



# Environmental assessment of N fertilizer management practices

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Yara International

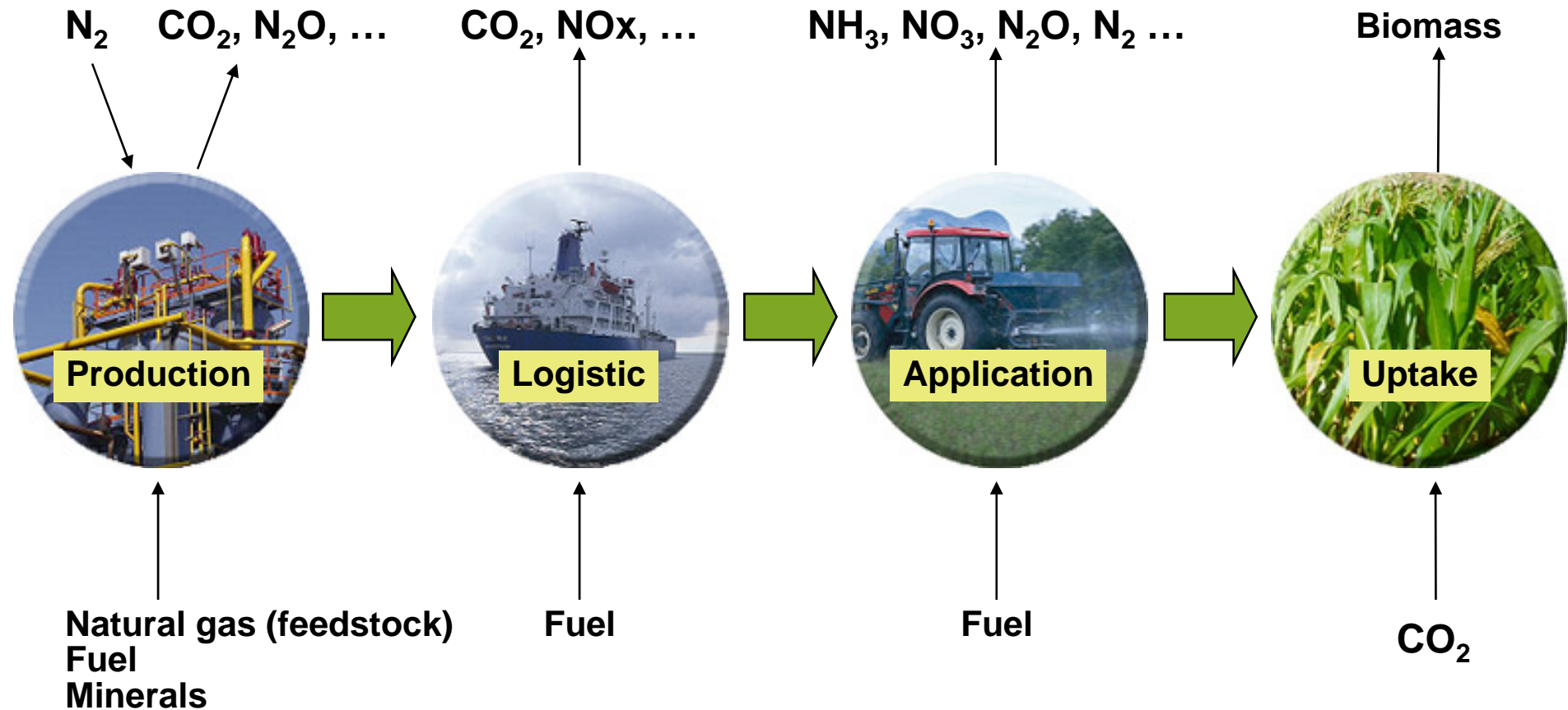
Research Centre for Plant Nutrition Hanninghof, Germany

# Contents

- Introduction – environmental impacts and benefits of N fertilizer use
- Life Cycle Assessment (LCA) – a methodology for the holistic environmental analysis of products and processes
- Environmental analysis of different N fertilizing intensities
- Regional adoption of the LCA methodology
- Summary



# A N-fertilizer's life-cycle and some of its interactions with the environment



# Environmental effects of N fertilizer use

## Impacts

- Eutrophication
  - Nitrate leaching
  - Ammonia Volatilisation
- Acidification
  - Ammonia Volatilisation
- Global warming
  - CO<sub>2</sub> emissions
  - N<sub>2</sub>O emissions

## Benefits

- Biomass production
  - Food, Feed, Energy
- Land preservation
- Carbon fixation



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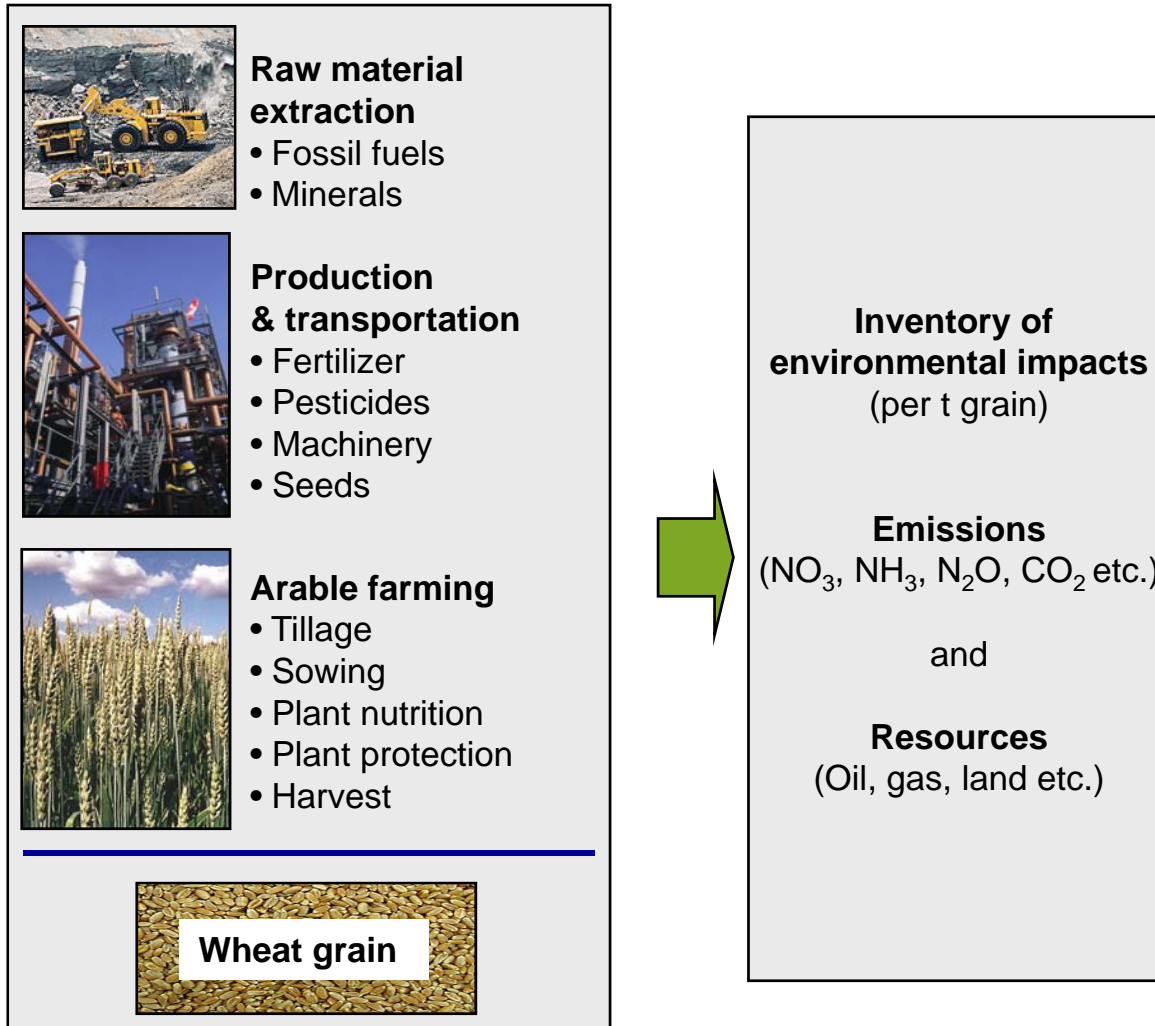


