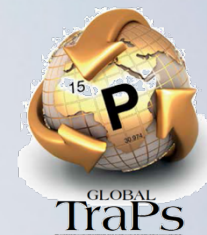
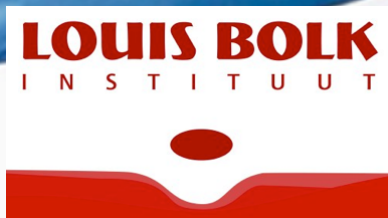
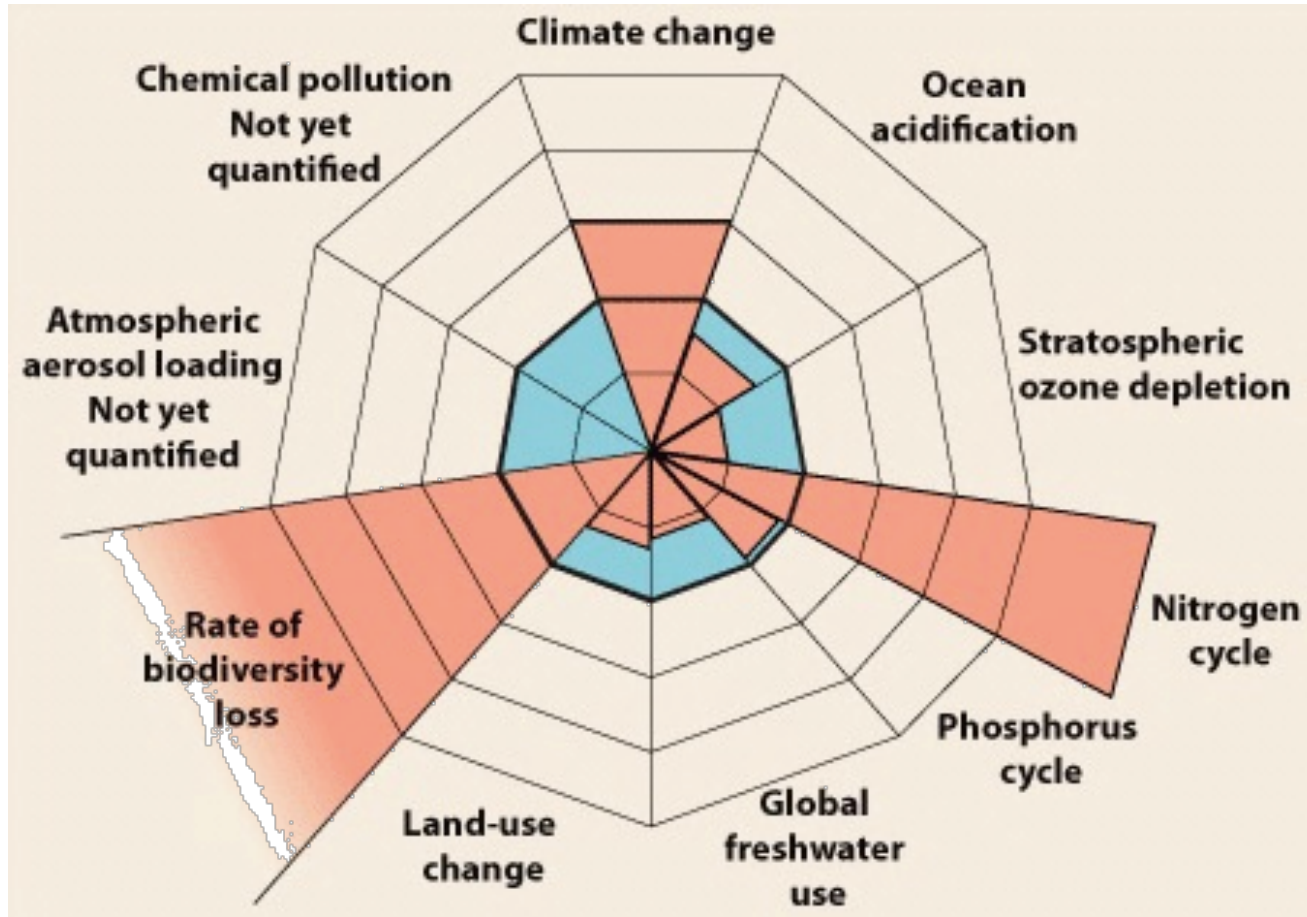


