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Food production and bioenergy, land allocation, land use with less environmental impact

Professor Jørgen E. Olesen

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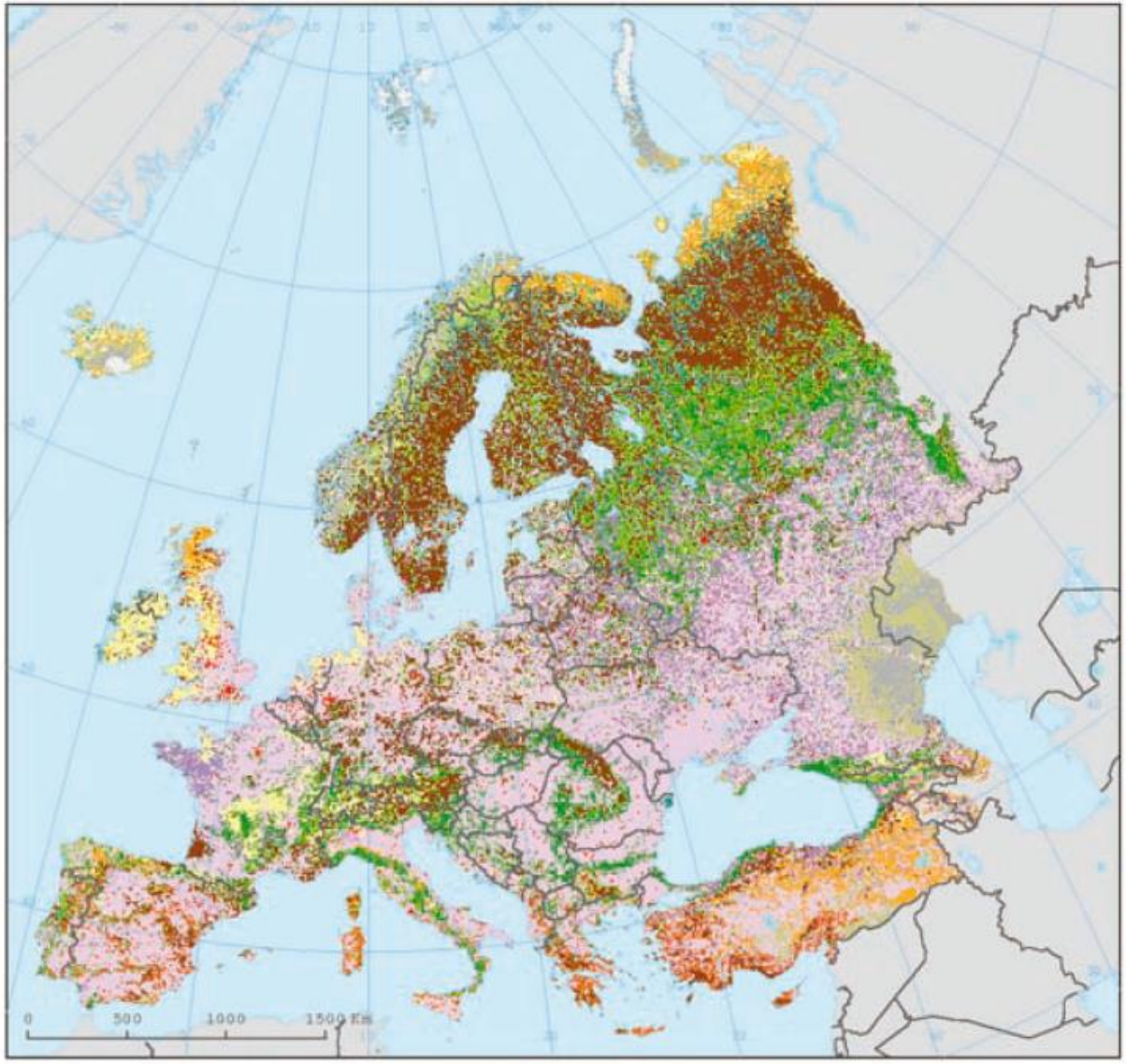
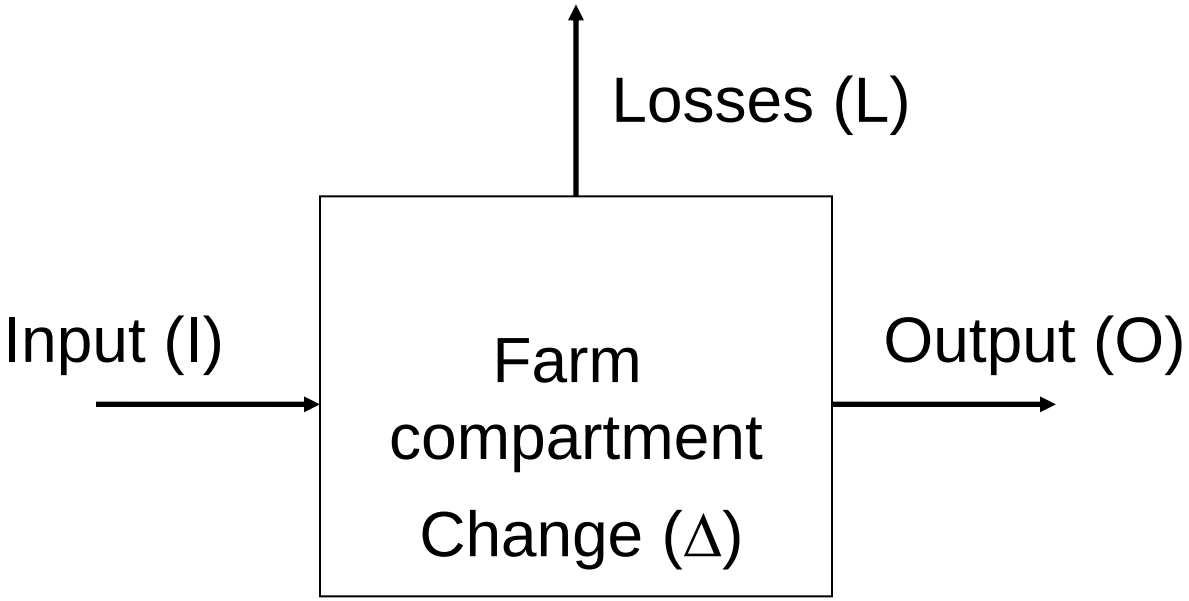
European land use – agriculture cover large areas