# Life Cycle Assessment = LCA

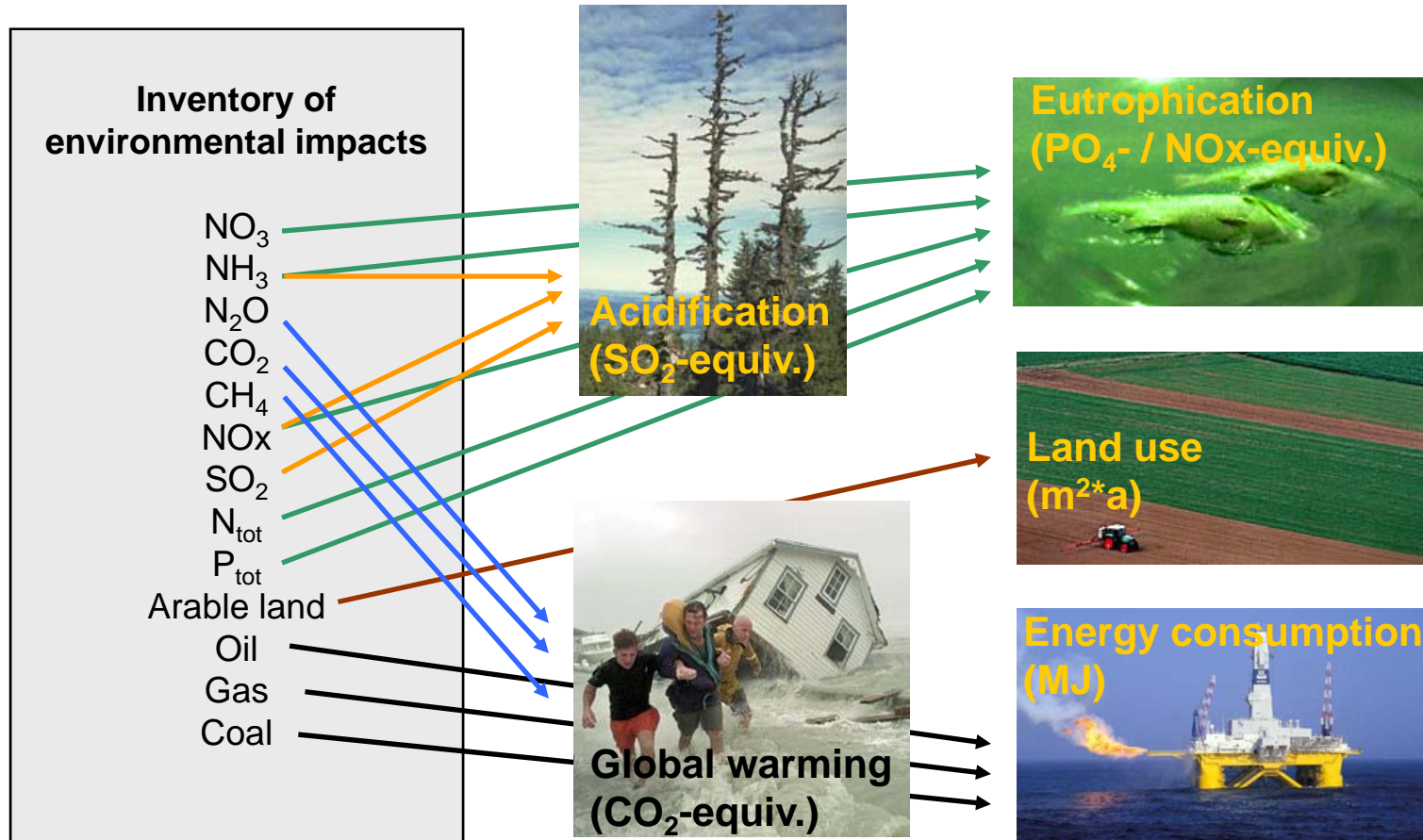
- Definition:
  - LCA is an inventory and evaluation of environmental impacts (emissions and resource consumption) along the „life-cycle“ of a product
  - For fertilizer: from raw material extraction, through fertilizer production to uptake by crop
- LCA is suitable to assess environmental impacts because:
  - the entire production system is considered and
  - all single environmental effects are included and evaluated,
  - conclusive indicators are calculated.
- The LCA methodology is standardized (ISO/DIN 14040 series)
- Application
  - to compare alternatives and /or to identify “hot-spots”



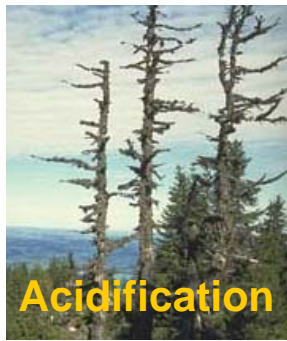
# Life Cycle Assessment of arable production



# The single impacts are combined into indicators for environmental effects



# The EcoX method has been developed to aggregate different environmental effects



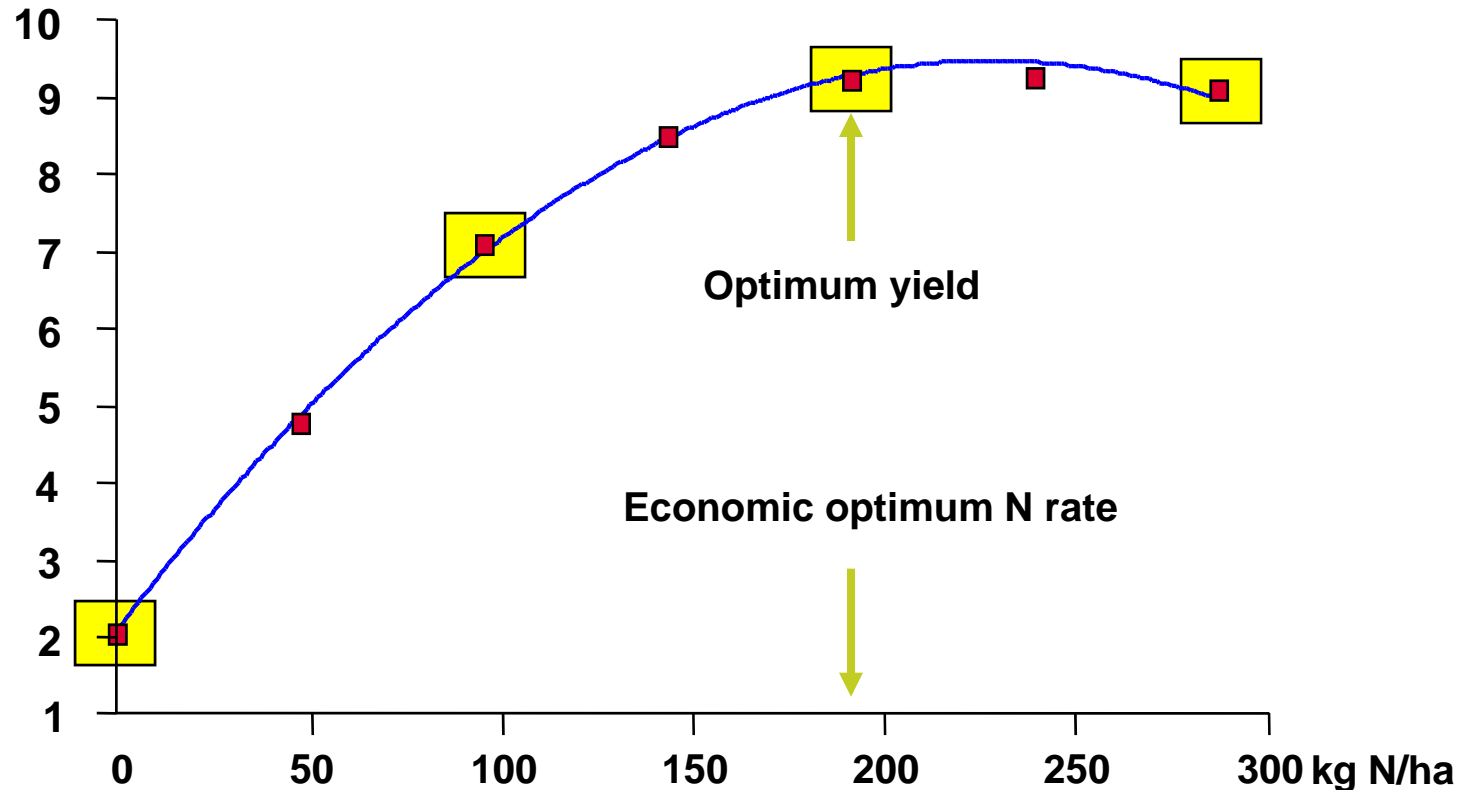
Environmental index 'EcoX'