# NUTRIENT MANAGEMENT, CLIMATE CHANGE AND CHALLENGES FOR AGRICULTURE

JAN WILLEM ERISMAN

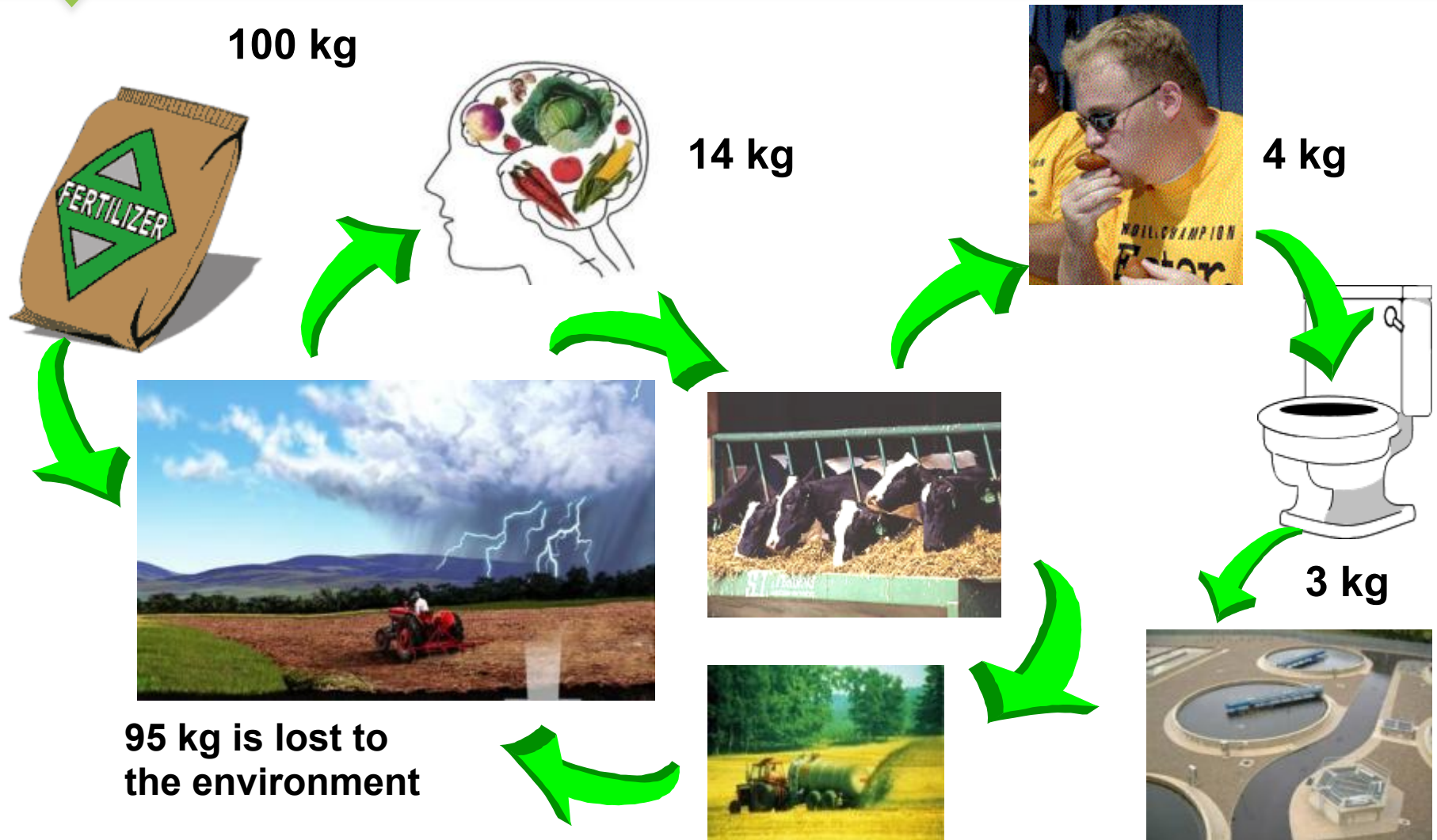


# PLANETARY BOUNDARY FOR NITROGEN EXCEEDED



*Rockström et al. 2009 Nature*

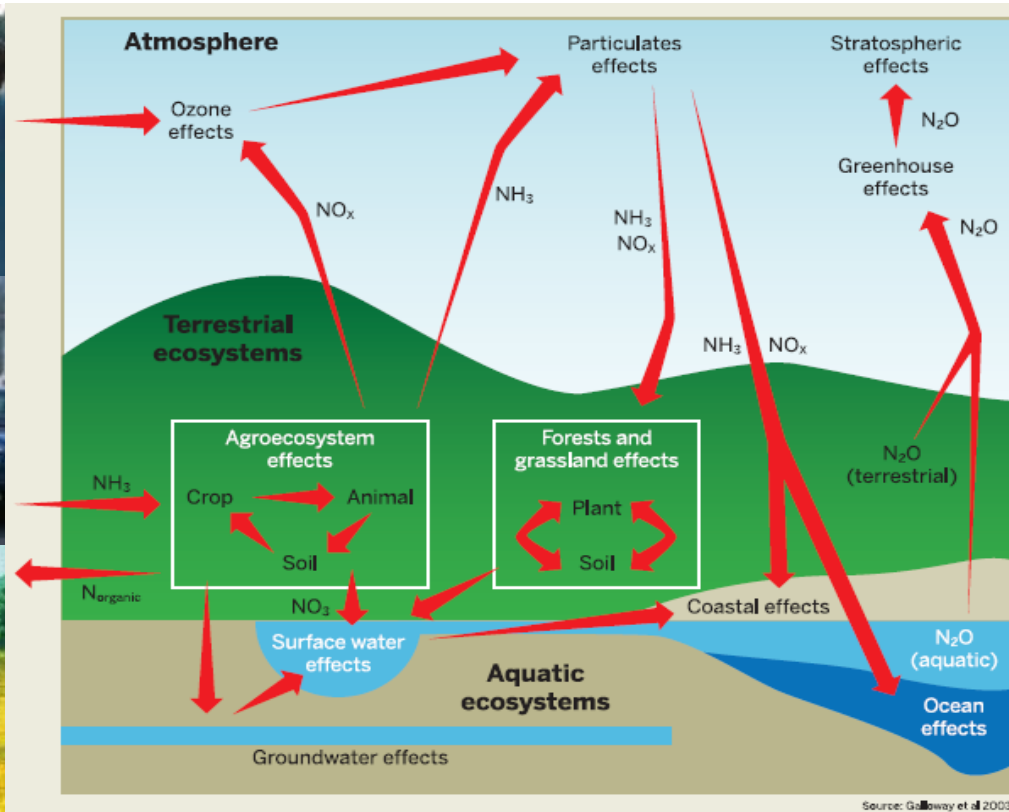
# FERTILIZER EFFICIENCY FOR FOOD



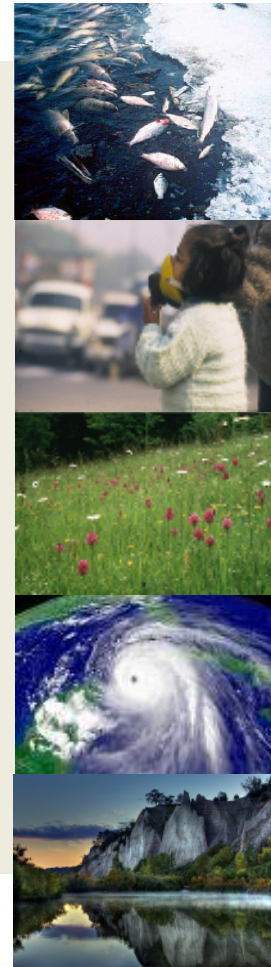
# FERTILIZING THE BIOSPHERE AND THE CASCADE



Natural & anthropogenic sources



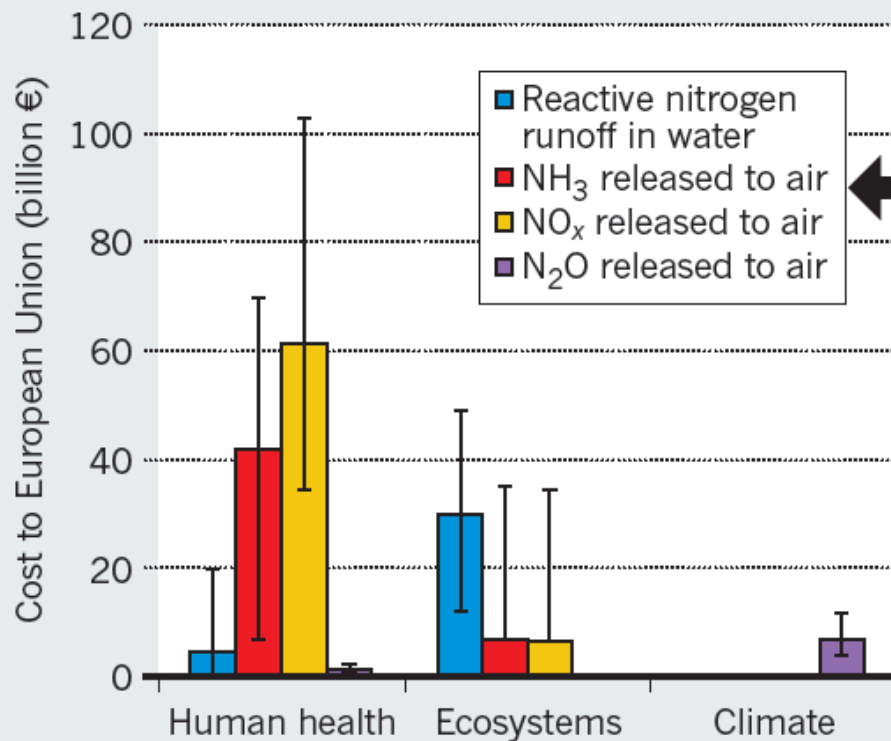
Cascade through the environment



# NITROGEN DAMAGE COSTS AND BENEFITS

## DAMAGE COSTS OF NITROGEN POLLUTION

Agriculture and fossil-fuel burning load the environment with reactive nitrogen, affecting water, soils and air.



Total cost for EU27:  
€70 – 320 billion  
or €150 - 750 pp

1-4% of average European income

Agriculture: €20 – 150 billion costs versus €10 – 100 billion benefit of fertilizers for farmers

Sutton et al. (2011)

# THE CONCERNS RELATED TO CLIMATE CHANGE



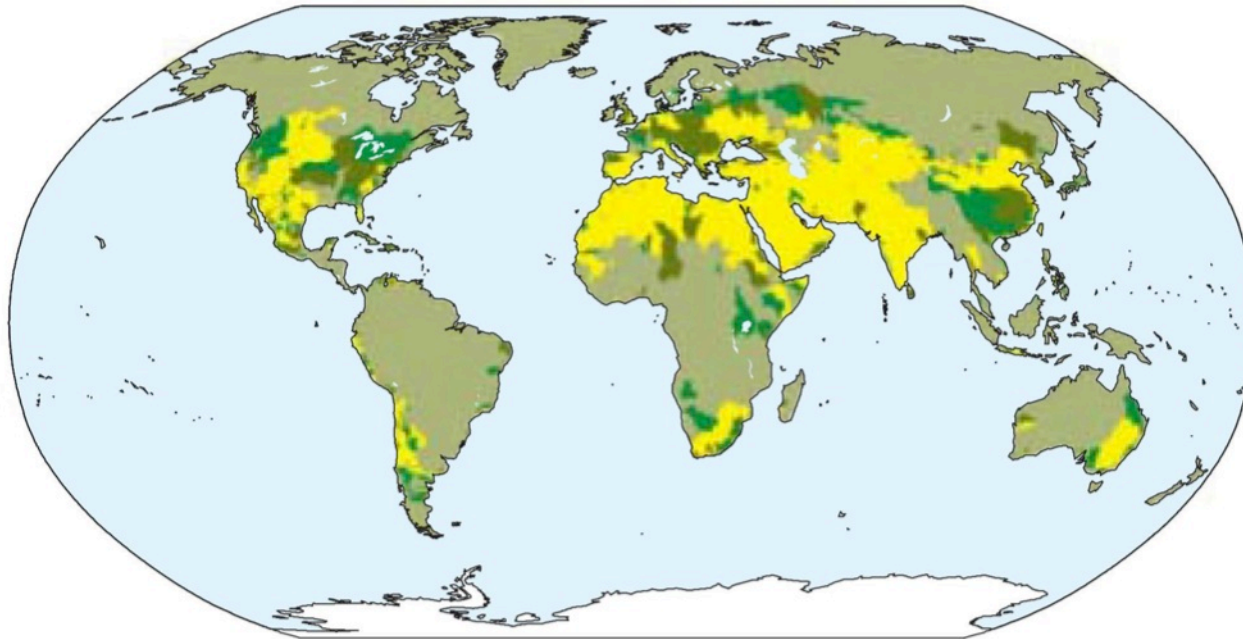
Events that are probably linked to global warming



Global climate change is predicted to affect air and water temperatures, sea-level rise, precipitation, wind patterns, and the frequency and intensity of storms.