Global Landcover 2000 - Europe

- No data
- Tree Cover, broad leaved, evergreen
- Tree Cover, broad leaved, deciduous, closed
- Tree Cover, broad leaved, deciduous, open
- Tree Cover, needle-leaved, evergreen
- Tree Cover, needle-leaved, deciduous
- Tree Cover, mixed leaf type
- Tree Cover, regularly flooded, fnesh water
- Tree Cover, regularly flooded, saline water
- Mosaic: Tree Cover / Other natural vegetation
- Tree Cover, bumt
- Shrub Cover, closed-open, evergreen
- Shrub Cover, closed-open, deciduous
- Herbaceous Cover, closed-open
- Sparse herbaceous or sparse shrub cover
- Regularly flooded shrub and/or herbaceous cover
- Cultivated and manged areas
- Mosaic: Cropland / Tree Cover / Other naturalvege
- Mosaic: Cropland / Shrub and / or grass cover
- Bare Areas
- Water Bodies
- Snow and Ice
- Artificial surfaces and associated areas
- Cropland, tem porarily flooded
- Outside data coverage

The N balance concept (mass balance)



Surplus: $S = I - O = \Delta + L$

Efficiency: O/I

Losses: $L = S - \Delta$

Conventional wisdom: Losses are directly related to inputs

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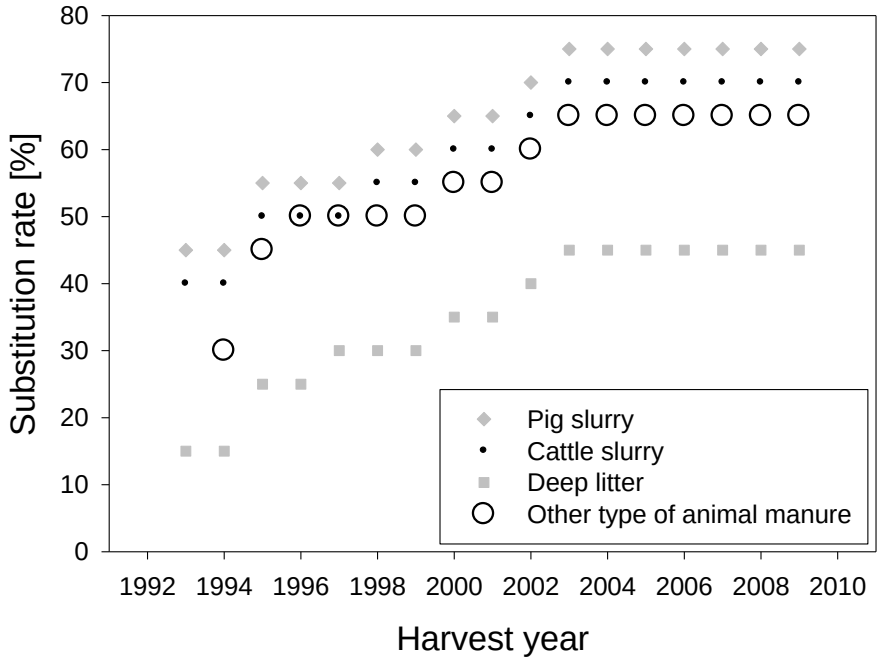
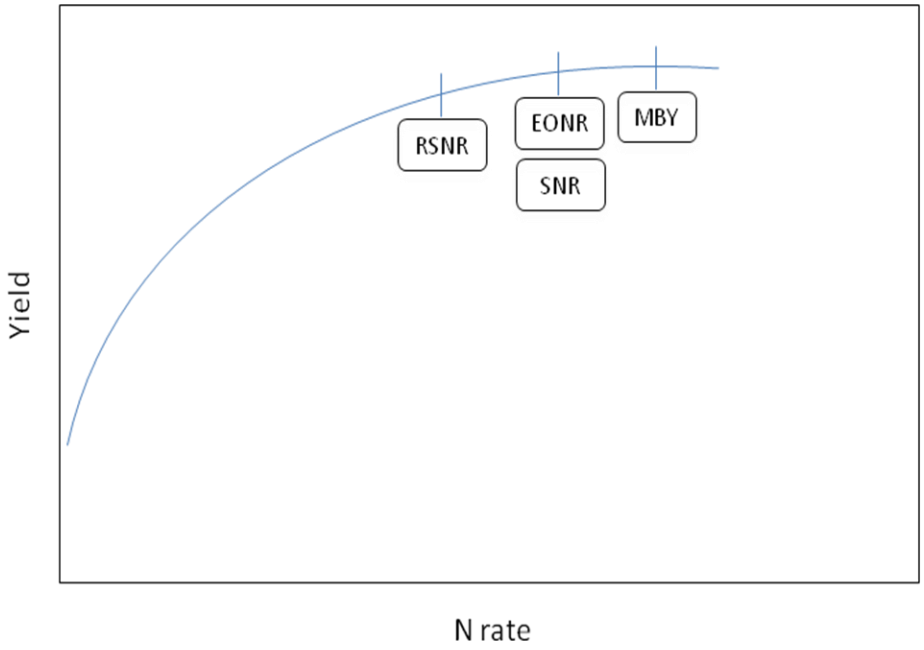
N losses vary and have different impacts

- Ammonia (NH_3): eutrophication, source of N_2O, particulate matter
- Nitrate (NO_3): Eutrophication, ground water pollution
- Nitrous oxide (N_2O): greenhouse gas
- Nitric oxide (NO): short-lived
- Dinitrogen (N_2): inert

The rate of emissions are strongly soil and climate dependent
So is the distribution of N surplus to different losses

Improved use of livestock manure and effect of reduced fertilisation rates in Denmark

