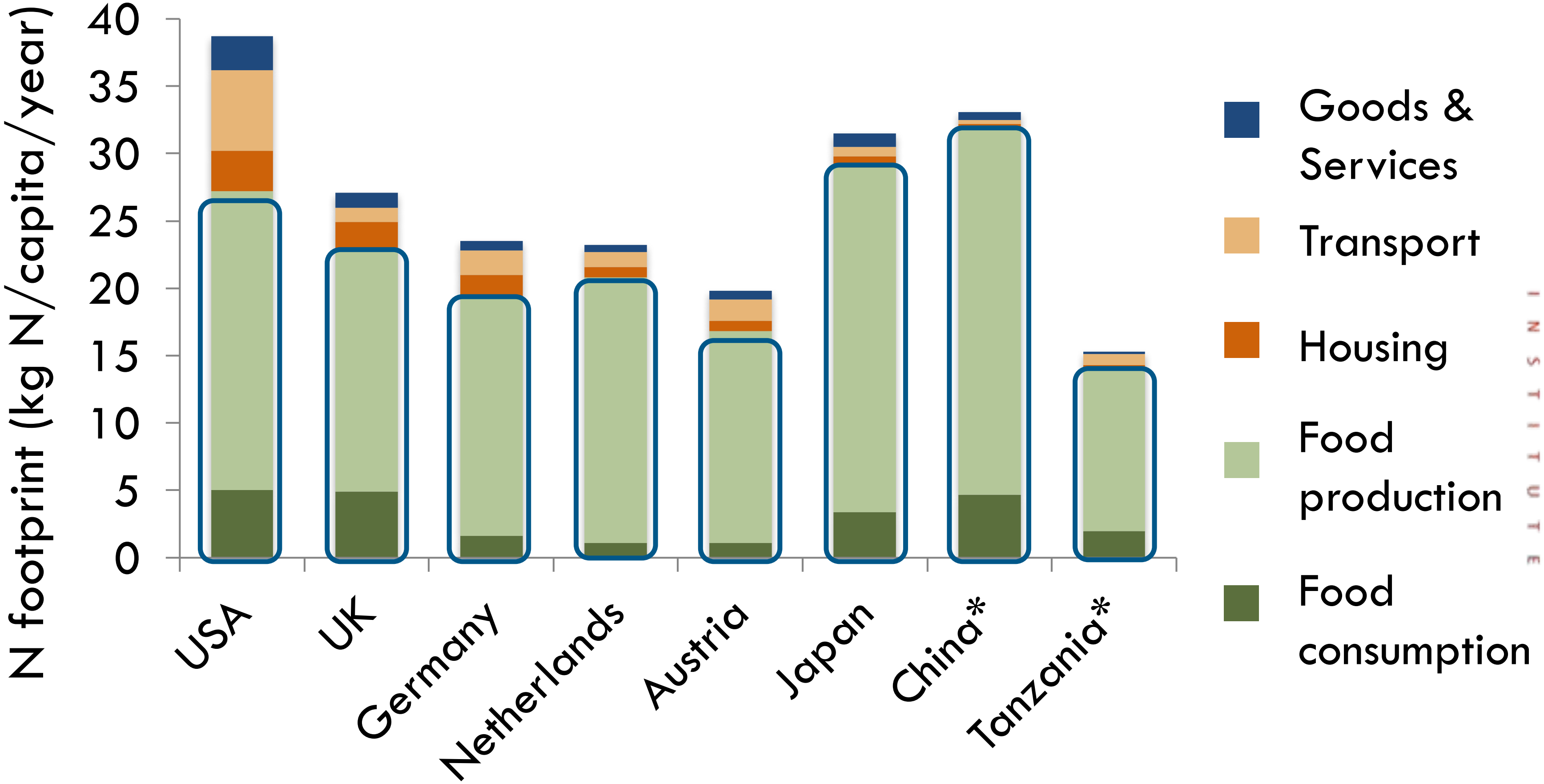
Germany

Chad

Personal N footprint by country

*Preliminary

Personal N footprint by country



Food makes up more than 75% of a personal nitrogen footprint

**Preliminary*

Options for reducing YOUR footprint

N Print — Calculate your N footprint: **www.N-PRINT.org**

Energy:

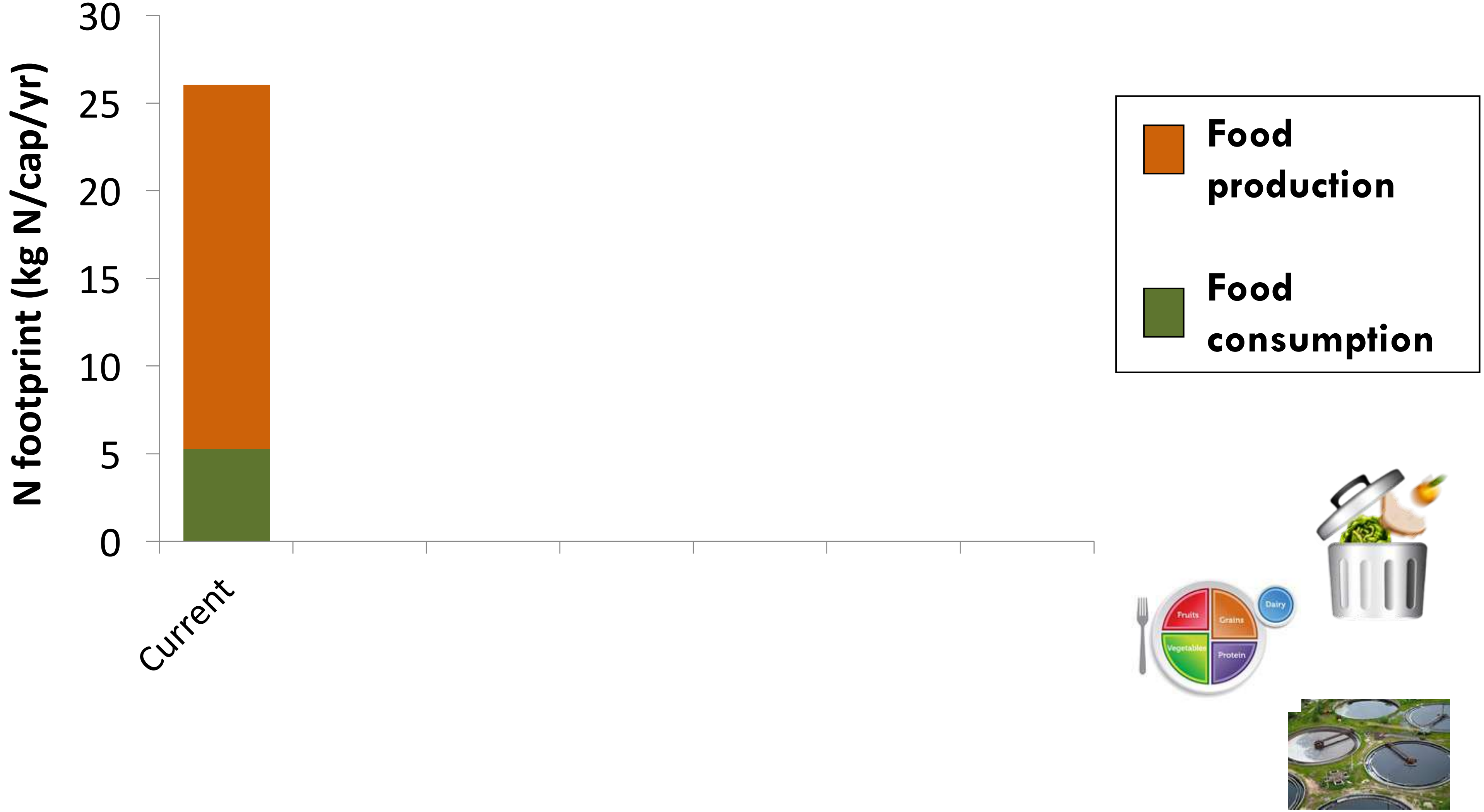
- Reduce utility usage
- Public transit
- Reduce, reuse, recycle!

Food:

- Recommended amount of protein
- Less animal protein
- Less N-intensive meat
- Food from sustainable farms
- Reduce food waste

Scenarios: US personal N footprint

Current N consumption: 5.3 kg N/cap/yr
Recommended N consumption: 3.0 kg N/cap/yr