# ENDANGERED PRODUCTIVITY: WATER STRESS IN 2030

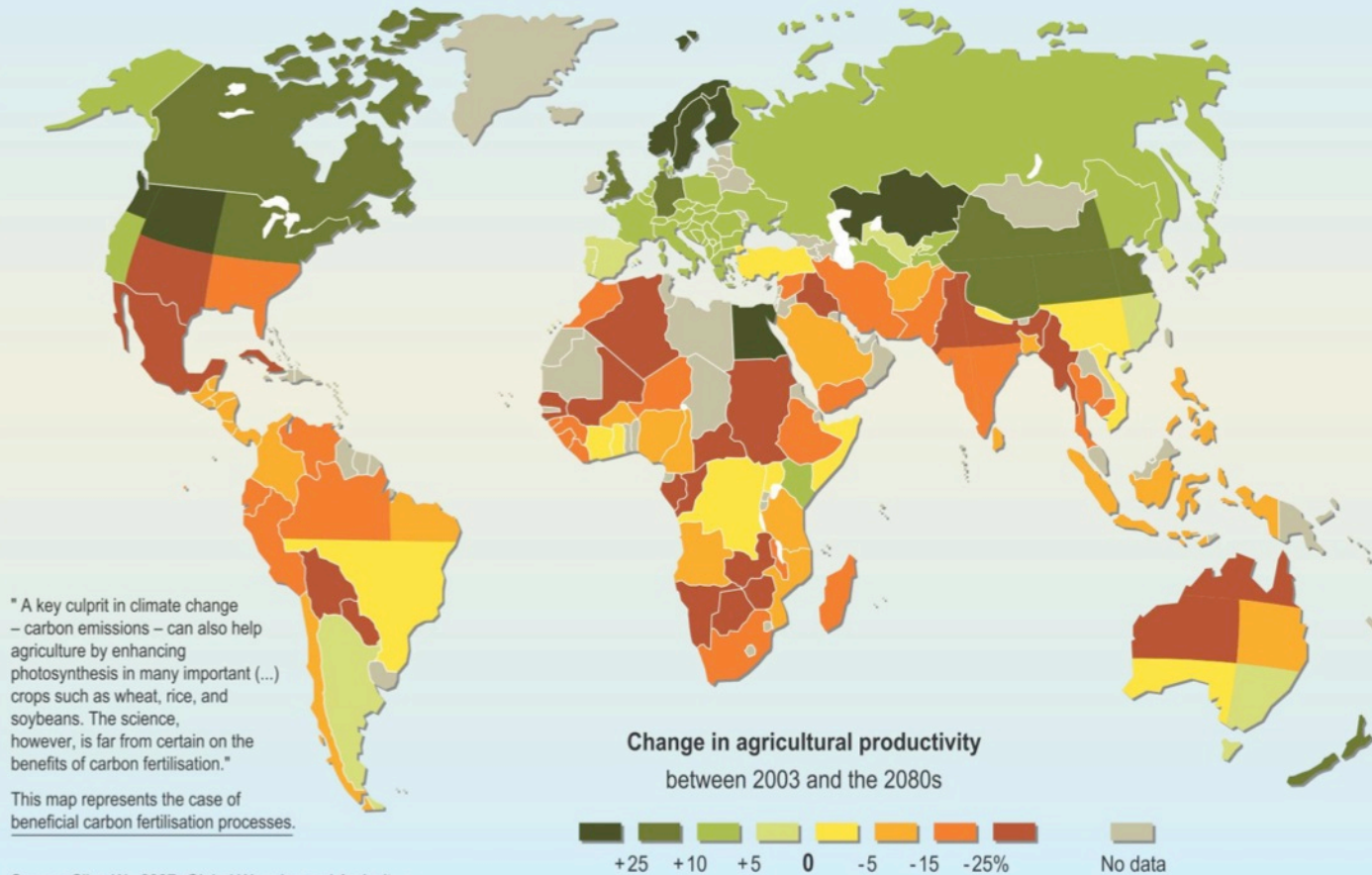
2030



Source: OECD Environmental Outlook Baseline.