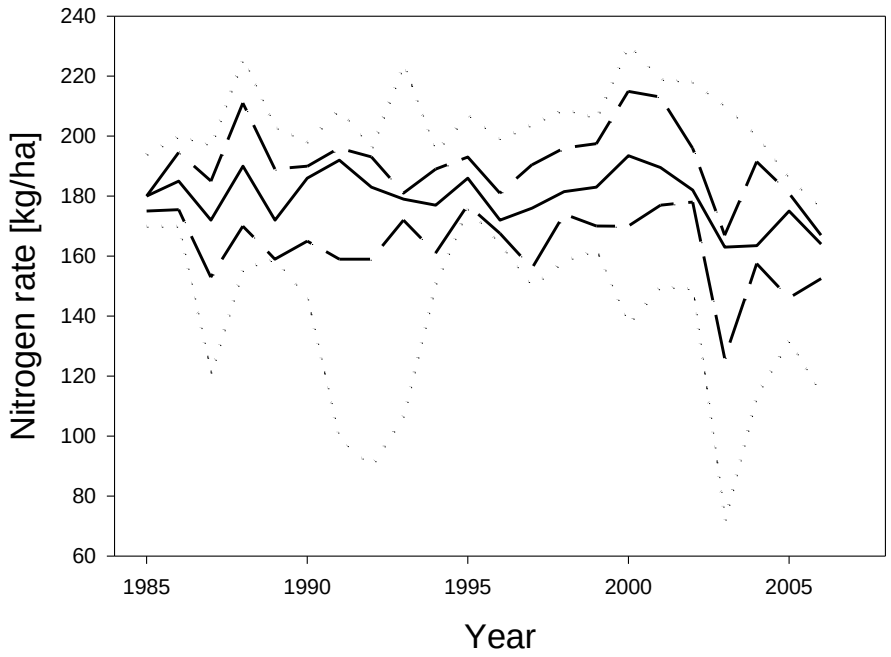




MBY - Maximum, biological yield
EONR – Economic optimal N rate
SNR - Standard N rate
RSNR – Reduced standard N rate

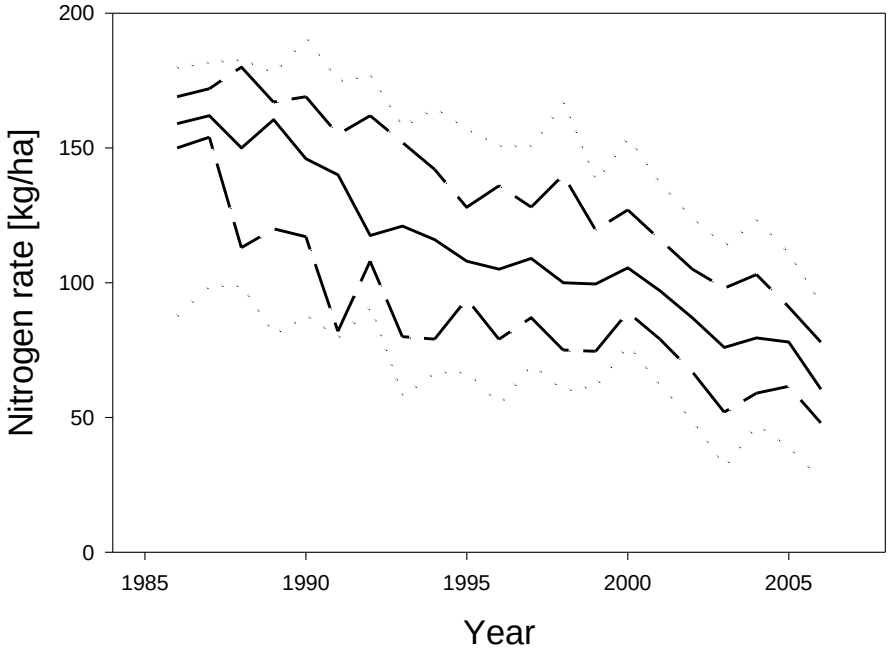
Levels of fertilisation in winter wheat in Denmark

Mineral fertiliser only



Reduction (1991-2000 to 2003-2006):
16-19 kg N/ha

Manure and mineral fertiliser



Reduction (1991-2000 to 2003-2006):
22 kg N/ha mineral fertiliser
33 kg N/ha manure

Estimated yield loss: about 0.5 t/ha

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Nitrogen fertilisation and quotas in Denmark

	07/08	08/09	09/10	10/11	11/12	12/13
Reduction of N norm (%)	15.0	14.5	15.5	16.1	16.7	13.8
N quota at national scale						
Economical optimal quota, ton N	426,619	442,188	450,937	458,487	451,633	444,805
Quota after reduction, ton N	362,923	378,623	381,962	384,162	376,600	383,904
Additional N leaching at economical optimal quota, ton N	63,696	63,565	68,975	74,325	75,033	60,901
Additional N leaching from fertilisation at economical optimal quota, tons N	19,109	19,070	20,693	22,298	22,510	18,270
Cultivated area, ha	2,468,900	2,556,290	2,650,830	2,701,452	2,675,647	2,636,102
Average per ha:						
Economical optimal norm, kg N/ha	173	173	170	170	169	169
Norm after reduction, kg N/ha	147	148	144	142	141	146
Additional leaching at optimal norm, kg N/ha	26	25	26	28	28	23
Additional N leaching from fertilisation to economical optimal norm, kg N/ha	8.5	8.0	8.1	8.3	8.1	6.5