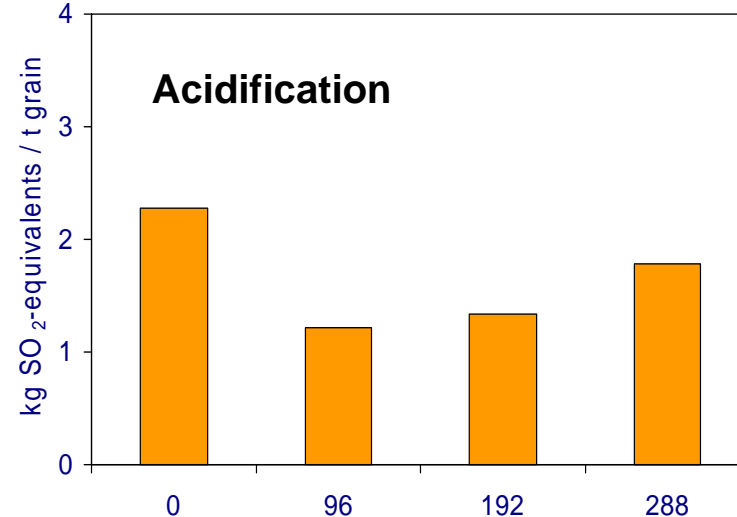
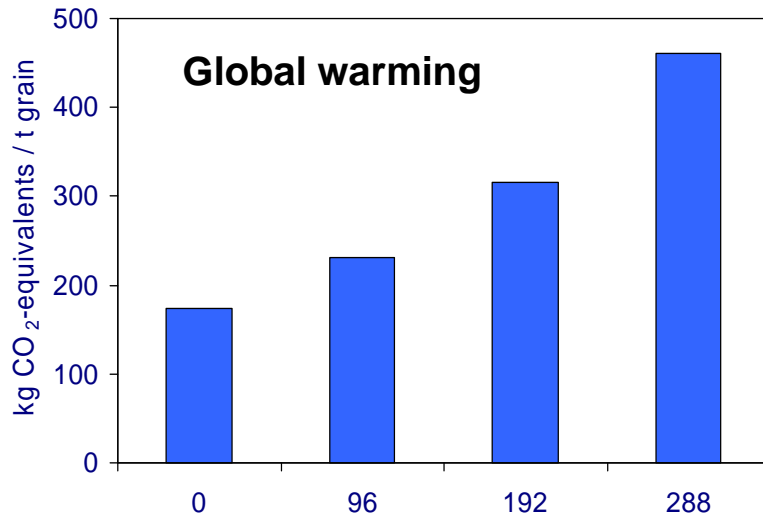
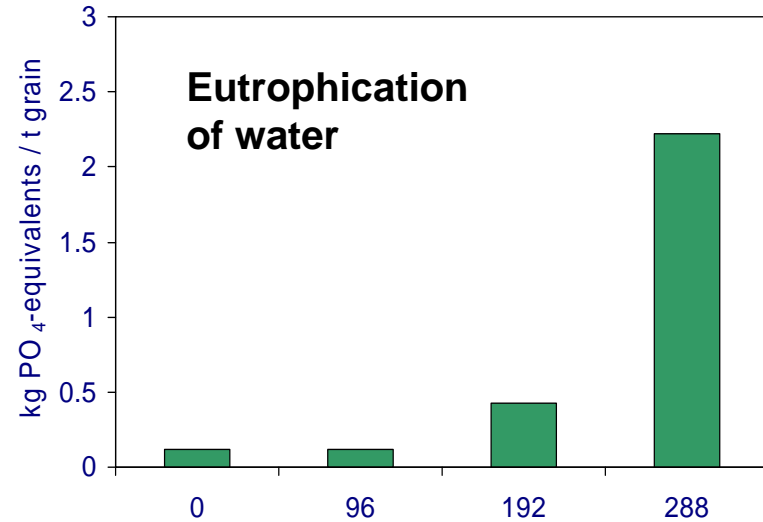
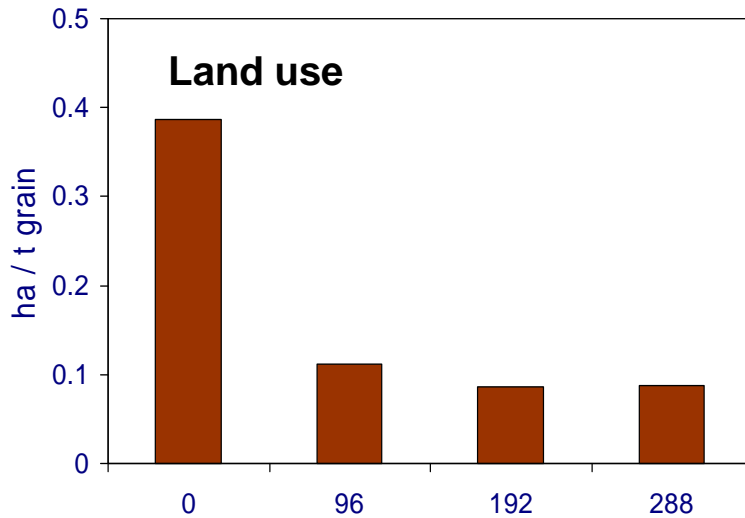
# LCA of wheat production at different nitrogen application rates

- Yield response in the long-term Broadbalk experiment, Rothamsted/UK, different N rates since 1856

Grain yield (t/ha)