# ENDANGERED PRODUCTIVITY: CLIMATE CHANGE

## Projected impact of climate change on agricultural yields



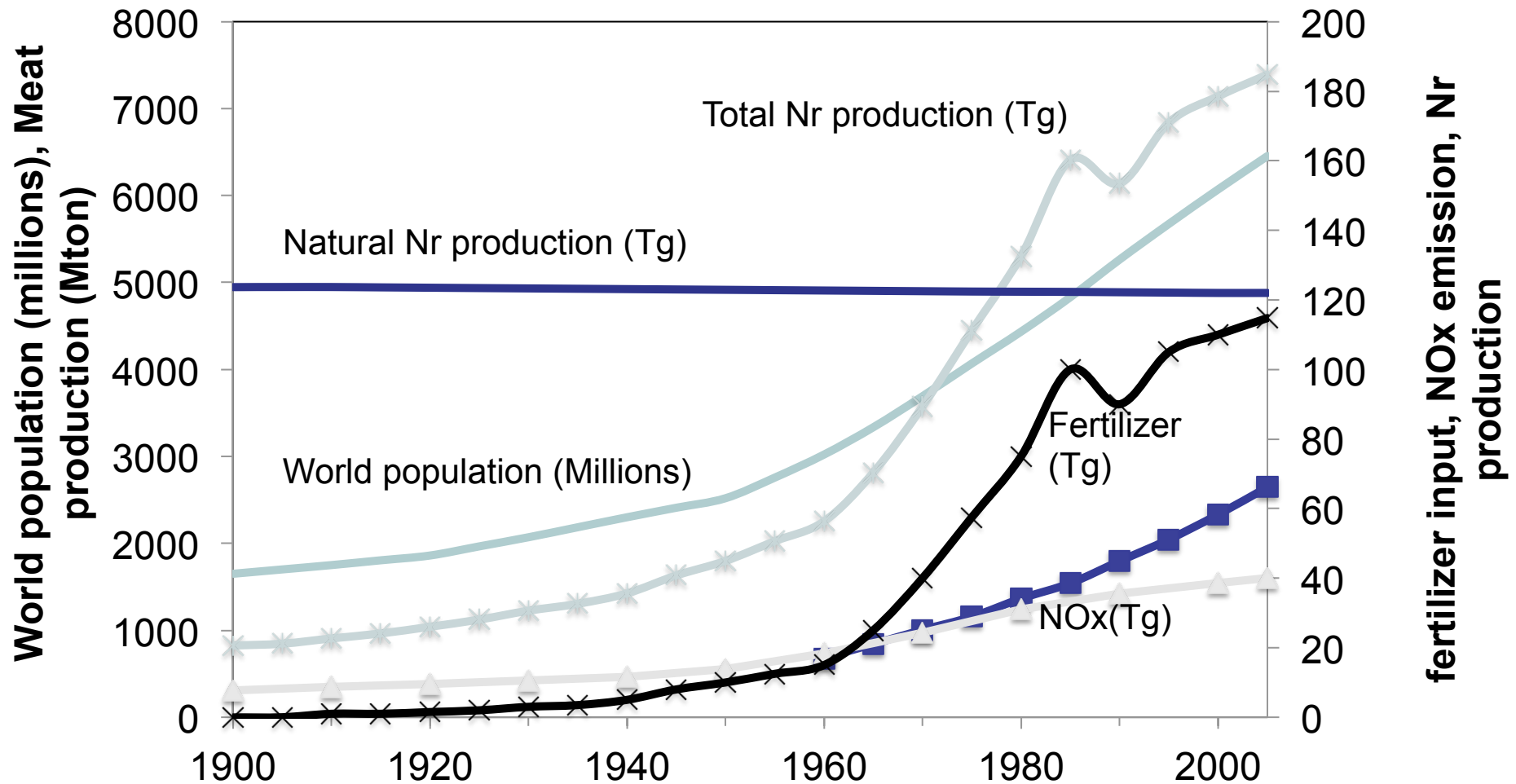
Source: SOER, Global Megatrends 2010



# CHANGES TO THE N CYCLE AND GHG EMISSIONS HAVE THE SAME DRIVERS

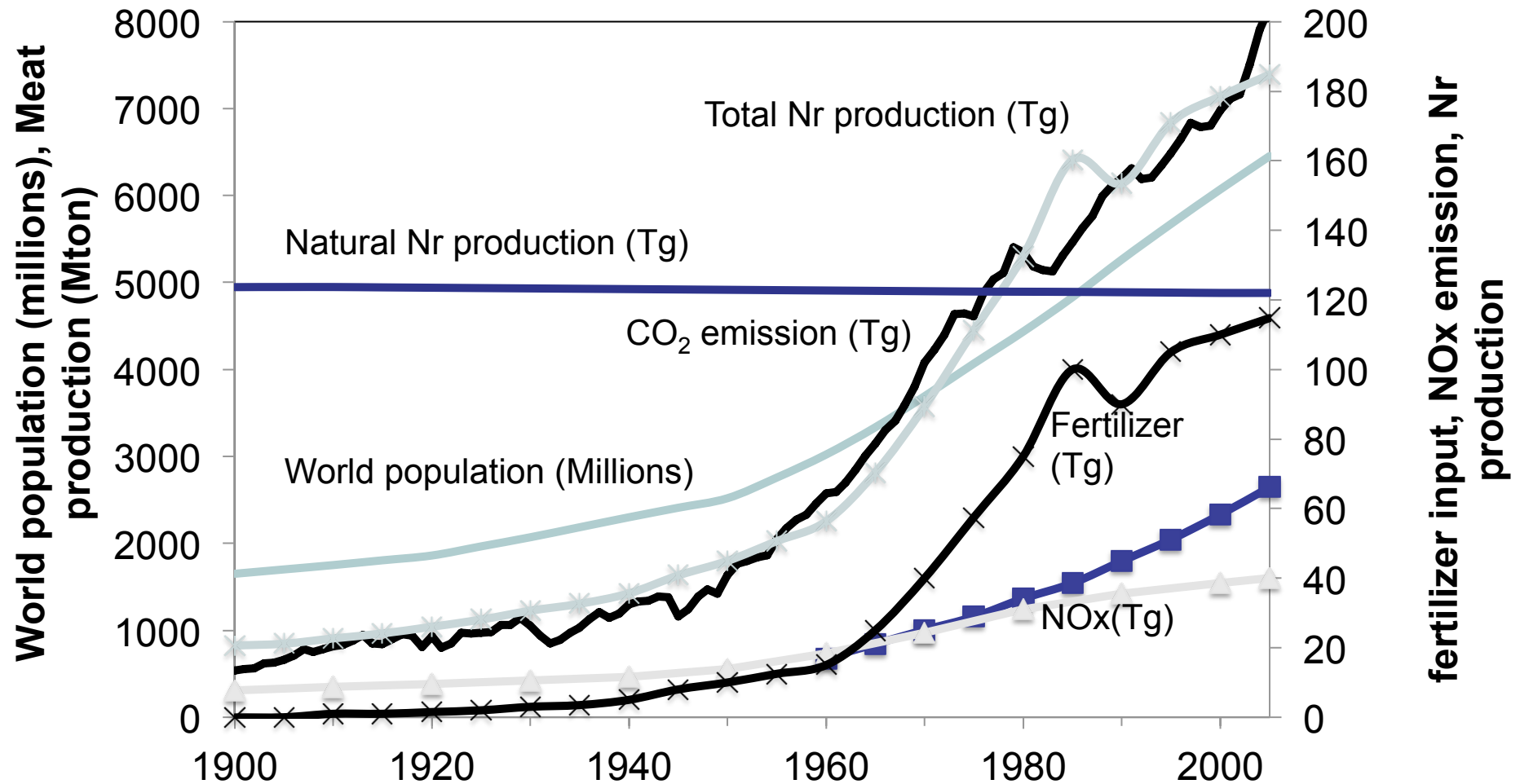


# MORE NITROGEN IS NOW FIXED BY HUMAN ACTIVITIES THAN BY NATURAL PROCESSES



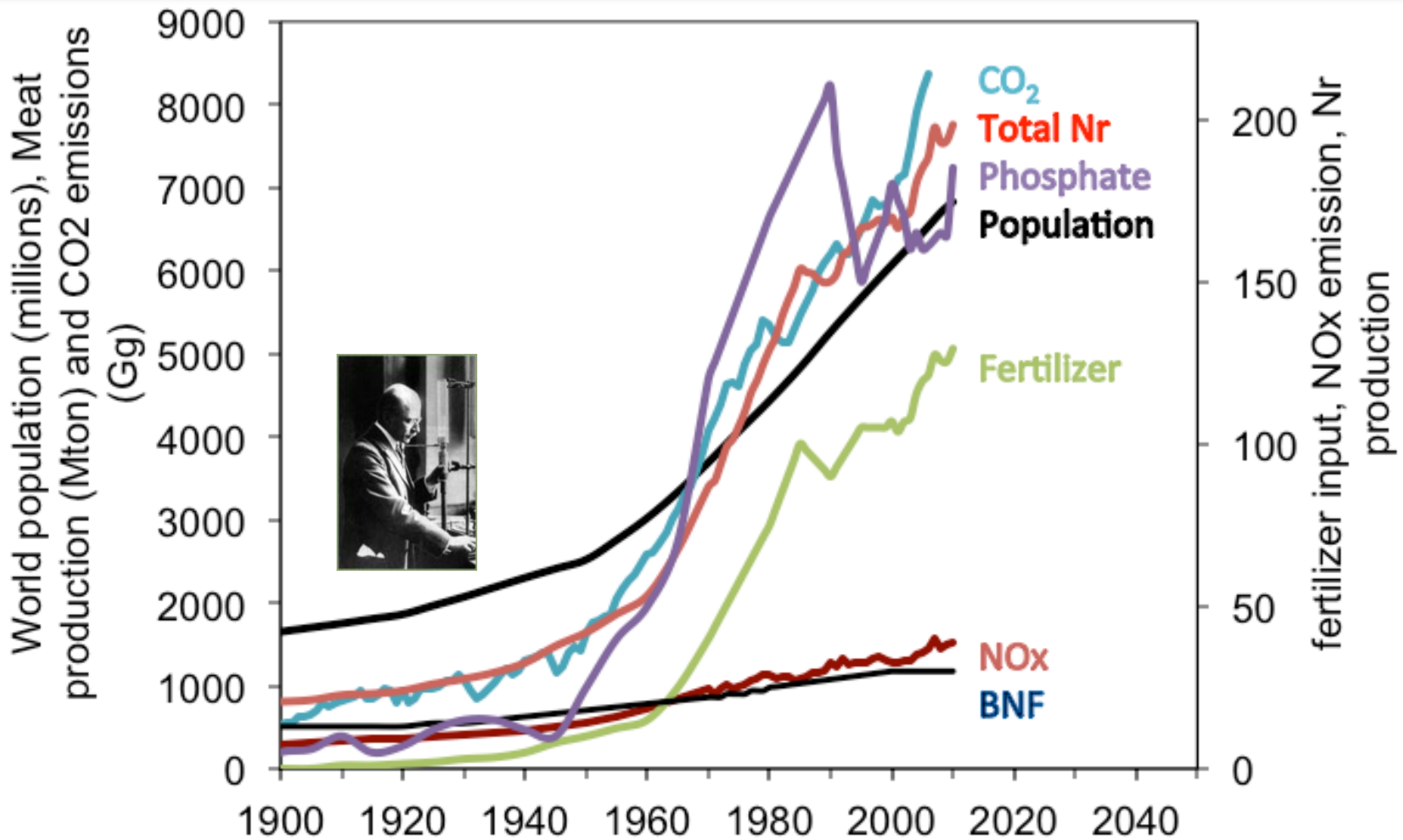
04.07.13

# TRENDS IN REACTIVE N FORMATION AND CO<sub>2</sub> EMISSIONS ARE SIMILAR

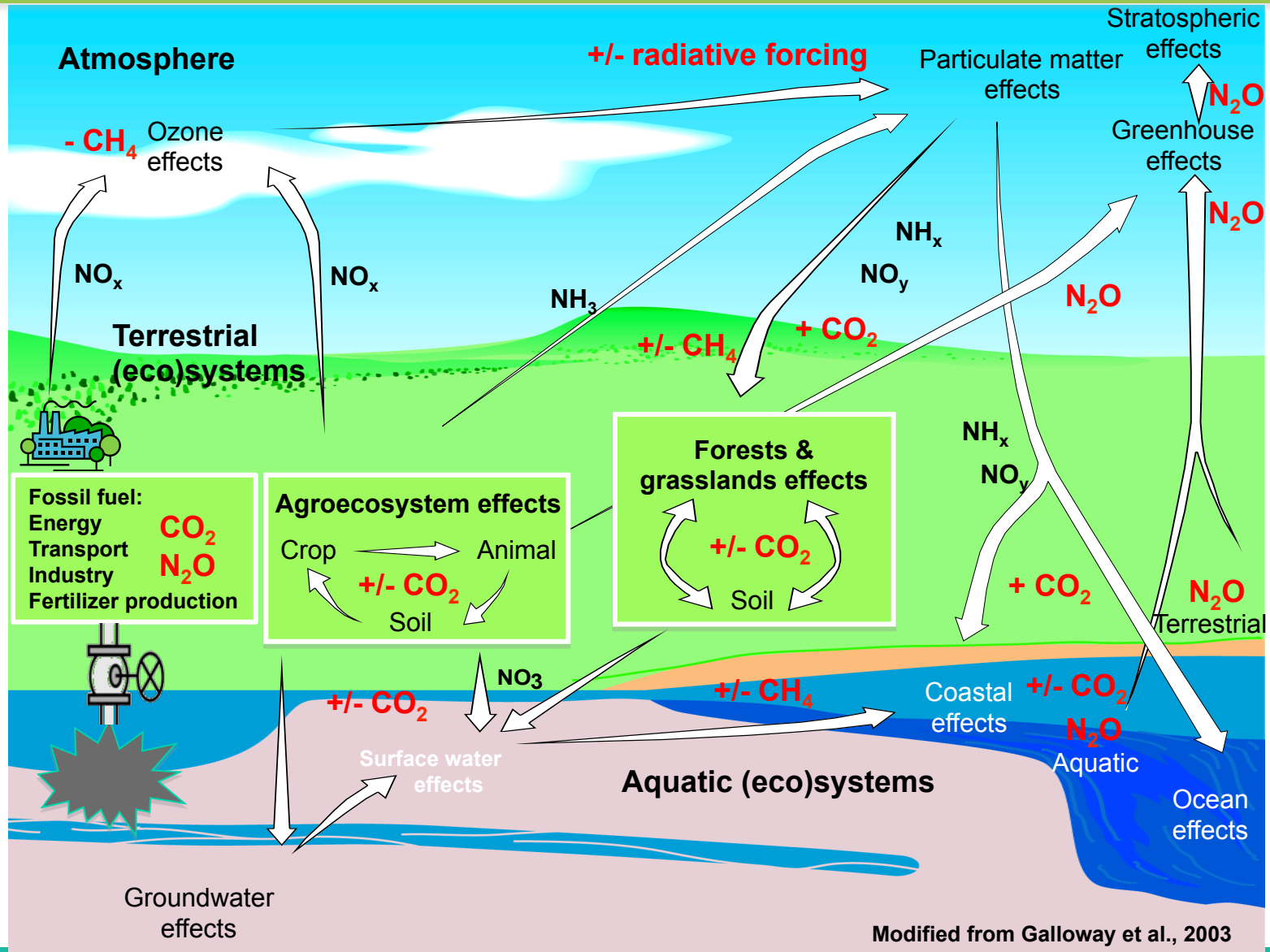


04.07.13

# GLOBAL TRENDS IN HUMAN POPULATION, N AND P USE AND CO2 EMISSIONS

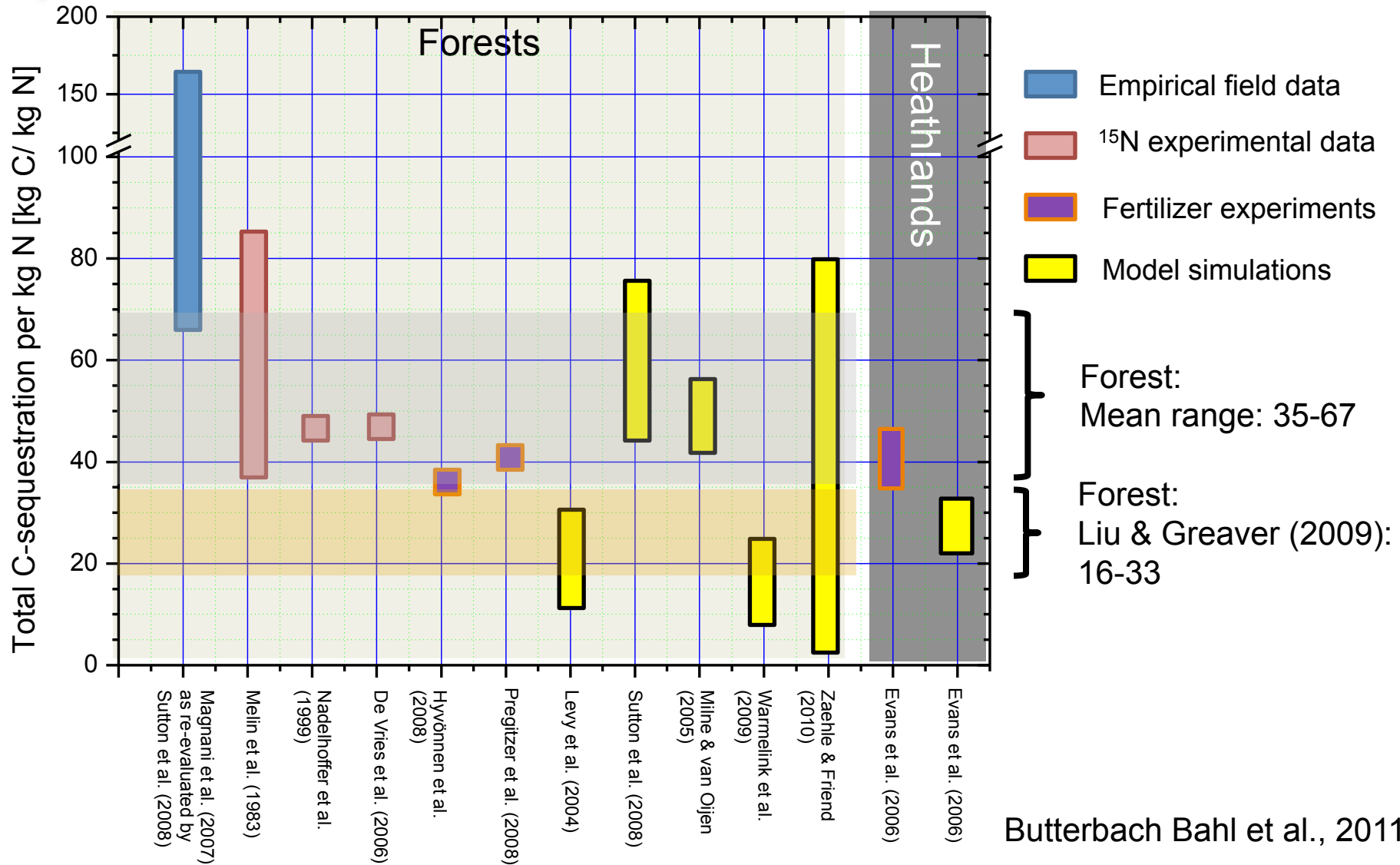


# THE 'CASCADE EFFECT' IN RELATION TO CLIMATE



Modified from Galloway et al., 2003