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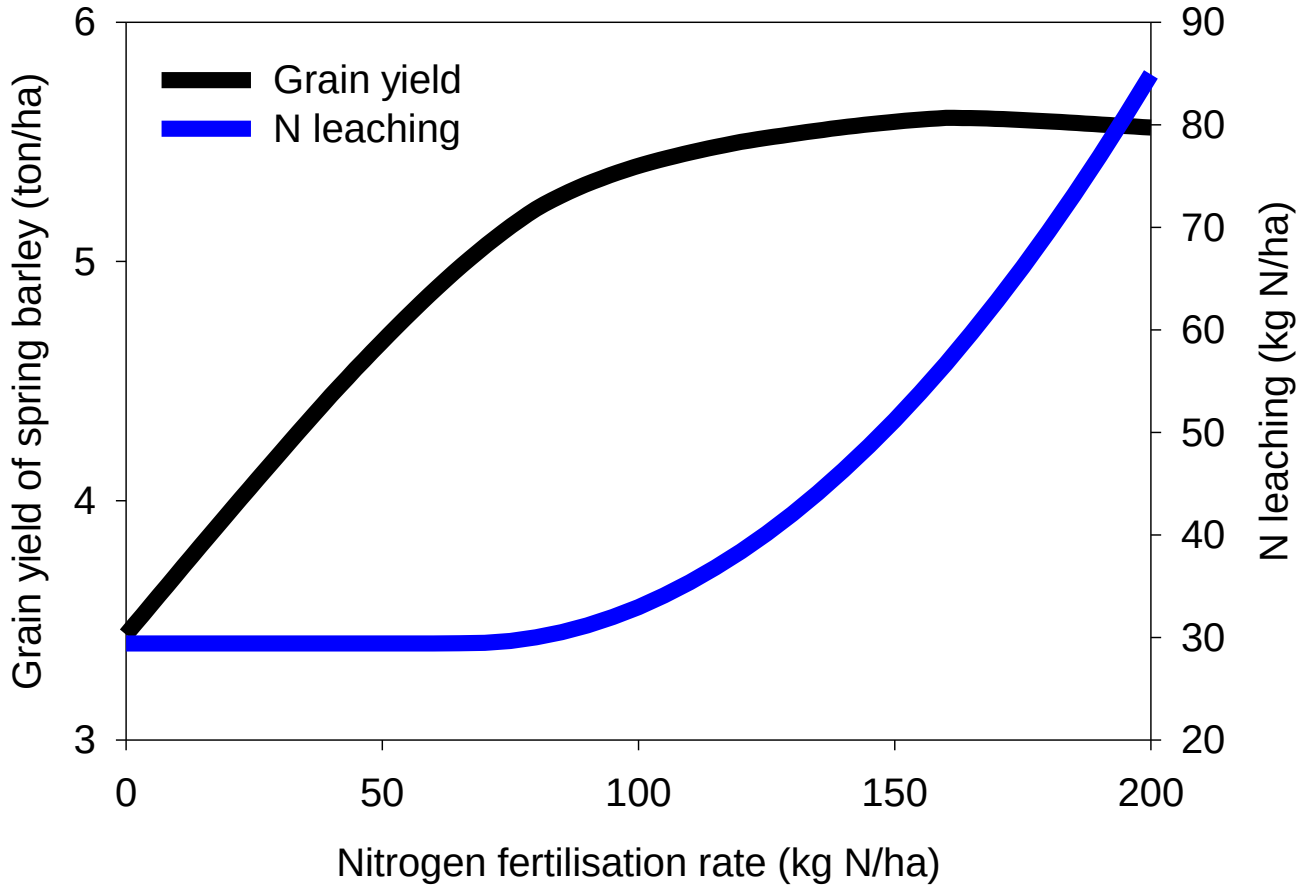
Estimated cereal grain yield loss in Denmark from N norm reductions

	DJF/FOI* 2004	VFL 2004*	AU/VFL 2010	VFL 2012	AU 2013**
Short-term effect	0.10	0.10 / 0.10	0.21-0.31	0.45	0.25 – 0.35
Long-term effect	0.02	0.13 / 0.08	0.04	0.15	0.15
Other		0.18 / 0.10			
Yield loss, grain	0.12	0.41 / 0.28	0.25 – 0.35	0.60	0.40 – 0.50

* Effect of 10% norm reduction. ** Preliminary estimate.

Recent estimates of annual income loss: 90 – 220 mill. €

Non-linear responses dominate



Many policy decisions have been based on 30% if applied N being leached

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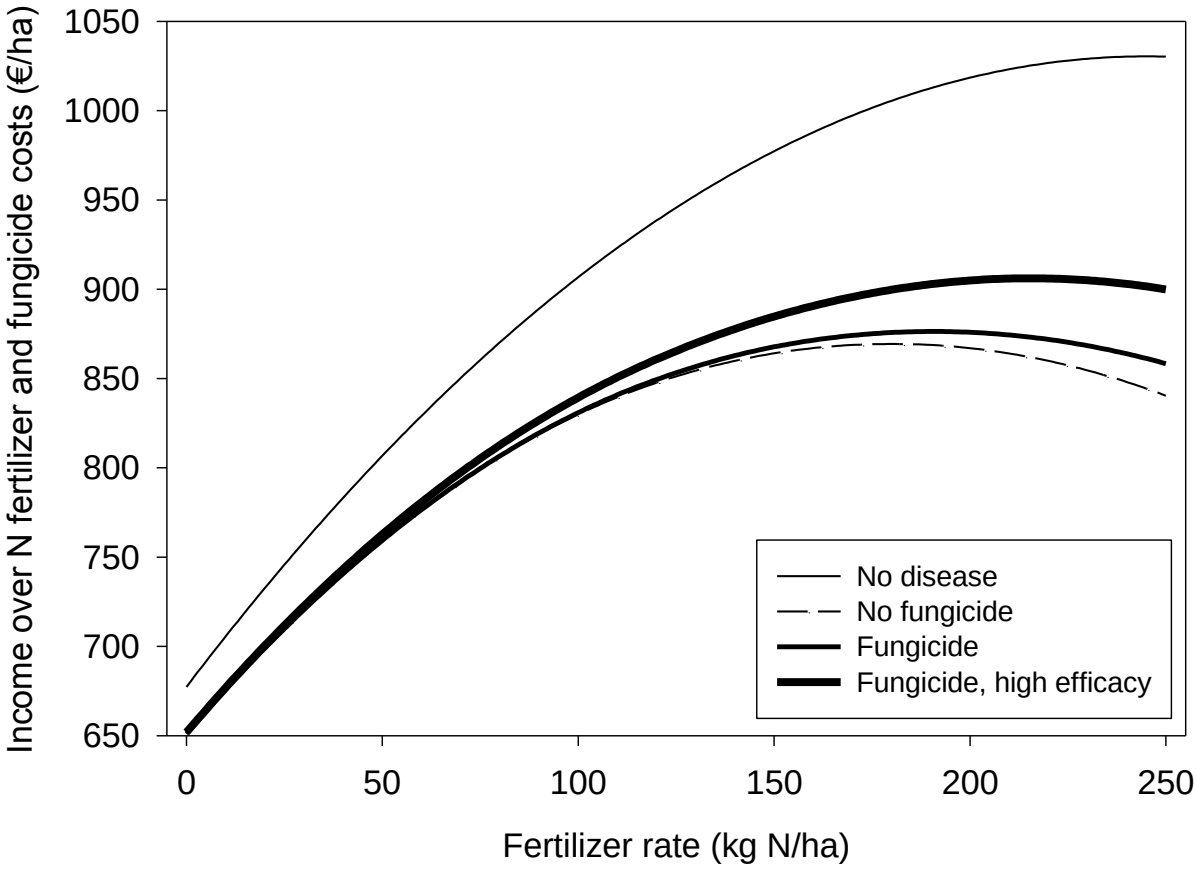
Improved crop growth increases yield and increases N use and reduces N losses