# Results from the Life Cycle impact assessment



Today in Africa about 2 mio tons of cocoa beans are produced on about 5 mio ha



other

crops

**Average yield 400 kg / ha**

**$2\ 000\ 000 = 0,4 \times 5\ 000\ 000\ ha$**



**2 mio tons of cocoa beans can be produced on  
50 % of the land that is planted today**

other

crops

**Land for biodiversity?**

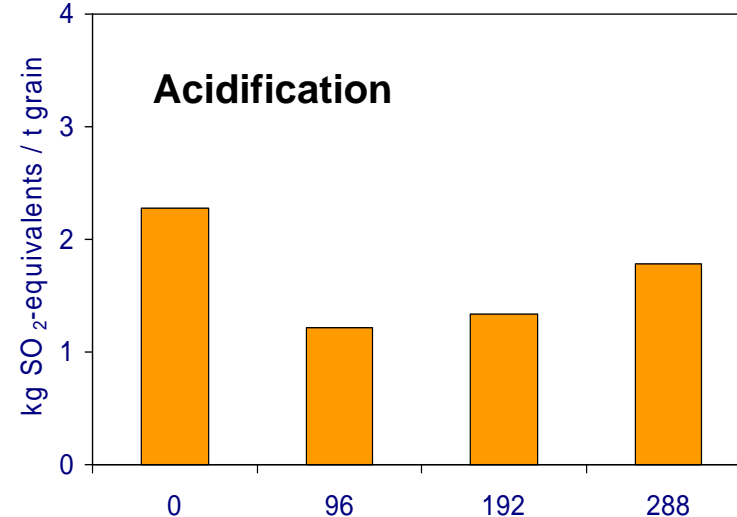
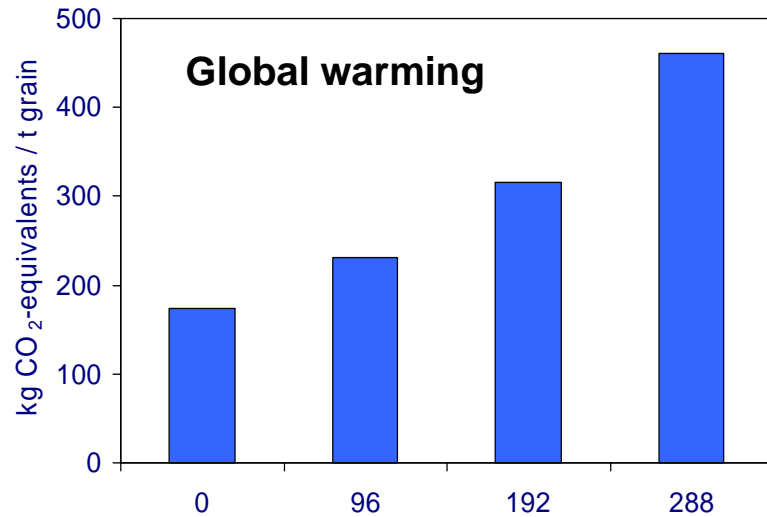
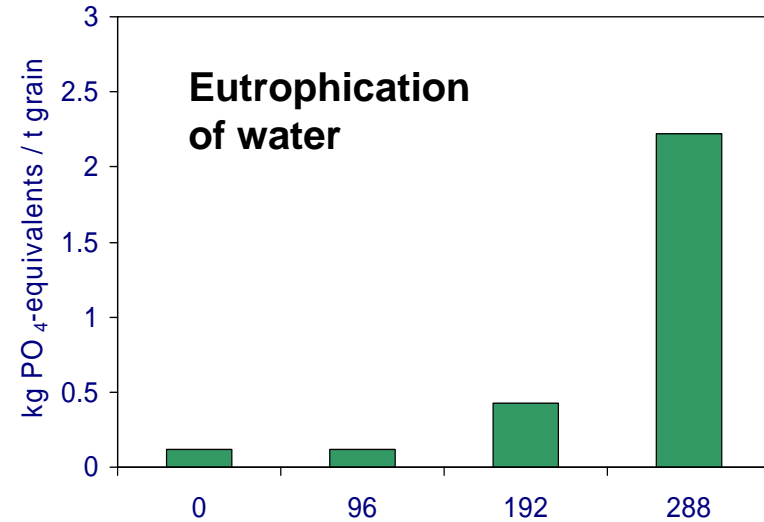
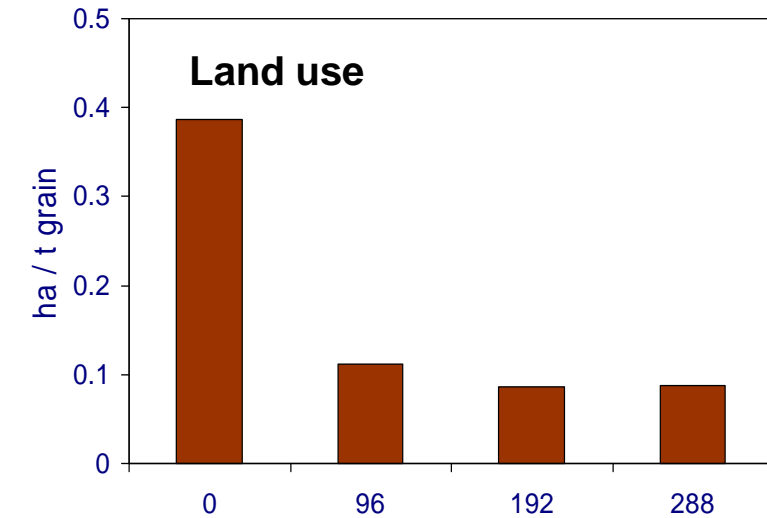
**With intensification**

**Average yield 800 kg / ha**

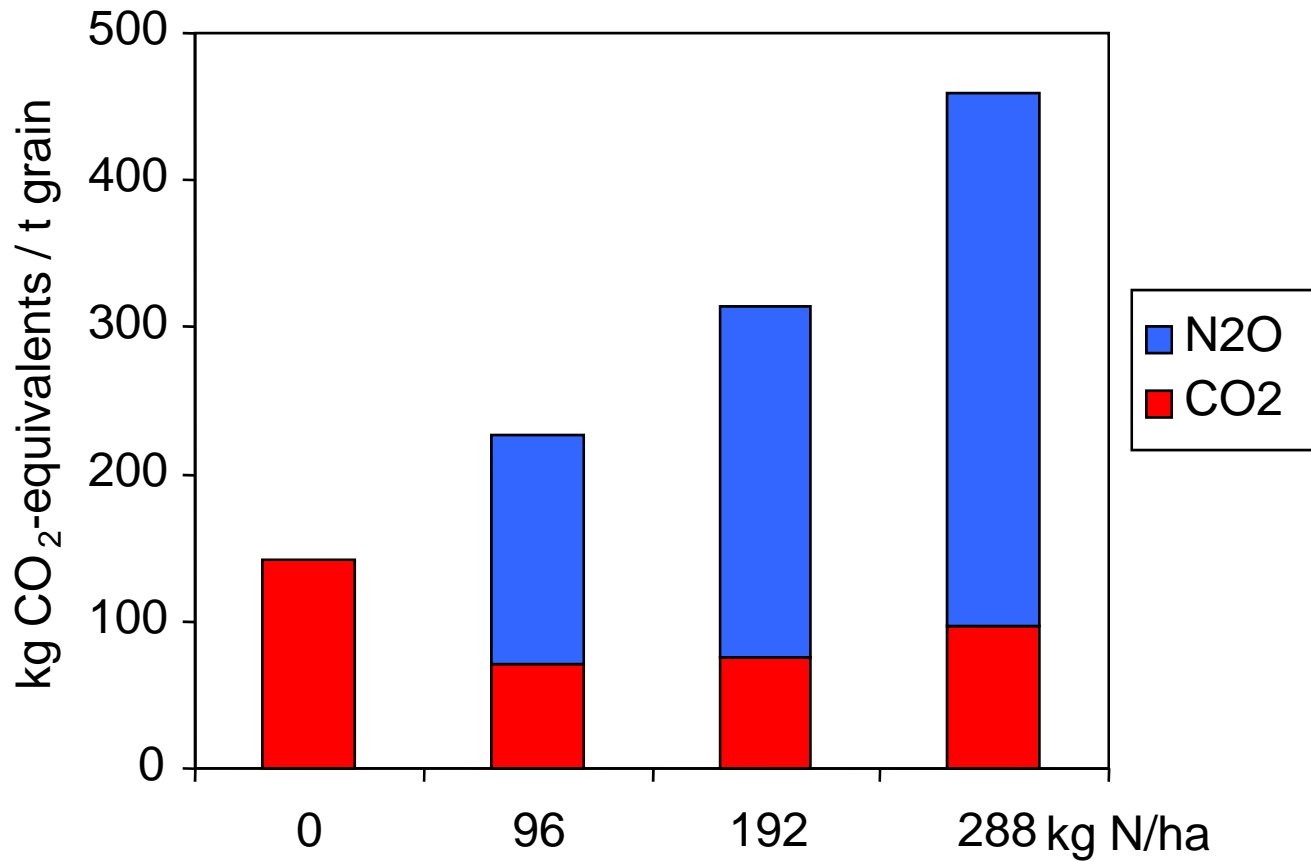
**$2\,000\,000 = 0,8 \times 2\,500\,000$  ha**