# NITROGEN ENHANCES TERRESTRIAL CARBON STORAGE

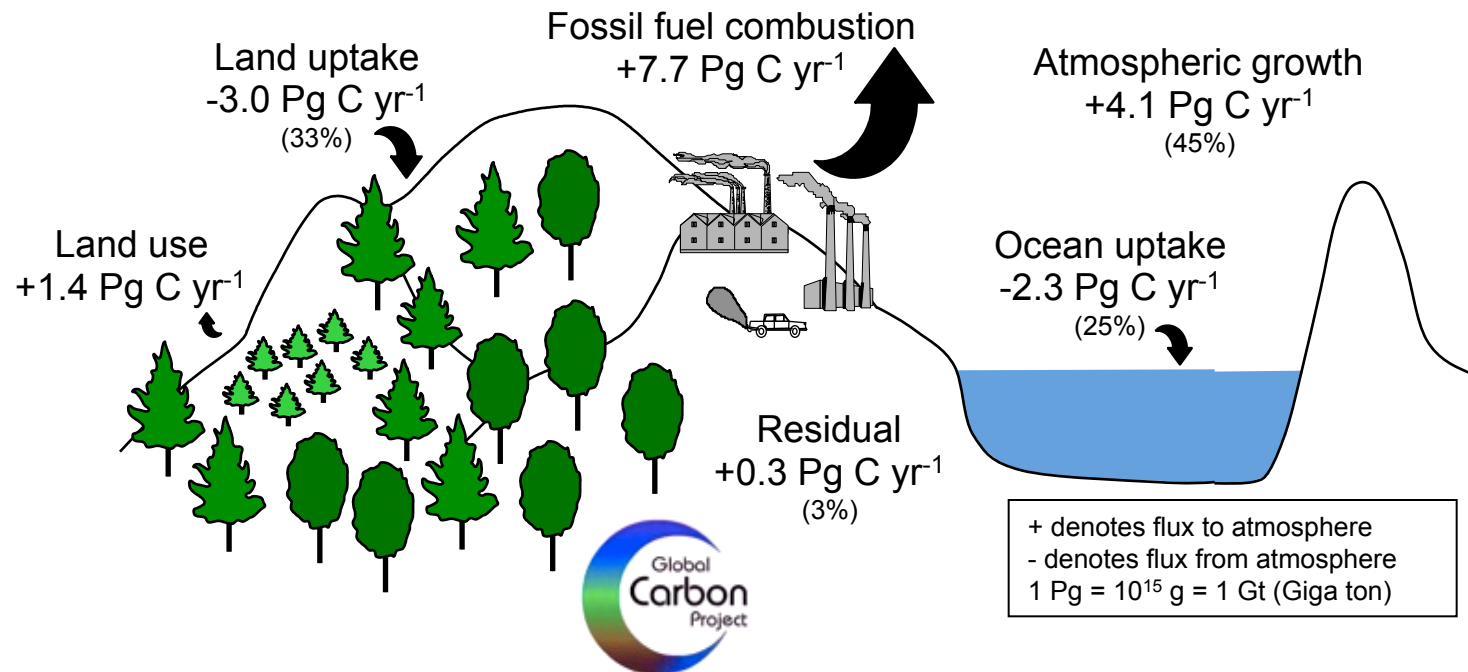


Butterbach Bahl et al., 2011

# NITROGEN AND THE CARBON CYCLE

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

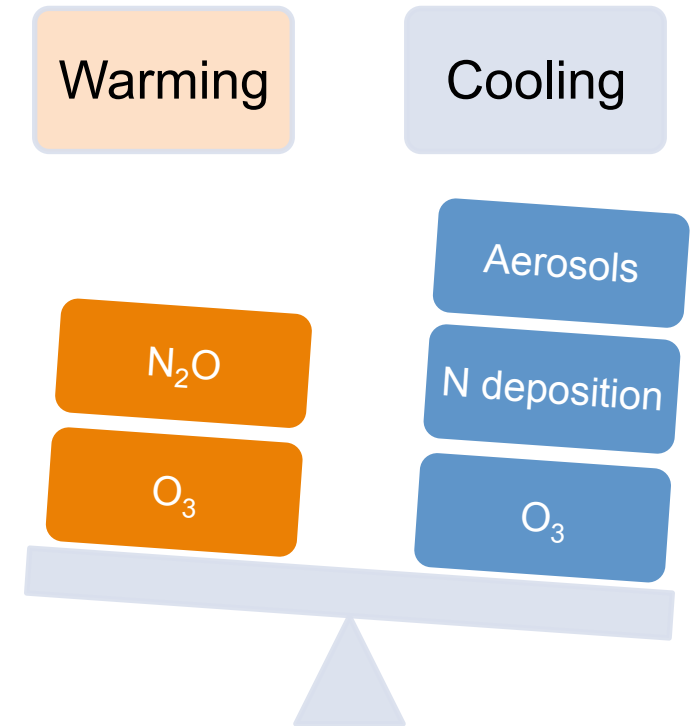
## Global carbon cycle, 2000-2008



# NET EFFECT OF N ON GLOBAL RADIATION BALANCE

Process	Forcing ( $\text{W m}^{-2}$ )
$\text{N}_2\text{O}$ emission	0.16
$\text{NO}_x$ emission atmosphere	-0.29
$\text{NH}_3$ emission atmosphere	-0.09
N and C in terrestrial systems and oceans	-0.2
Mineralisation	-0.2
$\text{O}_3$ phytotoxicity	0.25
$\text{CH}_4$	0
Total	-0.24

Total forcing:  $1.6 \text{ W m}^{-2}$ :  
N-effect  $-0.24 [-0.5 \text{ to } +0.2] \text{ W m}^{-2}$



Erisman et al., 2011



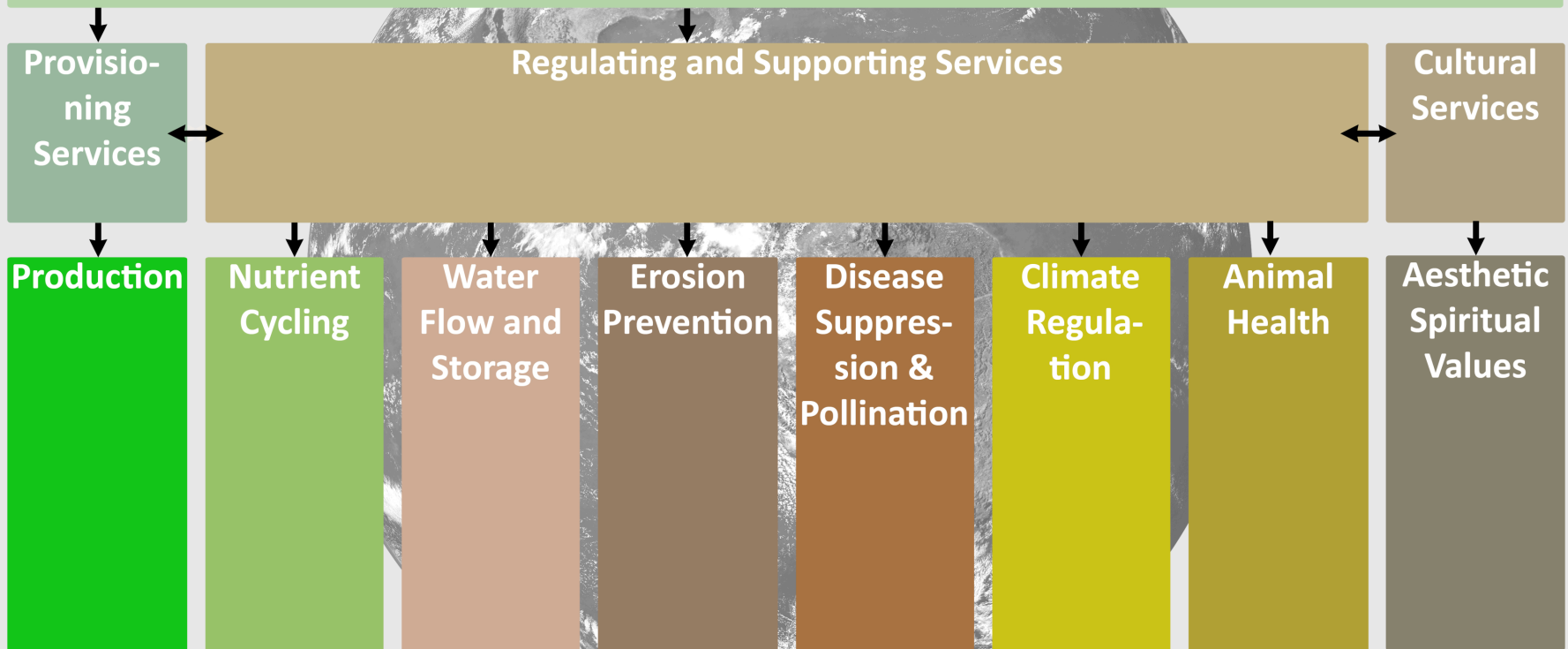
# CLIMATE AND NUTRIENT SMART AGRICULTURE