Olesen et al. (2003)

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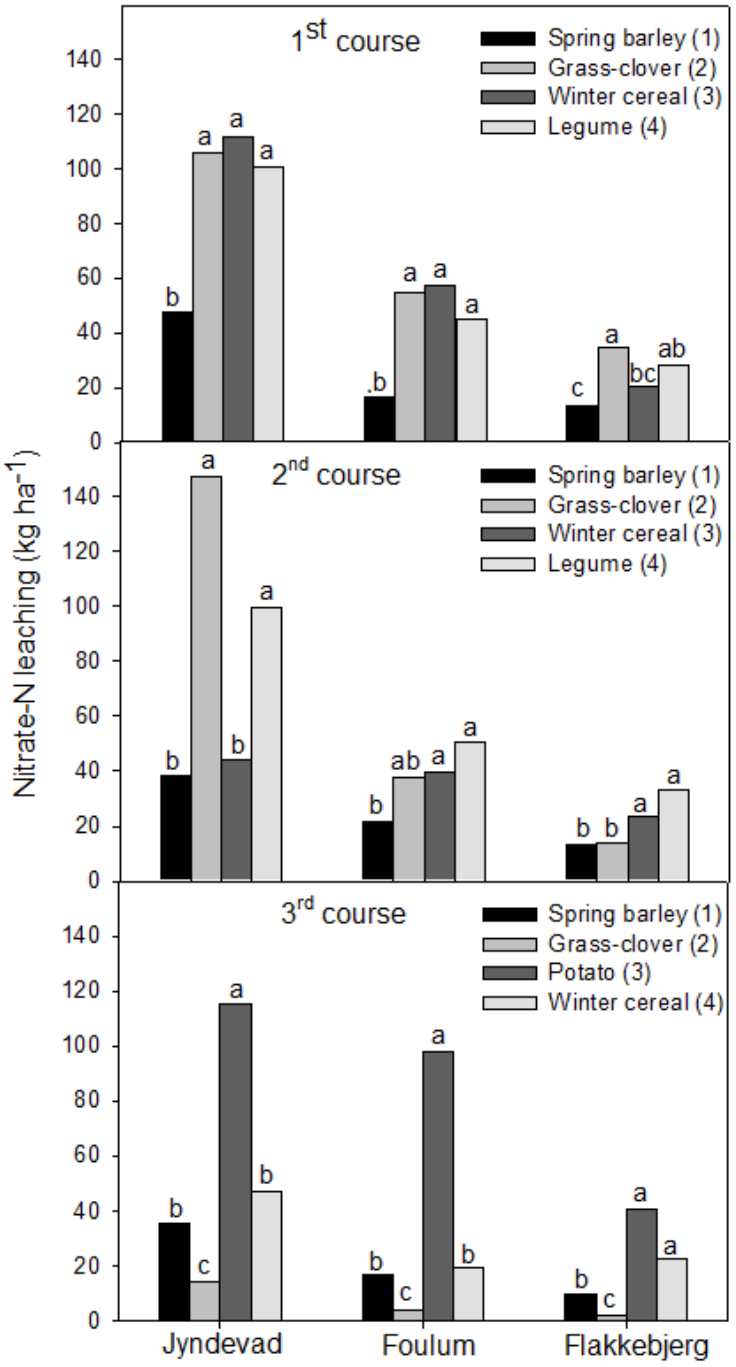
Nitrate leaching in organic arable crop production systems



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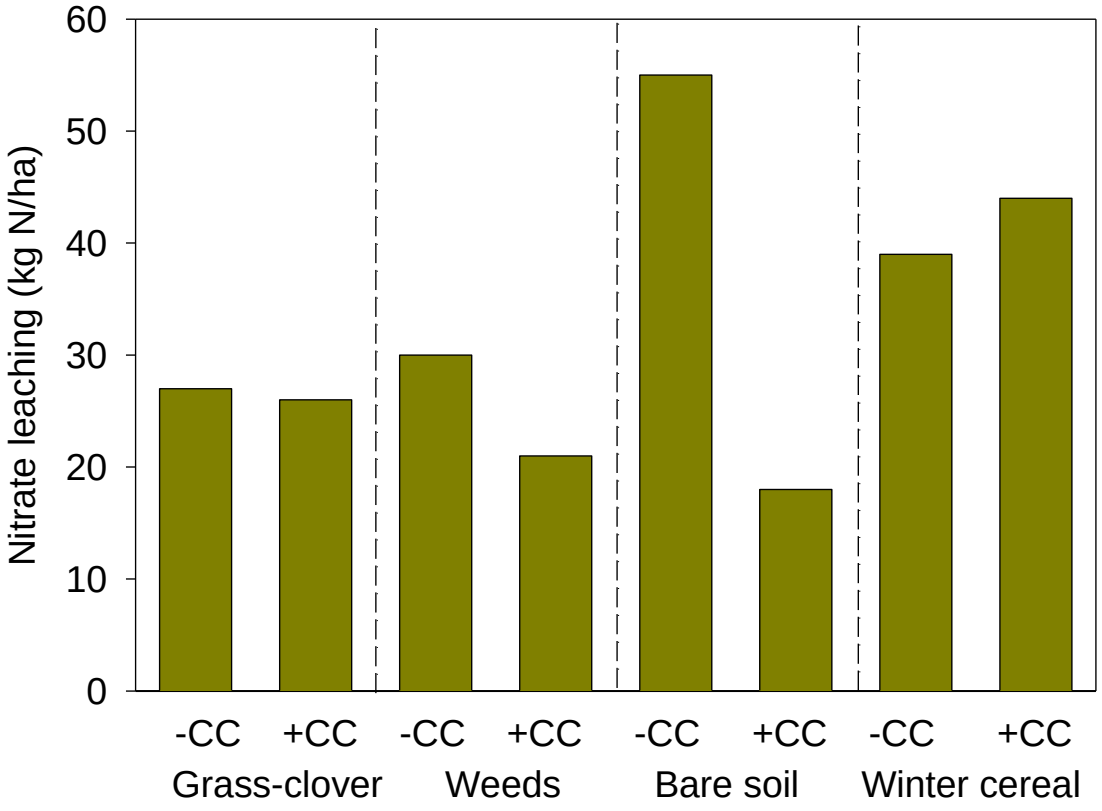
Nitrogen leaching in organic farming
Importance of autumn crop cover