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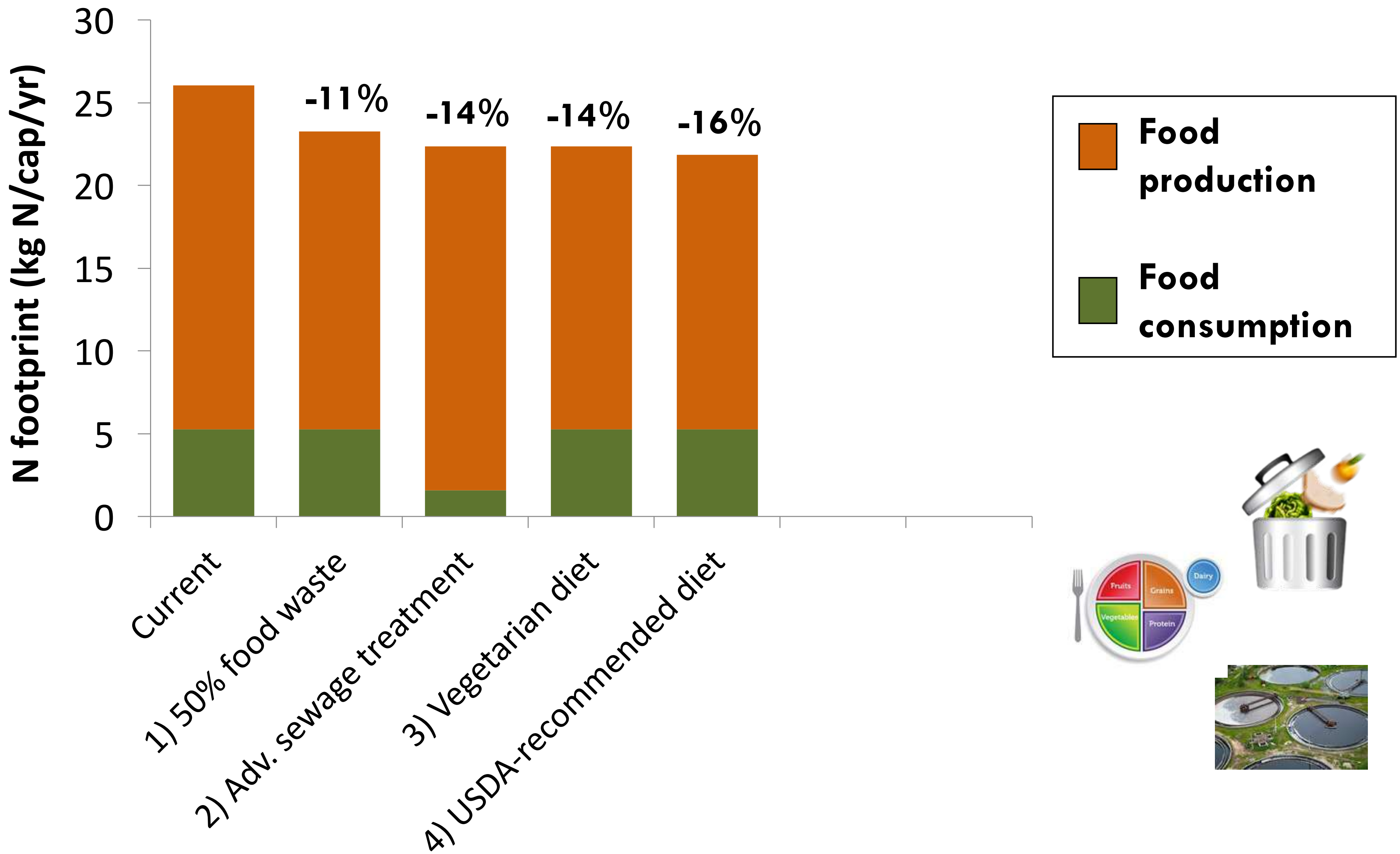