# PRINCIPLES FOR SUSTAINABLE AGRICULTURE

## Ecological Resilience of Agroecosystems

The Capacity of a System to Undergo Disturbance and Maintain its Functions



Saving our soils is  
saving our food!



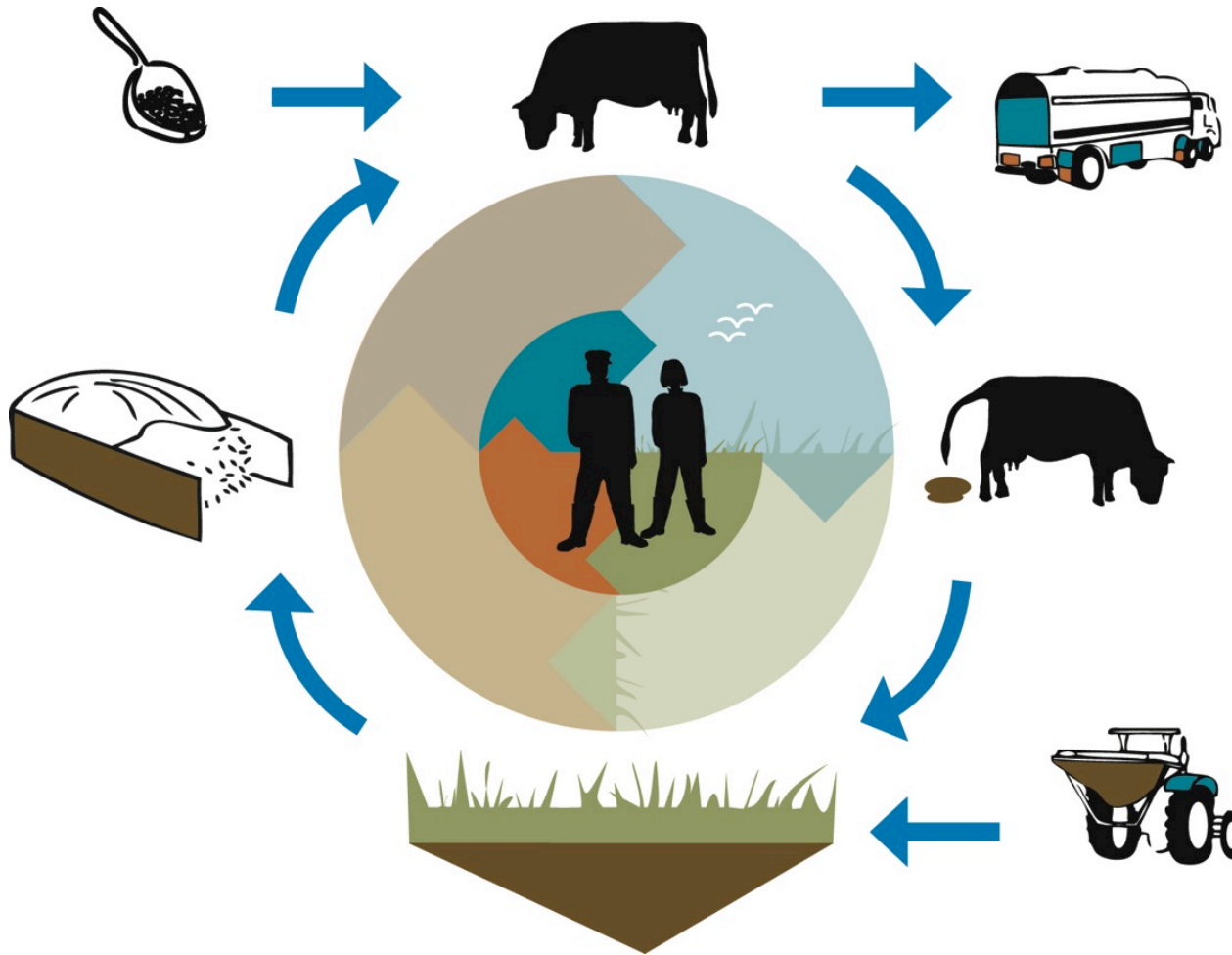
# SOIL (LIFE) MAKES THE DIFFERENCE!



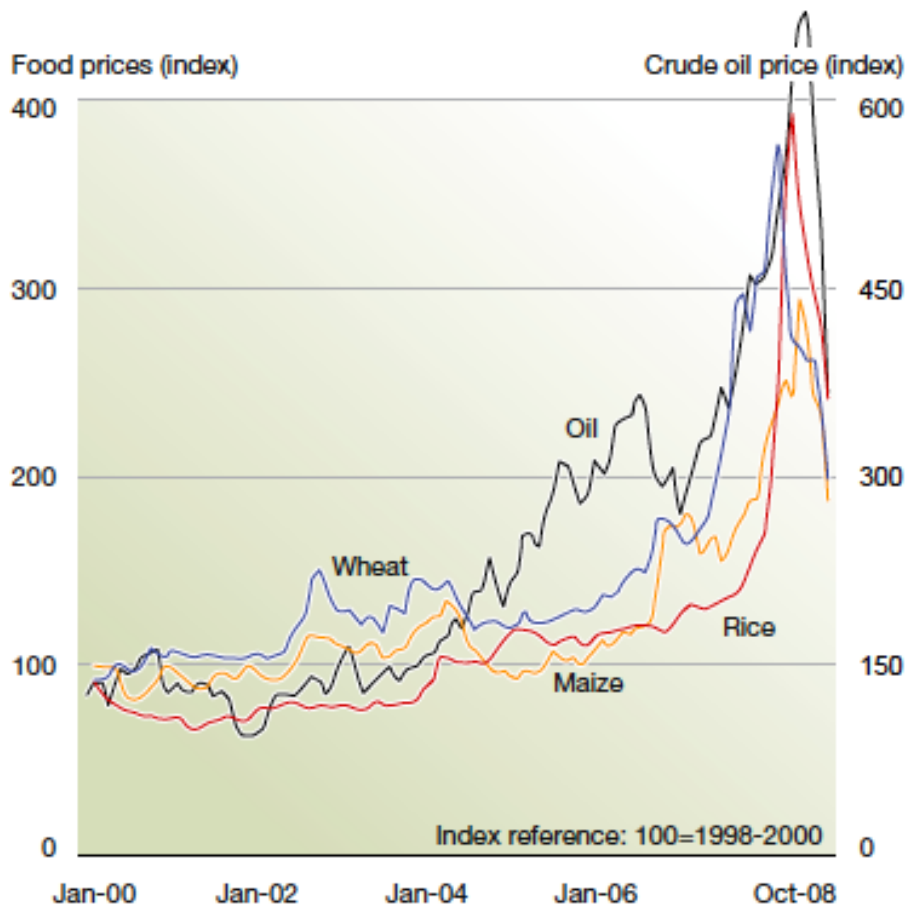
- 200 gr soil contains 0,5 gr soil life
- More than 12.000 species
- Many functions a.o. Nutrient management, water storage, etc.