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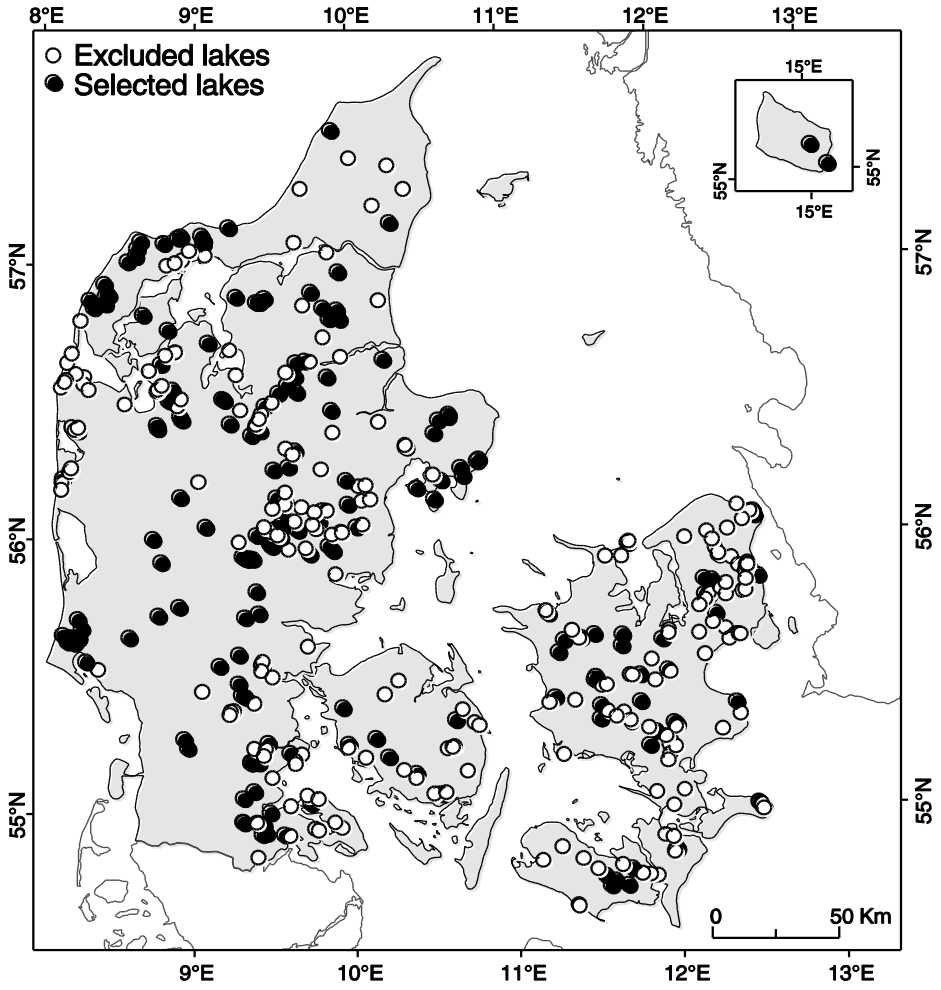
Danish lakes



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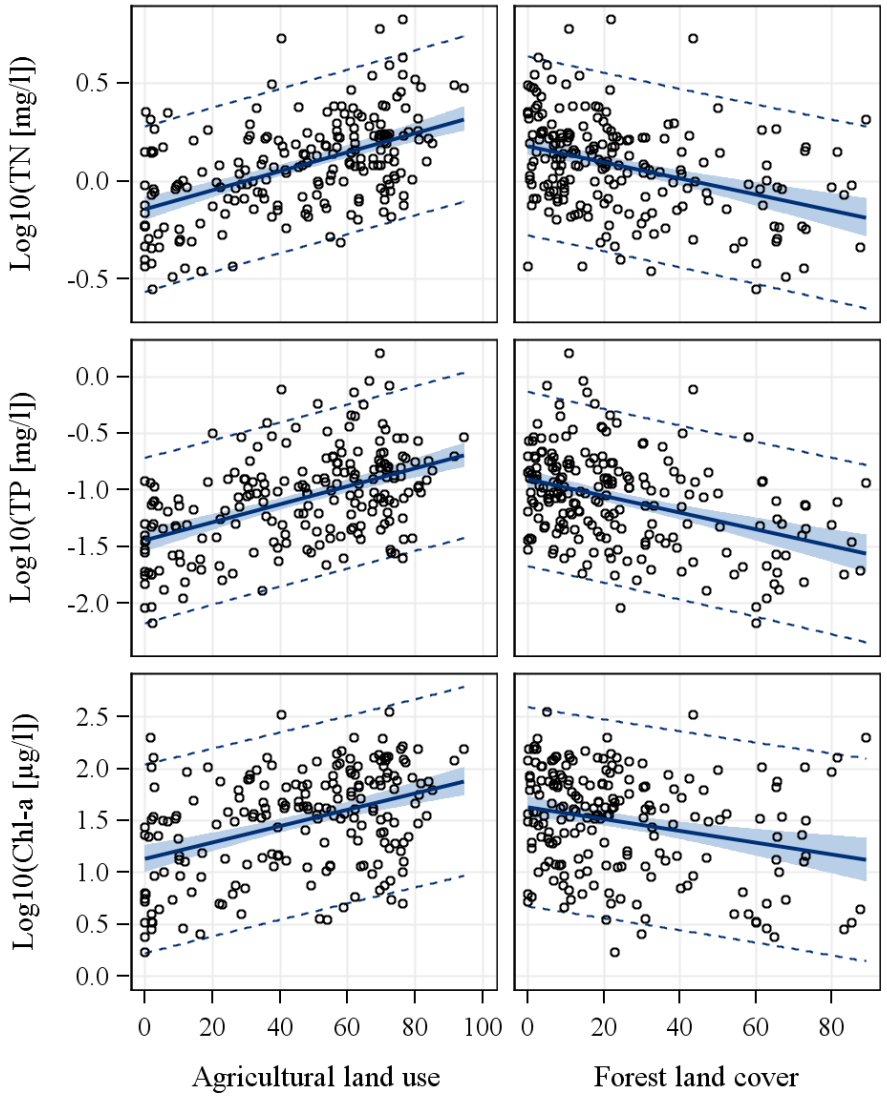
Danish lakes



EU Marine Strategy

- In Denmark N supply to marine areas are still too large. Loadings probably needs to be reduces by furhter 19.000 ton N/year
- However, this is not sufficient to reestablish the good ecological conditions in coastal marine environments
- Further measures are needed (establishing eelgrass, reestablishing good sea surface conditions, removal of nutrients etc.)