# Results from the Life Cycle impact assessment

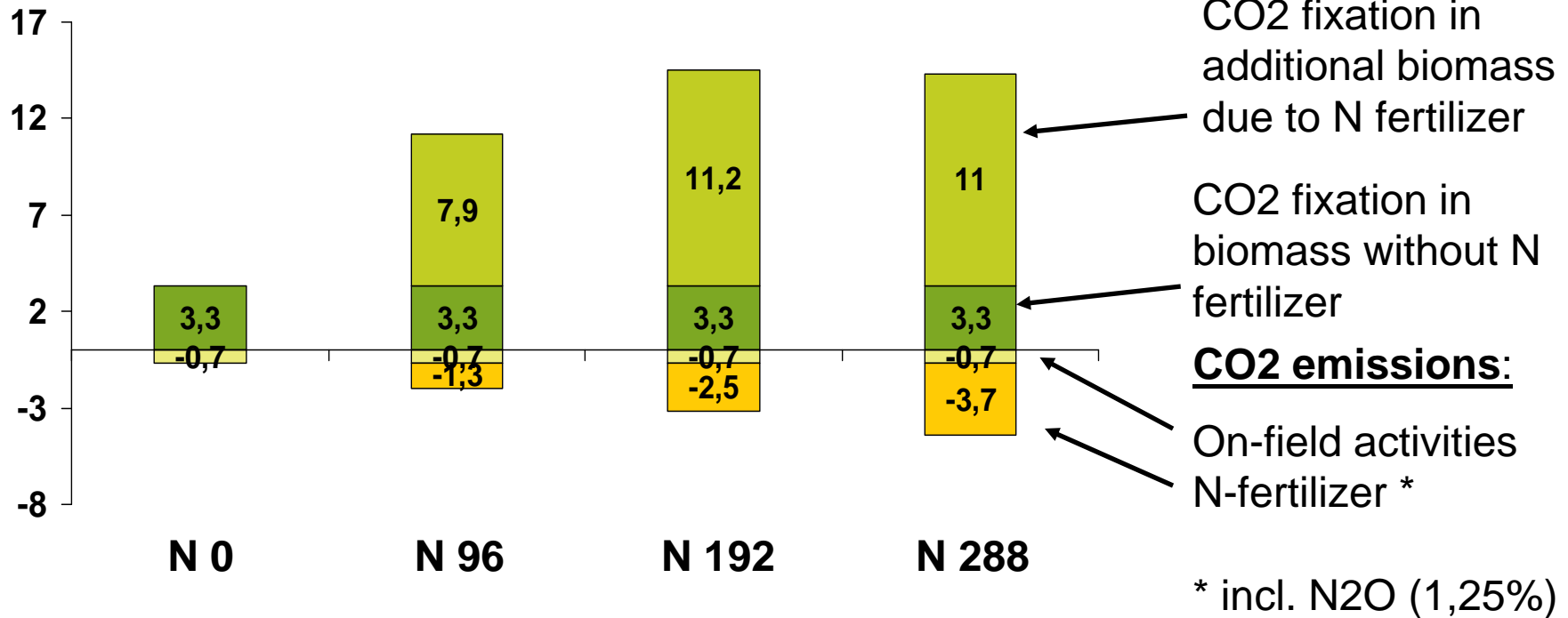


# Global Warming - Contribution of the different GHGs



# CO2 balance of wheat produced at different N-fertilizer rates

t CO2/ha

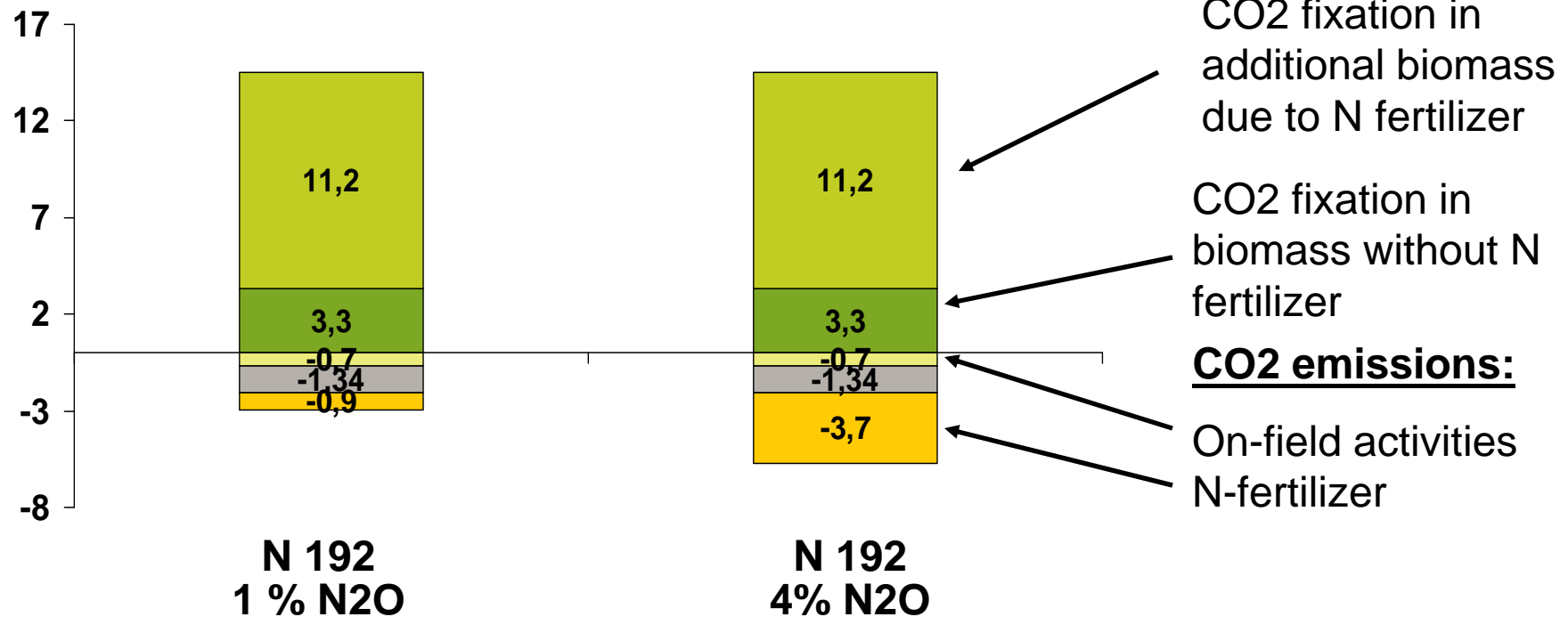


- Yield response in the long-term Broadbalk experiment, Rothamsted/UK, different N rates since 1856