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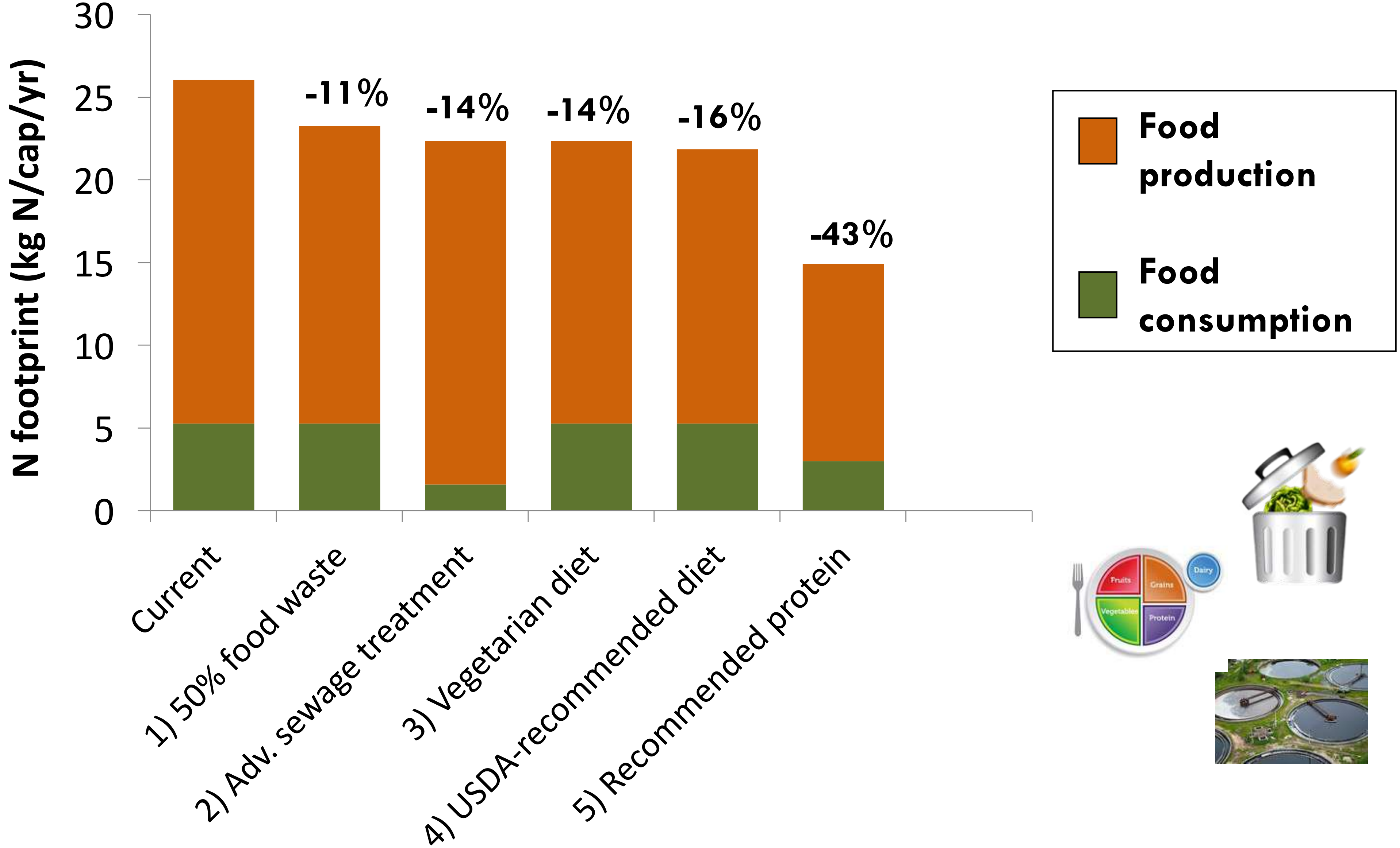