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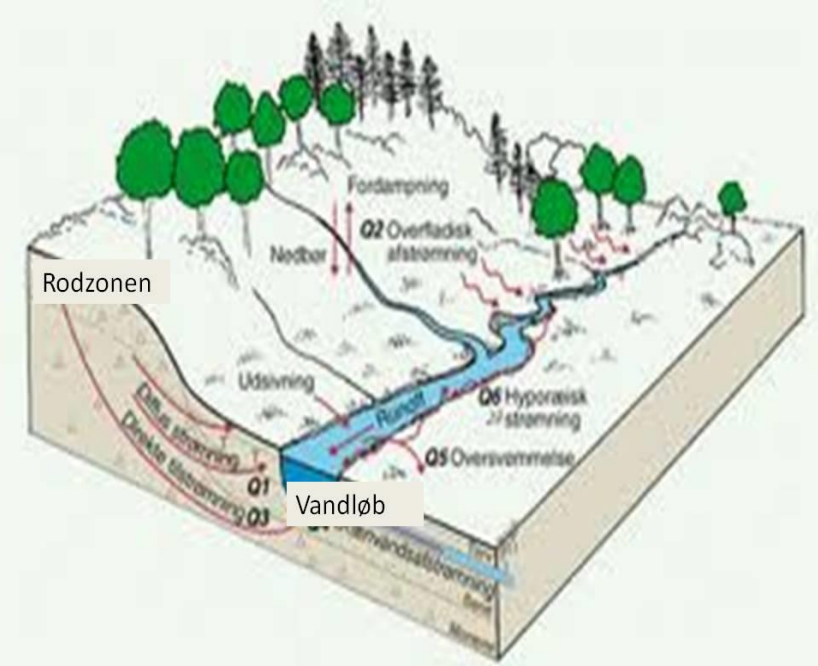
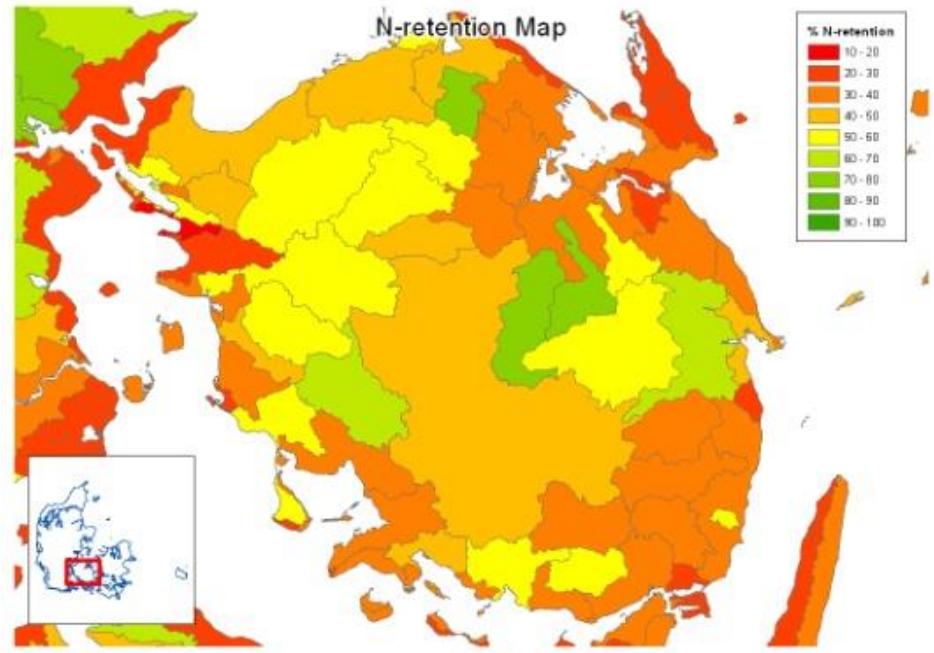
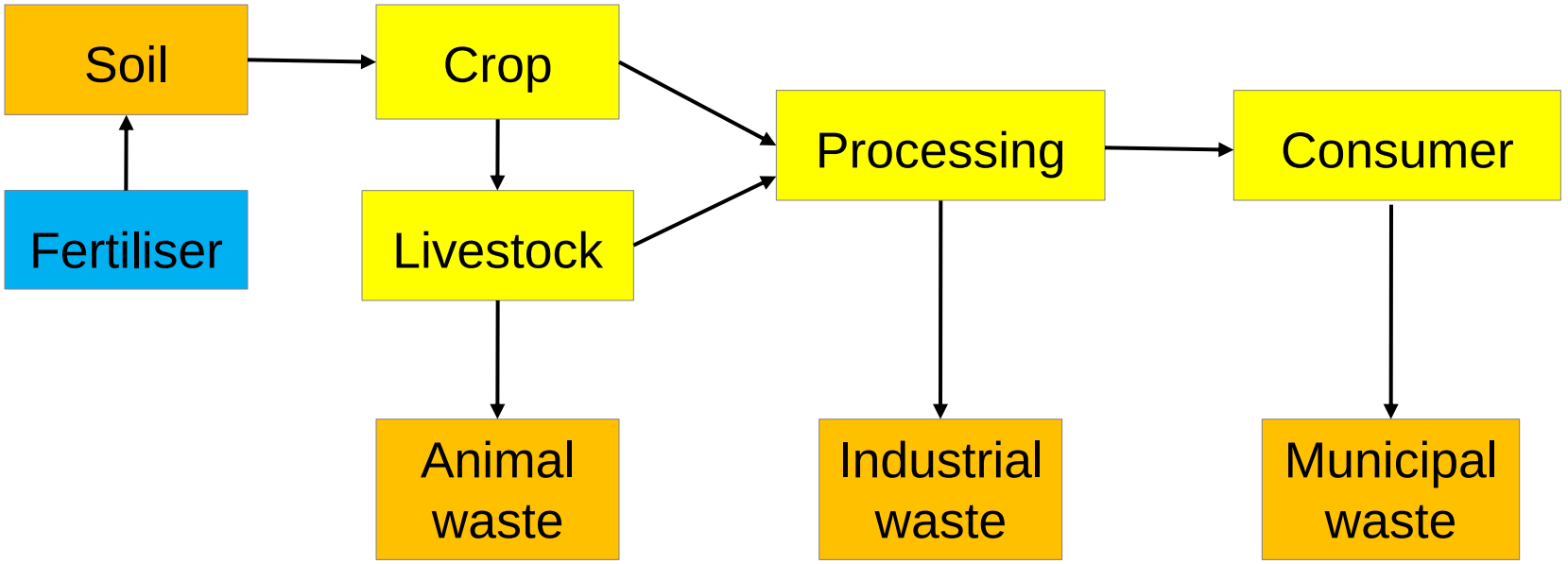
Flow pathways and N transformation processes determine how much N ends up in vulnerable ecosystems