# CO2 balance of wheat produced at optimum N rate with different N2O emission factors

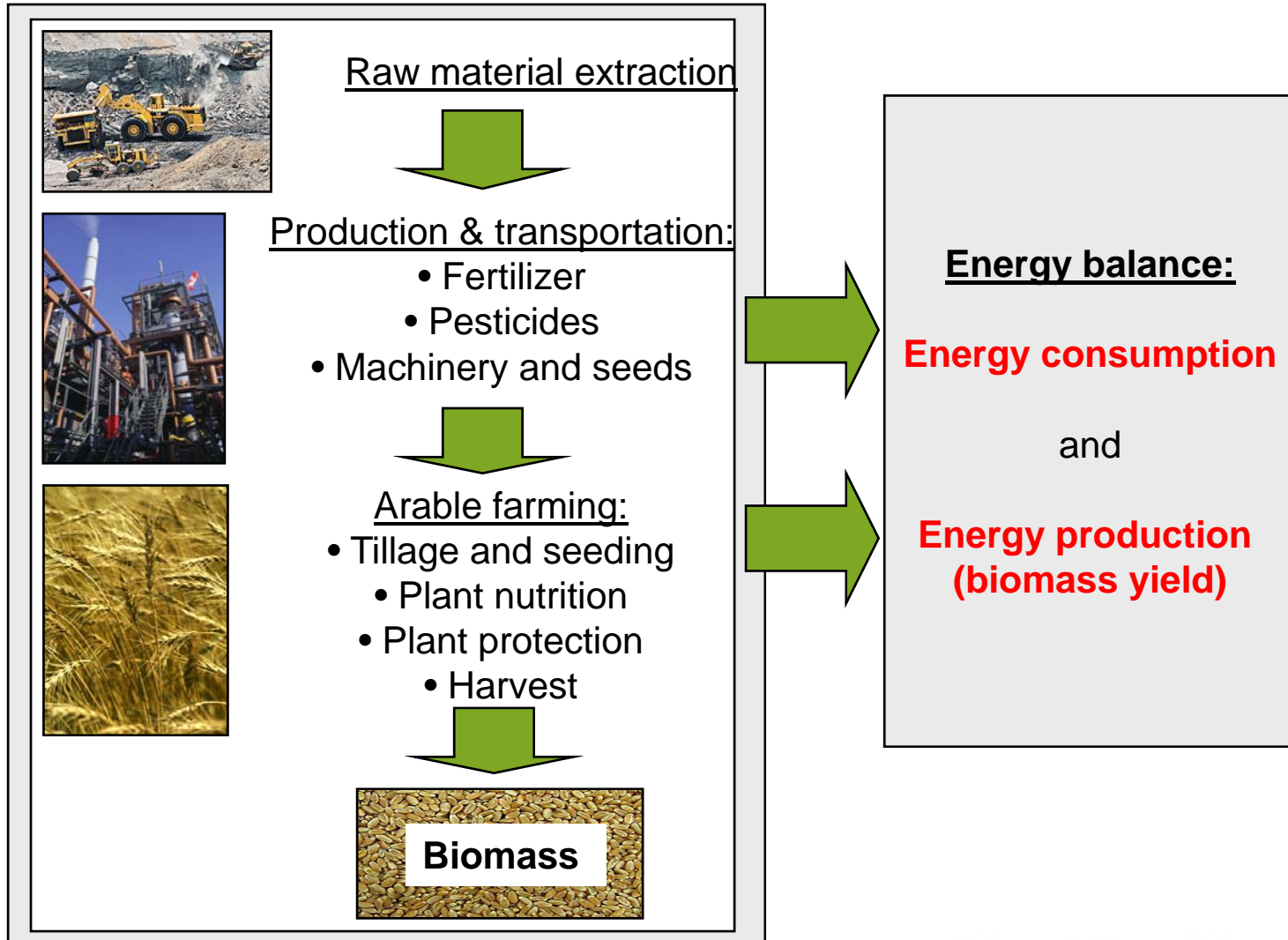
t CO2/ha



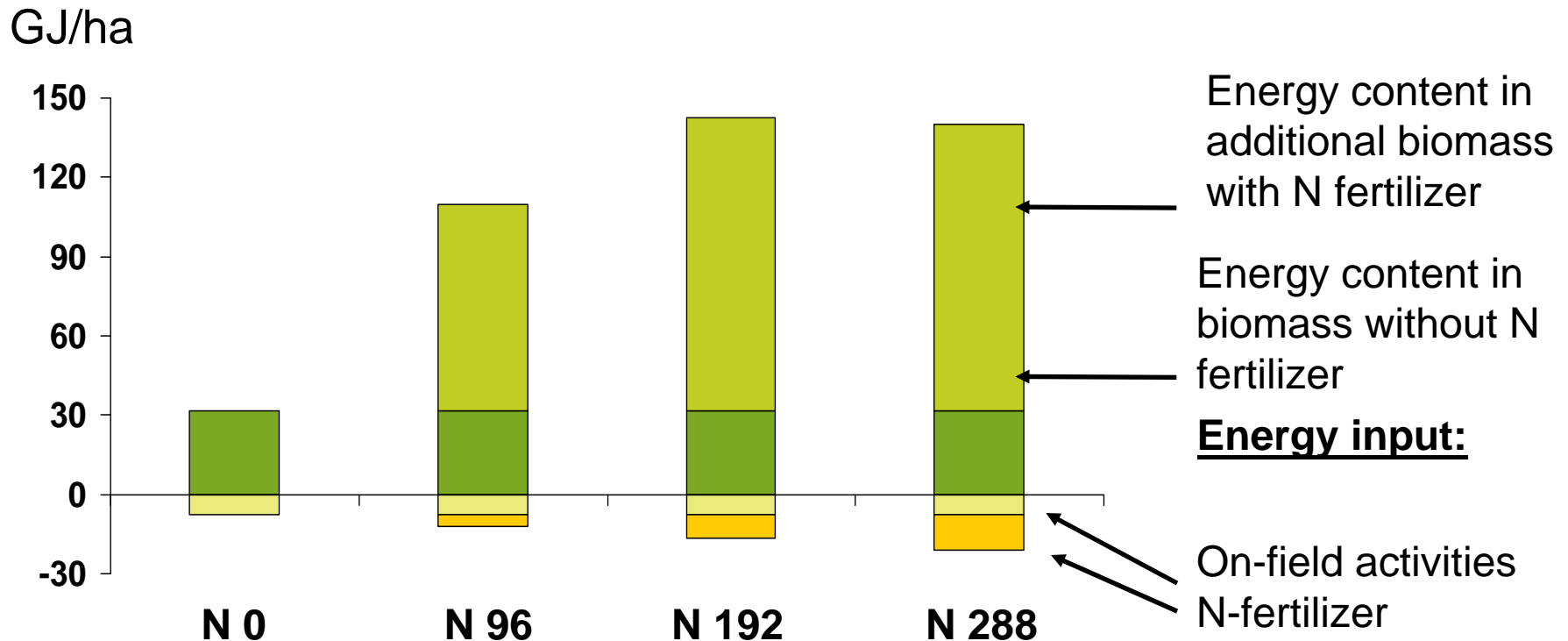
- Yield response in the long-term Broadbalk experiment, Rothamsted/UK, different N rates since 1856



# Energy balance of an arable production system



# Energy balance of wheat produced at different N-fertilizer rates



- Yield response in the long-term Broadbalk experiment, Rothamsted/UK, different N rates since 1856