# CLOSE NUTRIENT CYCLES



# FOSSIL FUEL DEPENDENCE OF AGRICULTURE



**Figure 3: Changes in commodity prices in relation to oil prices.**  
(Source: FAO, 2008; IMF, 2008).



# STRATEGIES TO MORE SUSTAINABILITY

## Smarter diets

- Healthier diets
- Less animal products

## Smart intensification

- Resource (land, feed, nutrient) efficiency
- Closing yield gap, reducing waste

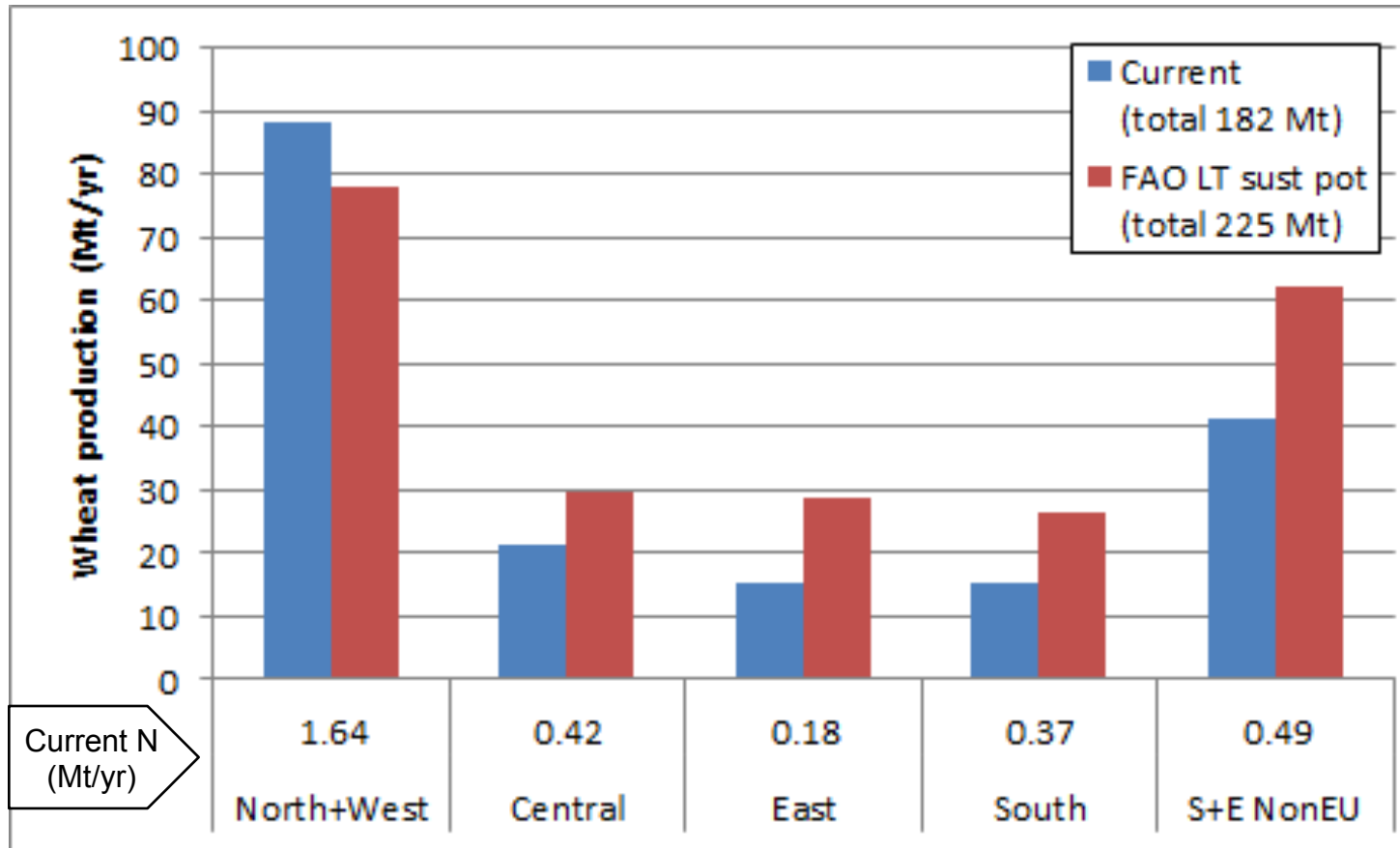
## Smart extensification

- Less local impacts, public image
- Animal welfare, human health, odour, landscape