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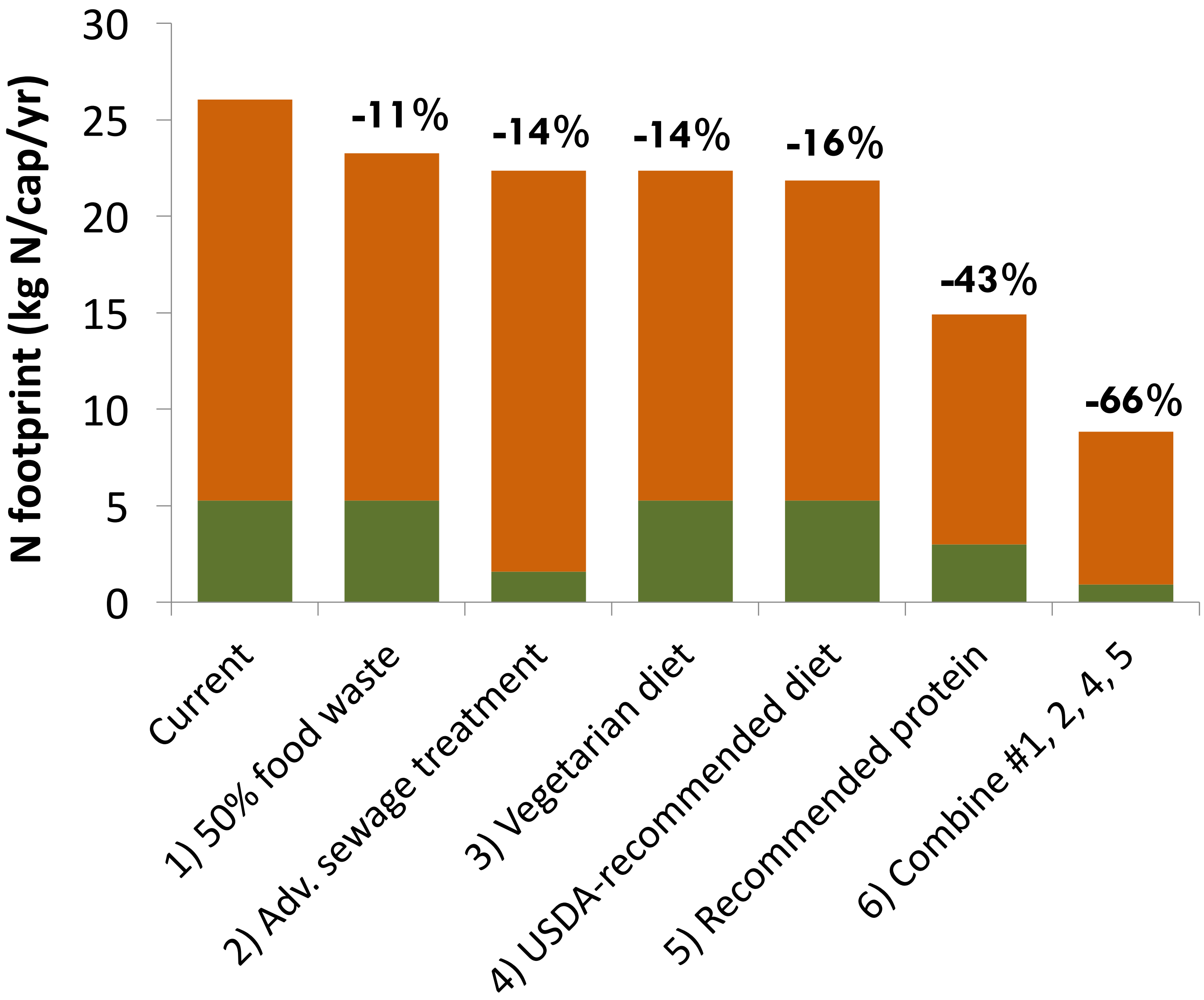