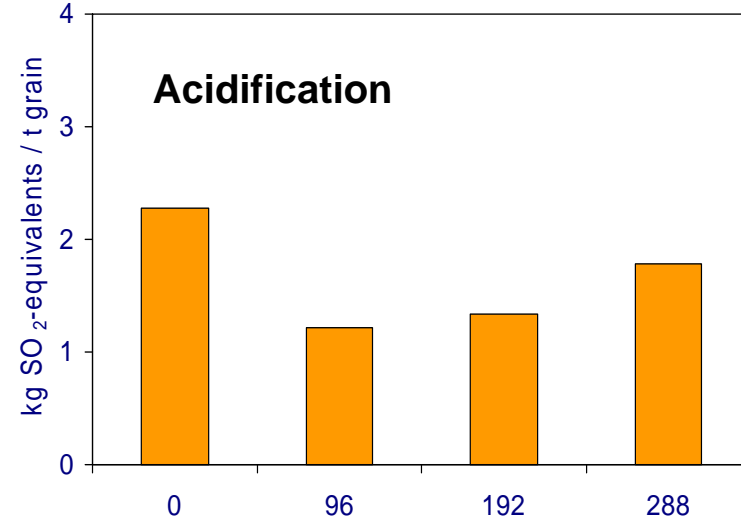
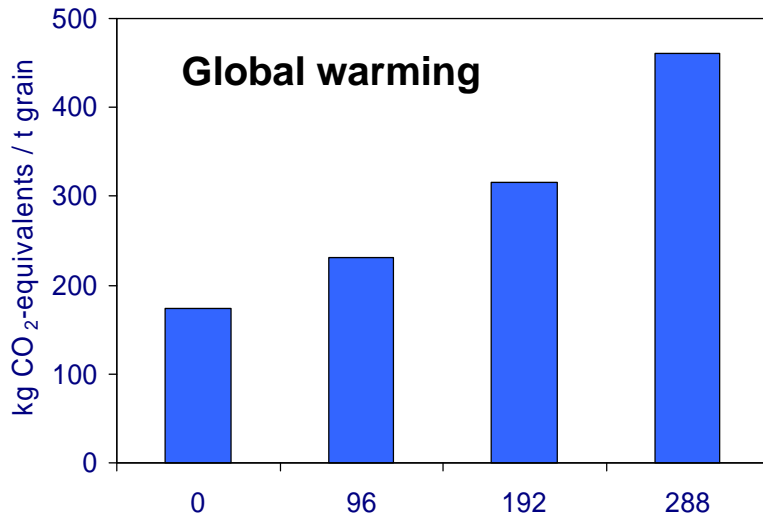
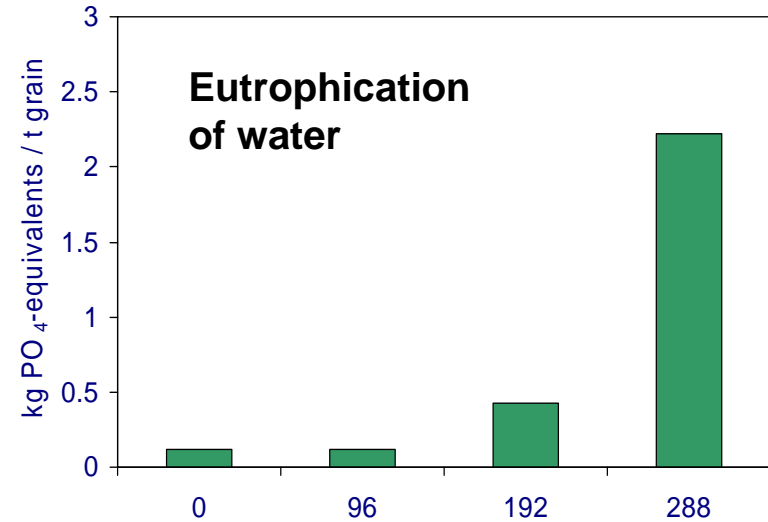
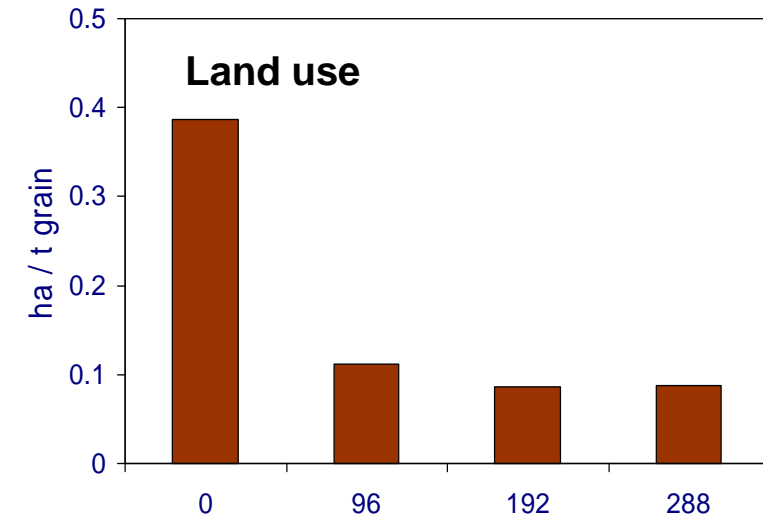


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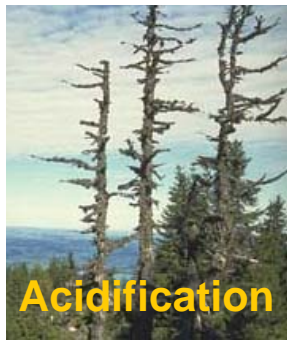
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# Results of the Life Cycle impact assessment



# The EcoX method has been developed to aggregate different environmental effects



Environmental index 'EcoX'



# The EcoX method is based on a weighting of the different effects

Weighting principle:

- “Distance-to-Target”

Example: Global warming:

Current situation in EU15 (EMEP, 2002):	3,93 Bio t CO <sub>2</sub> -equiv./year
Target value for EU15 (Kyoto-Protocol, 1997):	3,68 Bio t CO <sub>2</sub> -equiv./year

$$\frac{3,93 \text{ Bio t CO}_2\text{-equiv./year}}{3,68 \text{ Bio t CO}_2\text{-equiv./year}} = 1,07 = \text{weighting factor for global warming}$$



# The EcoX method is based on a weighting of the different effects

## Weighting principle:

- **“Distance-to-Target”**

## Weighting factors (for EU15):

Global warming:	1,07 (Kyoto-Protokoll, 1998)
Acidification:	1,34 (UN-ECE/CLRTP convention, 1999)
Eutrophication, water:	1,36 (OSPAR/HELCOM conventions, 1995/2001)
Eutrophication, land:	1,26 (UN-ECE/CLRTP convention, 1999)
Land use:	1,00 (provisional: maintaining current status)



# The EcoX method is based on a weighting of the different effects

Application of the weighting factors, e.g. global warming:

$$\begin{array}{rcll} \text{normalised value} & \times & \text{weighting factor} & = \text{environmental index (EcoX)} \\ 0,032 & \times & 1,07 & = 0,034 \text{ EcoX / t grain} \end{array}$$