Current thinking: Linear food chains



Consequences: Ressource depletion, emissions, pollution (low total efficiency)

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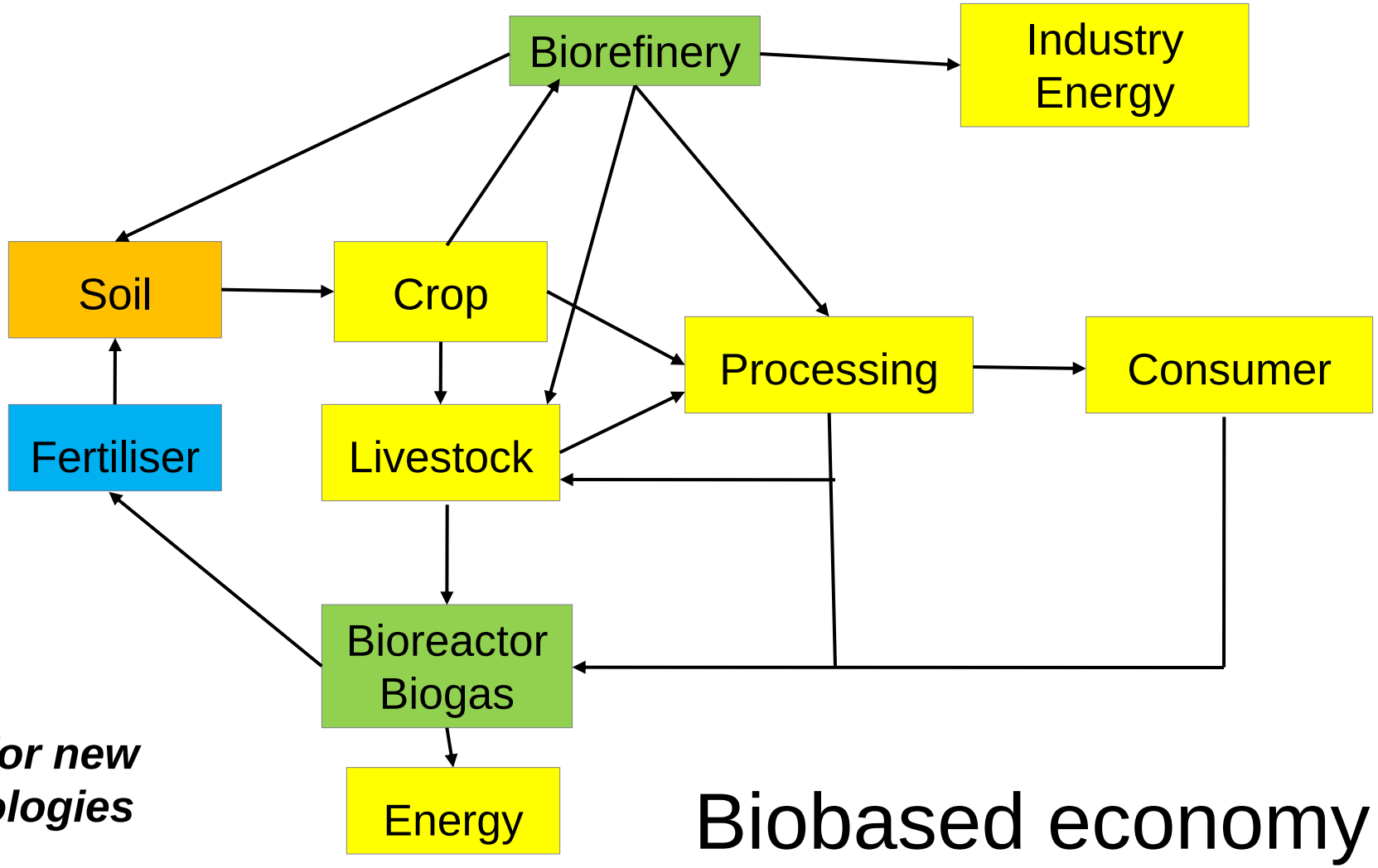
Future: Circular food chains - recycling



Need for new technologies

Biobased economy

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Three bioenergy scenarios for DK in 2020

- Business as usual
  - No changes in crop choice or technologies
  - Historical increasses in crop yield and feed efficiency
  - Existing biomass resources (straw, manure, rapeseed oil etc)
  - Additional biomass: 4 mill. ton biomass. Reduction in N leaching: 6,800 ton N

- Biomass optimised
  - Cereal varieties with greater straw yield
  - Increased efficiency in straw harvesting
  - Less rapeseed – more perennial energy crops
  - Fertilisation and harvesting of grass in managed wetlands
  - Harvesting roadsides, weeds in streams, cover crops etc.
  - Additional biomass: 10 mill. ton biomass. Reduction in N leaching: 9,200 ton N

- Environmentally optimised
  - No straw harvesting in regions with critically low soil organic carbon
  - Maximum area of cover crops and perennial energy crops
  - No cereals in areas susceptible to N leaching
  - No fertilisation of grass in managed wetlands
  - Increased afforestation
  - Additional biomass: 8 mill. ton biomass. Reduction in N leaching: 23,100 ton N

More intelligent and differentiated regulation

- Spatial variation in N retention
  - Some land areas have less N leaching per input and/or higher retention after leaching from root zone than other land areas
- Management is highly important
  - Crop and soil management outside of the growing season may be more important than fertiliser rates for leaching
- Shifts to other production systems are needed
  - Perennial cropping systems may deliver higher productivity and certainly have less N losses and more carbon storage

- **How to develop regulatory systems that allow farmers to apply N where and when it has little environmental impact?**