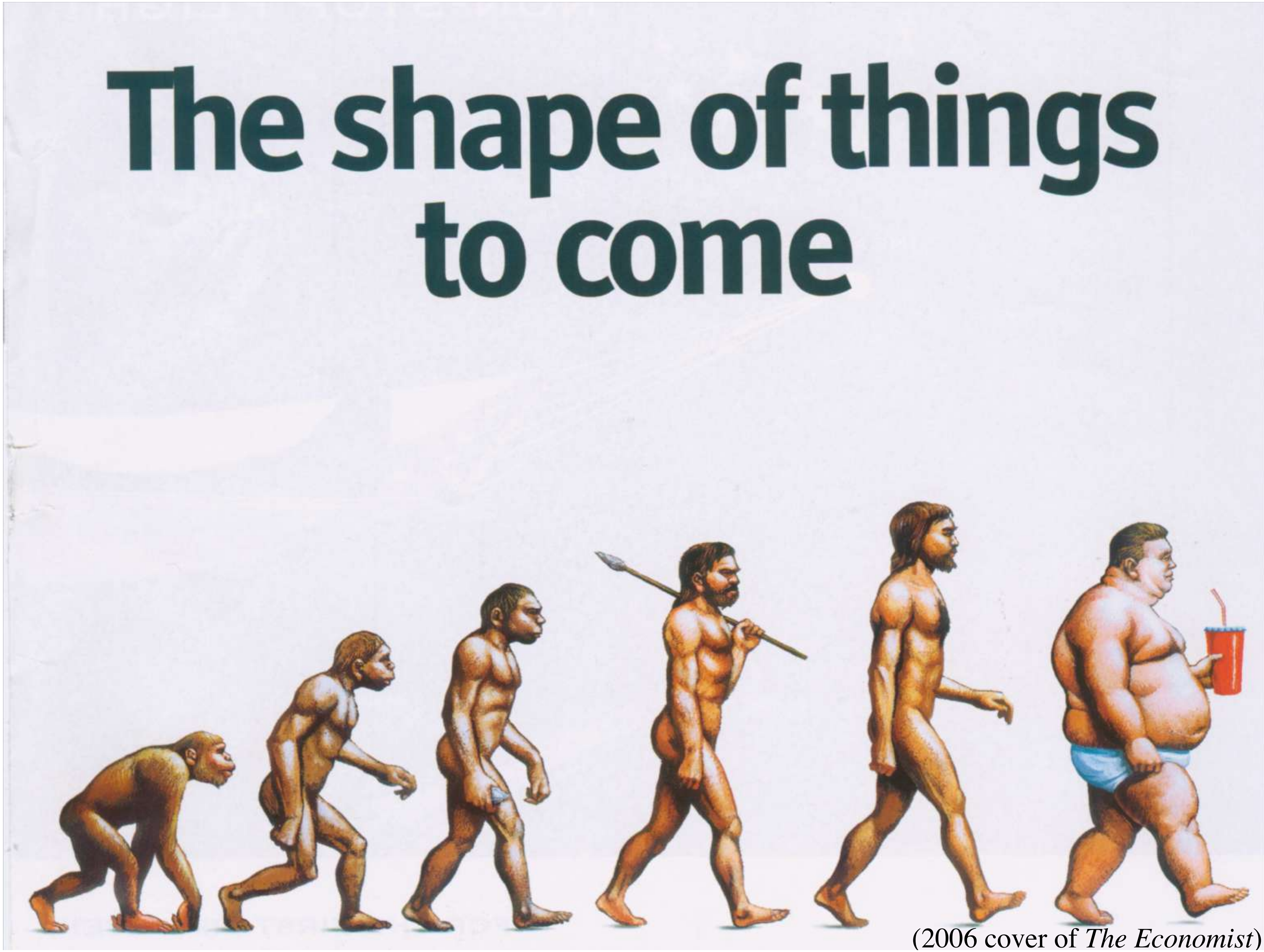
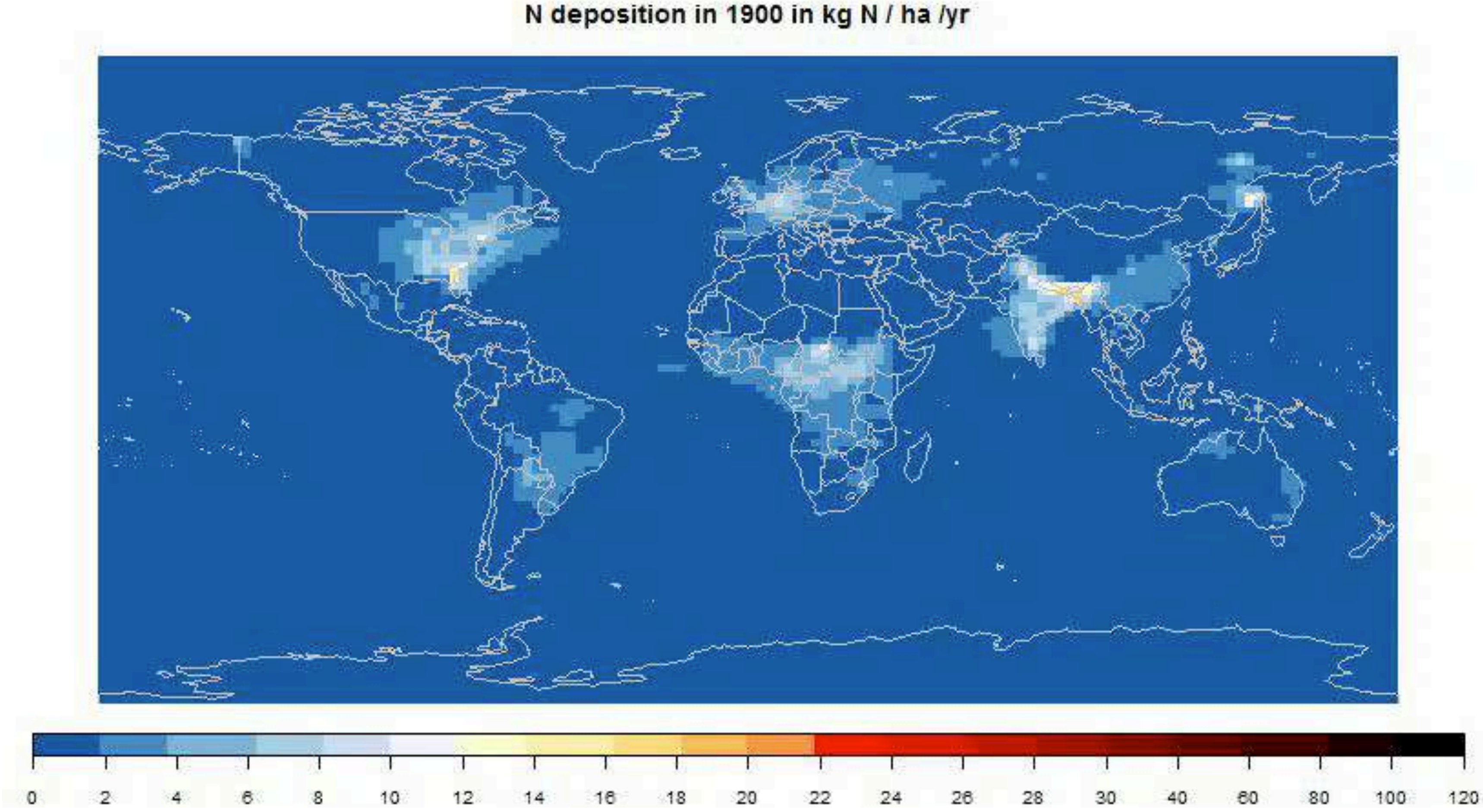