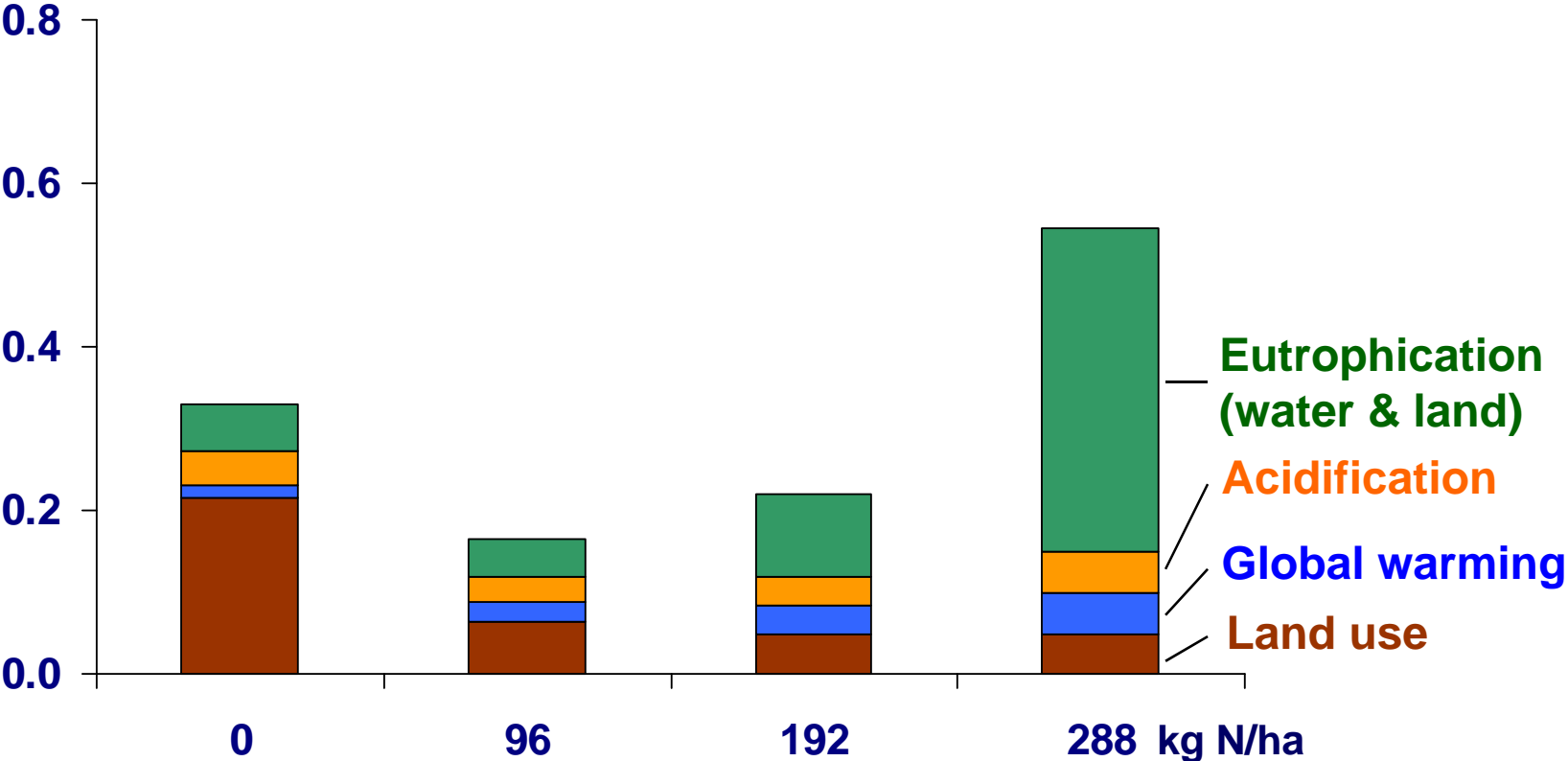
Result after weighting for 192 kg N/ha:

Global warming:	$0,032 \times 1,07 = 0,034$
Acidification:	$0,028 \times 1,34 = 0,038$
Eutrophication, water:	$0,050 \times 1,36 = 0,068$
Eutrophication, land:	$0,026 \times 1,26 = 0,033$
Land use:	$0,048 \times 1,00 = 0,048$
	-----
	0,221 EcoX / t grain



# Results of a LCA study on different N fertilizer rates

Environmental index (EcoX / t grain)



- Yield response in the long-term Broadbalk experiment, Rothamsted/UK, different N rates since 1856



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# Regional adoption of the LCA methodology

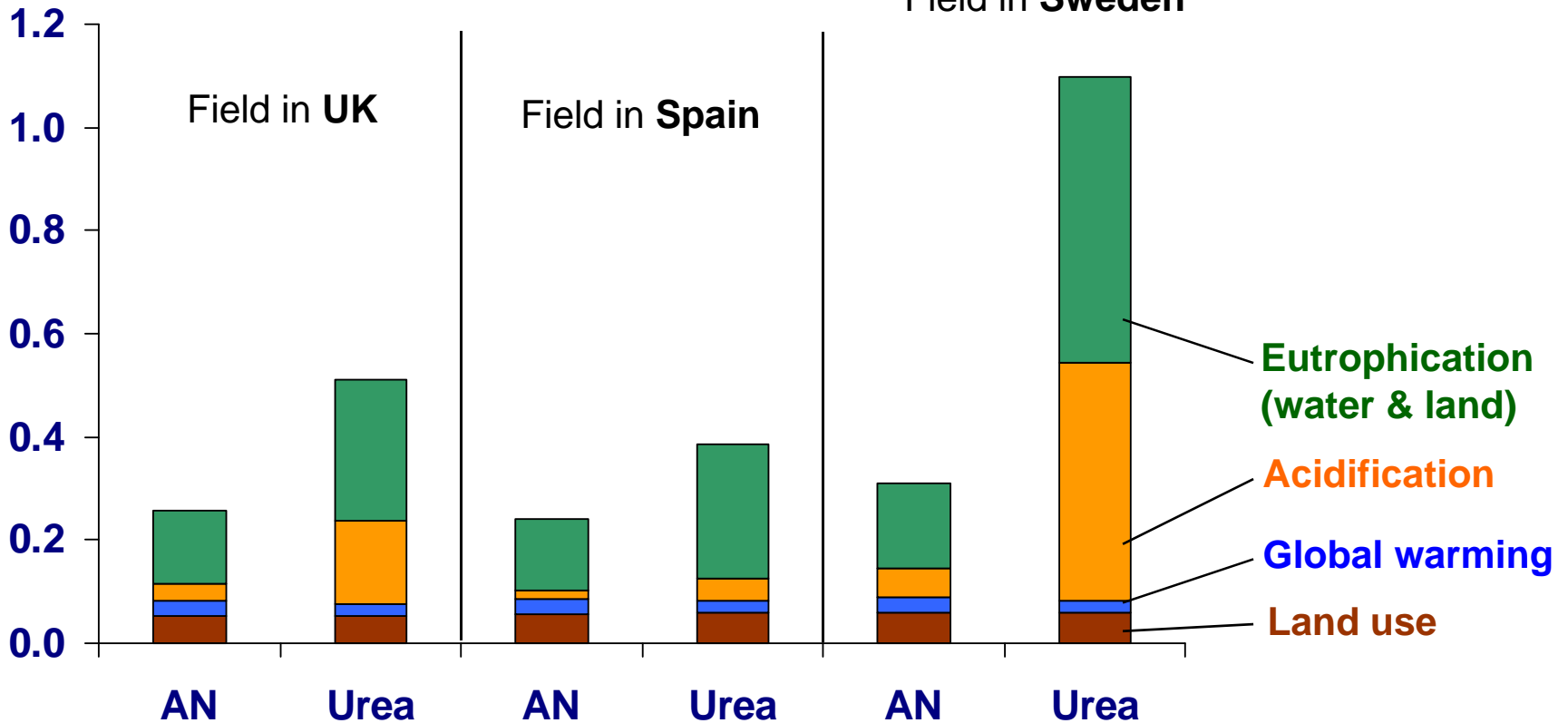
- Impact assessment
  - Environmental impacts may differ regionally e.g. because of different environmental background. (e. g. ammonia deposition may have little negative impact on arable land, while the impact is large on natural ecosystem or on oligotrophic lakes)
- Normalisation
  - Emissions from agricultural may be more relevant in regions where agriculture is the major contributor to environmental issues
- Weighting
  - If environmental targets are used for weighting, these should be valid for the region of application.
  - Some targets like GHG emissions are global



# LCA can be regionally adopted

example AN or Urea in different countries in Europe

Environmental index (EcoX / t grain)



# Conclusion

- The environmental impacts of nitrogen fertilizer use can be best described by a holistic consideration of all effects related to the use of N fertilizer
- Life Cycle Assessment (LCA) – is the appropriate methodology for the holistic environmental analysis of products and processes
- The LCA methodology is well documented and the data bases are available
- More LCA studies should be conducted in order to prioritise the right issues to further improve nitrogen fertilizer management