Synergies &  
Trade-offs

# PRESENT AND POTENTIAL WHEAT PRODUCTION EUROPE

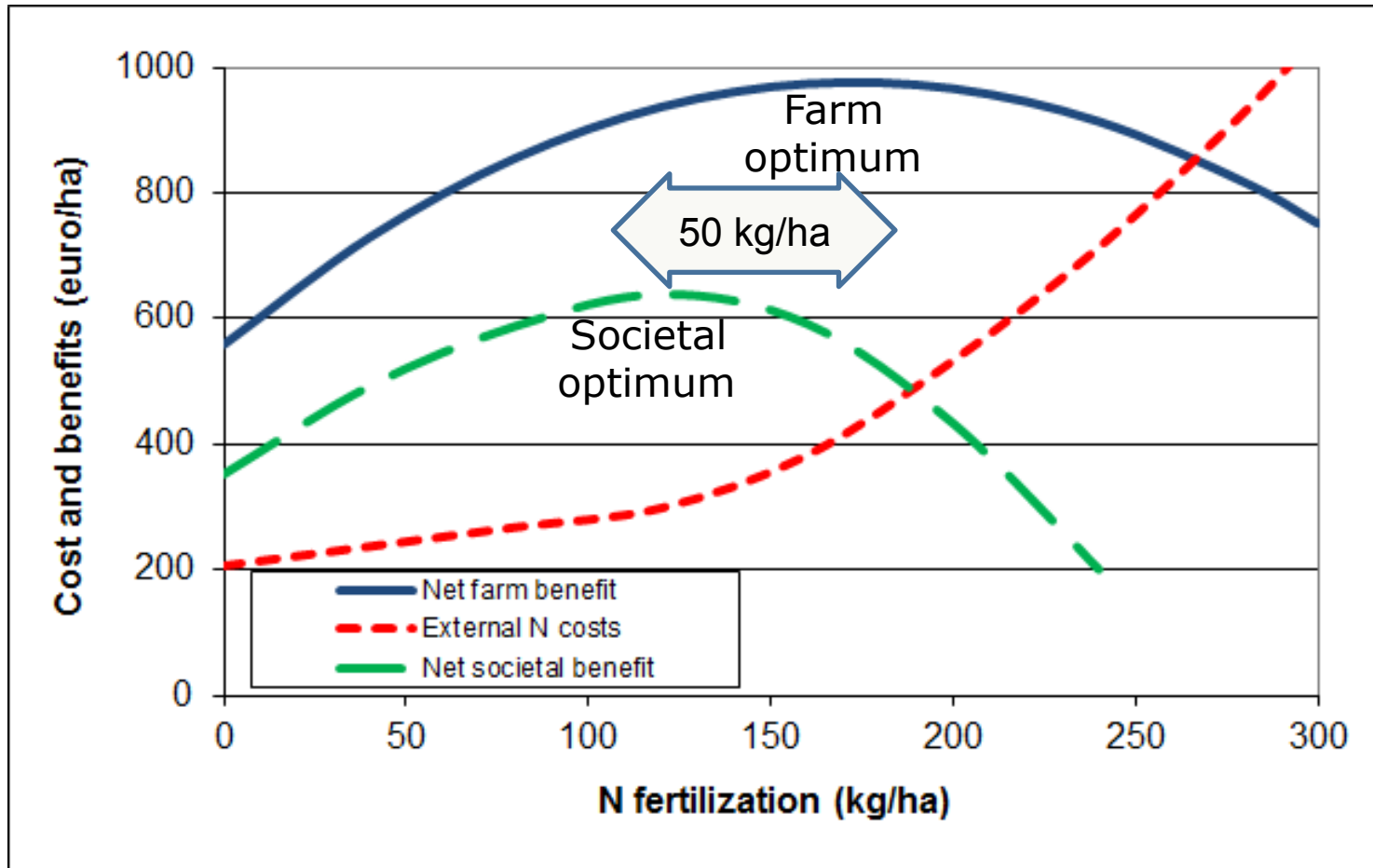
Smart intensification



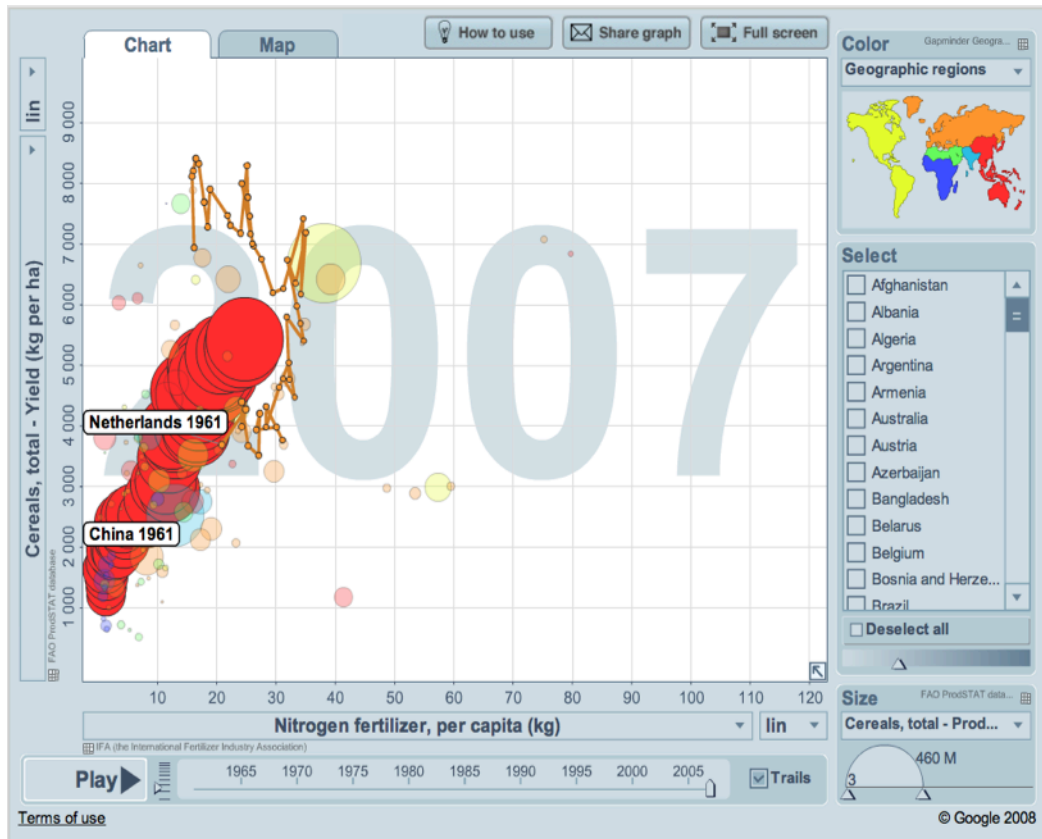


# WHAT IS THE SOCIETAL OPTIMAL N RATE FOR WHEAT?

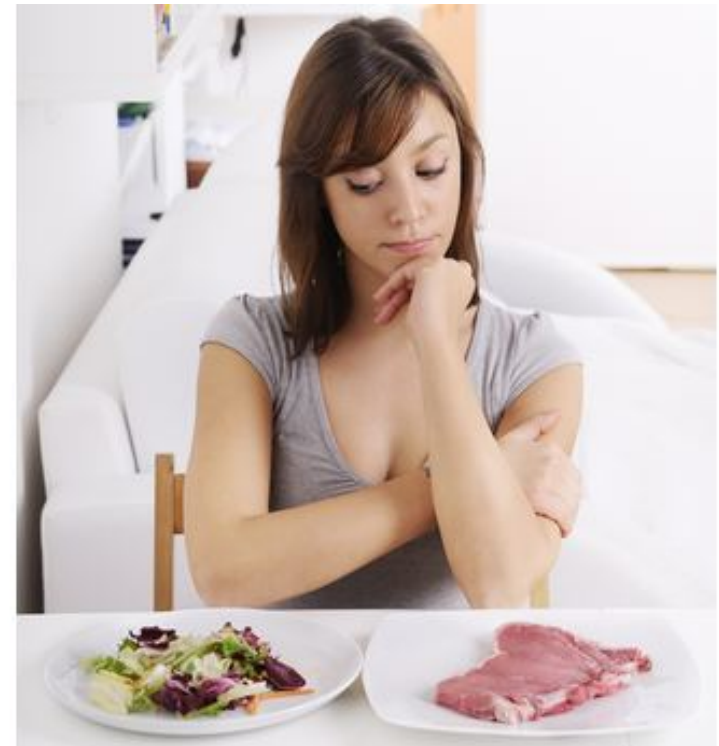
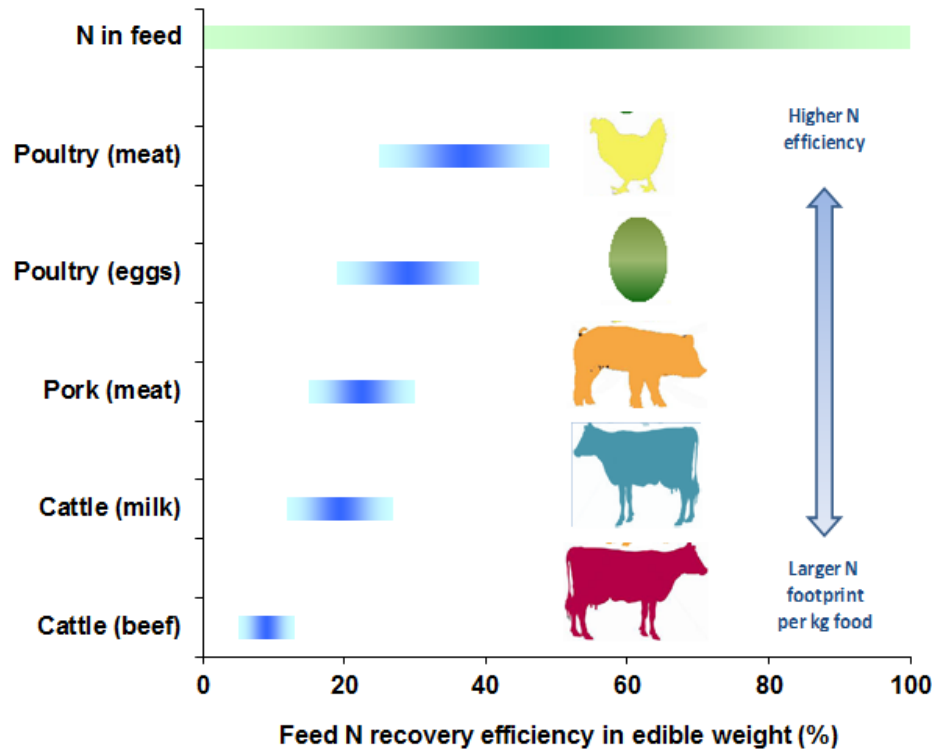
Smart extensification



# CEREAL YIELD AND FERTILIZER USE



# CHANGING PROTEIN SOURCES SAVES FEED, NUTRIENTS AND LAND



Sources: ENA, 2011, Protein Puzzle, PBL, 2011

# THE NITROGEN FOOTPRINT



## Introduction

Welcome to the Nitrogen Footprint Calculator! A nitrogen footprint is a measure of the amount of nitrogen released to the environment as a result of human activities.

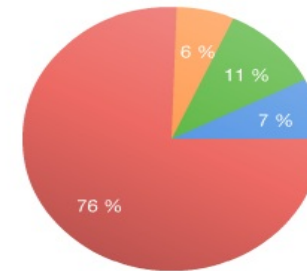
The human use of nitrogen through agriculture, energy use, and resource consumption has profound beneficial and detrimental impacts on all people. The beneficial impacts include food produced by nitrogen fertilizer. However, in areas that already have a lot of nitrogen, excess nitrogen lost to the environment negatively impacts both people and ecosystems. Once lost to the environment, nitrogen moves through the Earth's atmosphere, forests, grasslands, and waters. This excess nitrogen can lead to smog, acid rain, forest dieback, coastal "dead zones", biodiversity loss, stratospheric ozone depletion, and an enhanced greenhouse effect. This expansive impact makes it important to understand one's nitrogen footprint.



The pie chart to the right initially shows the average footprint of a person from the country you selected. As you answer the N Calculator questions, the pie chart will change to reflect your answers.

## Your footprint

This is your personal footprint.



- Food consumption: 76.3 kg
- Housing: 6.3 kg
- Transportation: 10.9 kg
- Goods and Services: 7.5 kg

Please choose your language

Choose

Please choose your unit

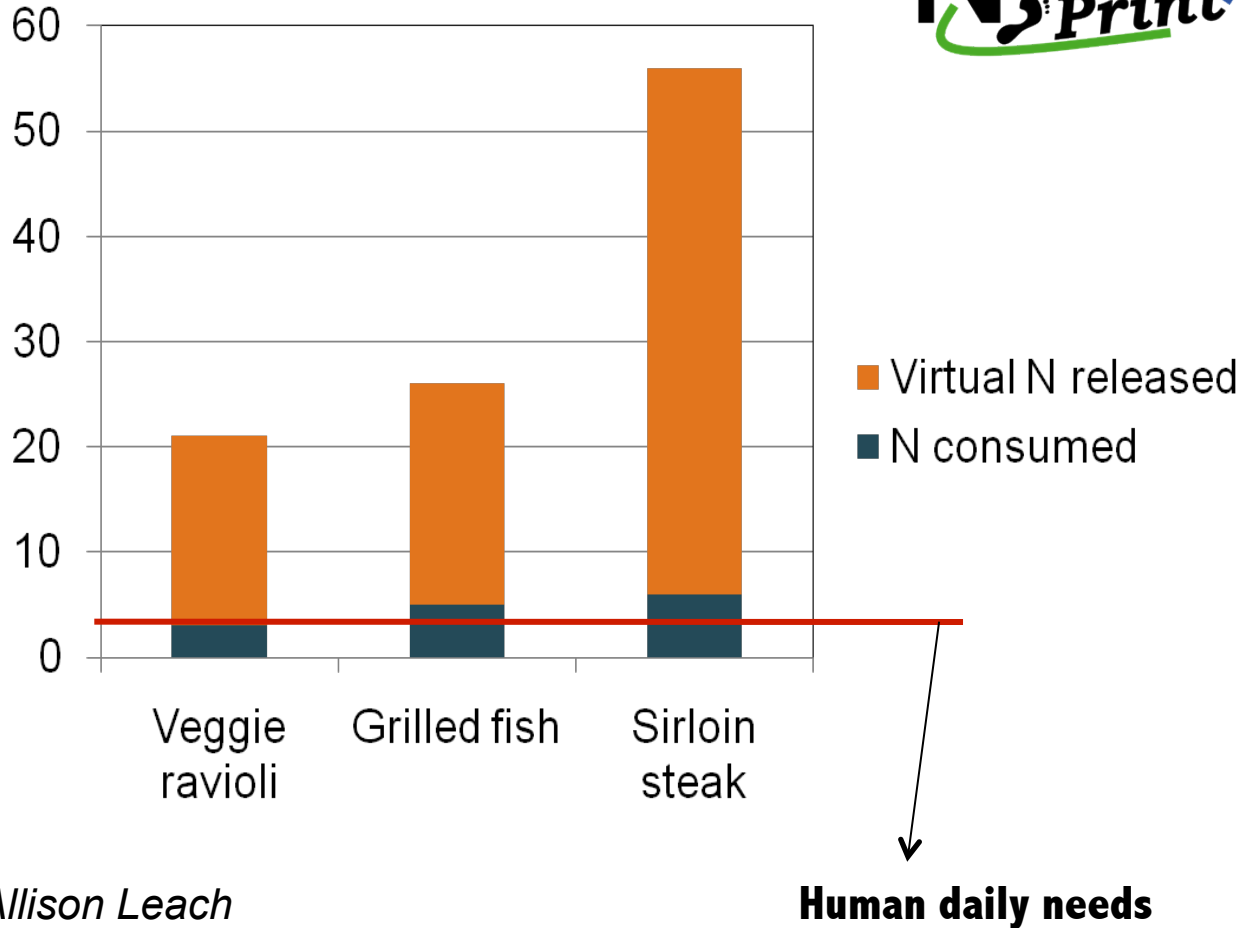
Choose

For which country is the Footprint calculated?

Choose

[www.n-print.org](http://www.n-print.org)

# THE NITROGEN FOOTPRINT: YOUR LUNCH TODAY



**Veggie ravioli**



**Grilled fish**



**Sirloin steak**

Allison Leach  
[www.n-print.org](http://www.n-print.org)

# THANK YOU

And don't forget to reduce food waste!

Food waste per person per year in  
The Netherlands



(© Zembla)