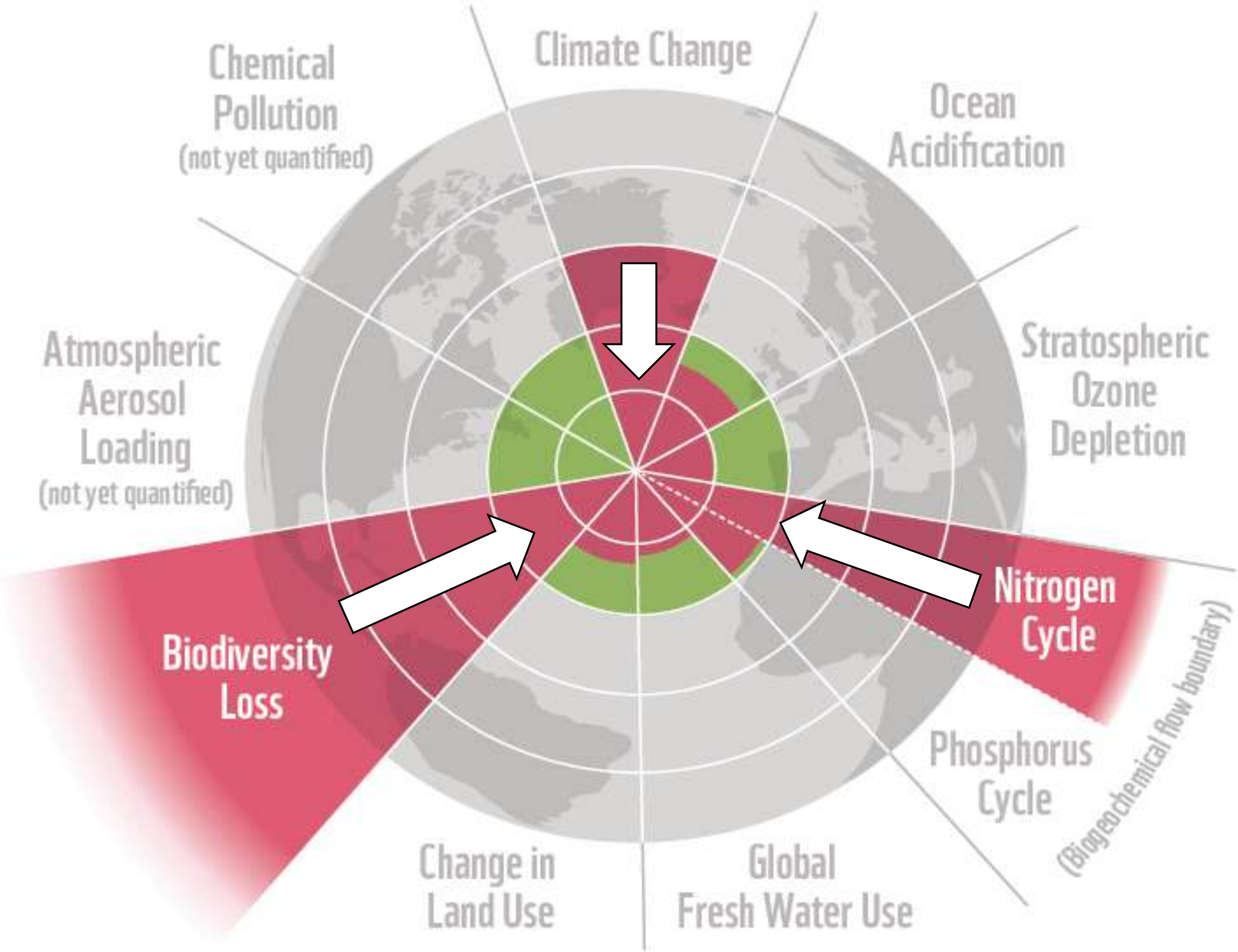
(2006 cover of *The Economist*)

Past and future N deposition



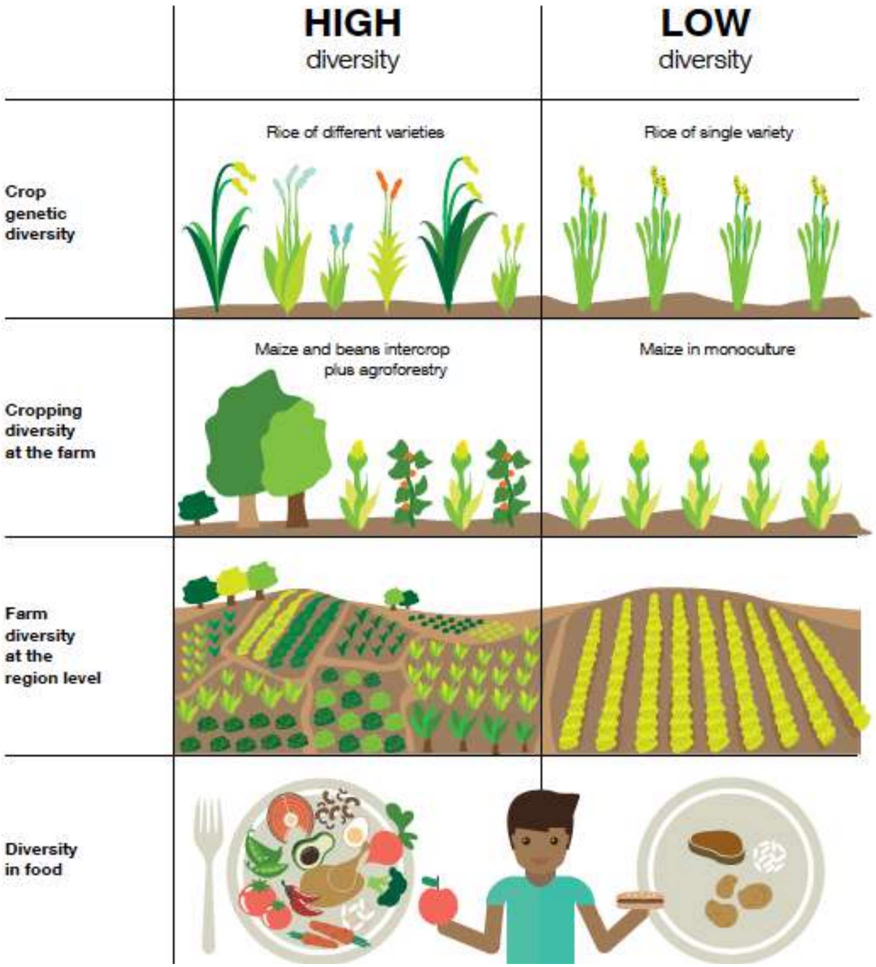
Lamarque et al. 2013

In order to meet the planetary boundaries system changes are needed

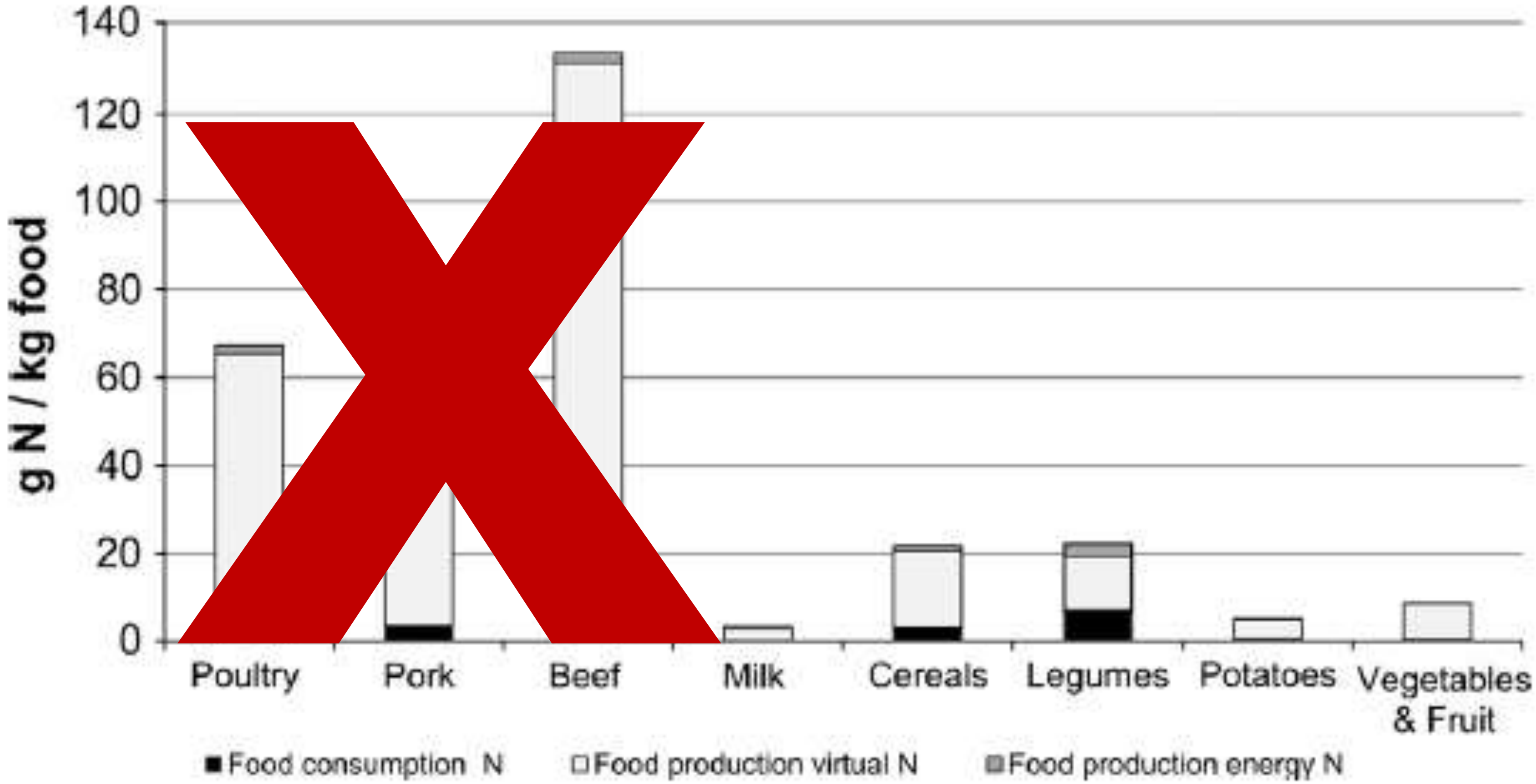


Rockström et al. 2009 Nature

A resilient food system requires a system approach



Product N footprint (g N/kg food) for different food items in Austria



Pierer et al 2014

Thank you for your attention

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