Interreg
Öresund-Kattegat-Skagerrak
European Regional Development Fund
EUROPEAN UNION
Green Valleys

Agricultural systems that improve soil quality, soil C sequestration and reduce pesticide impacts

Christel Cederberg, Chalmers

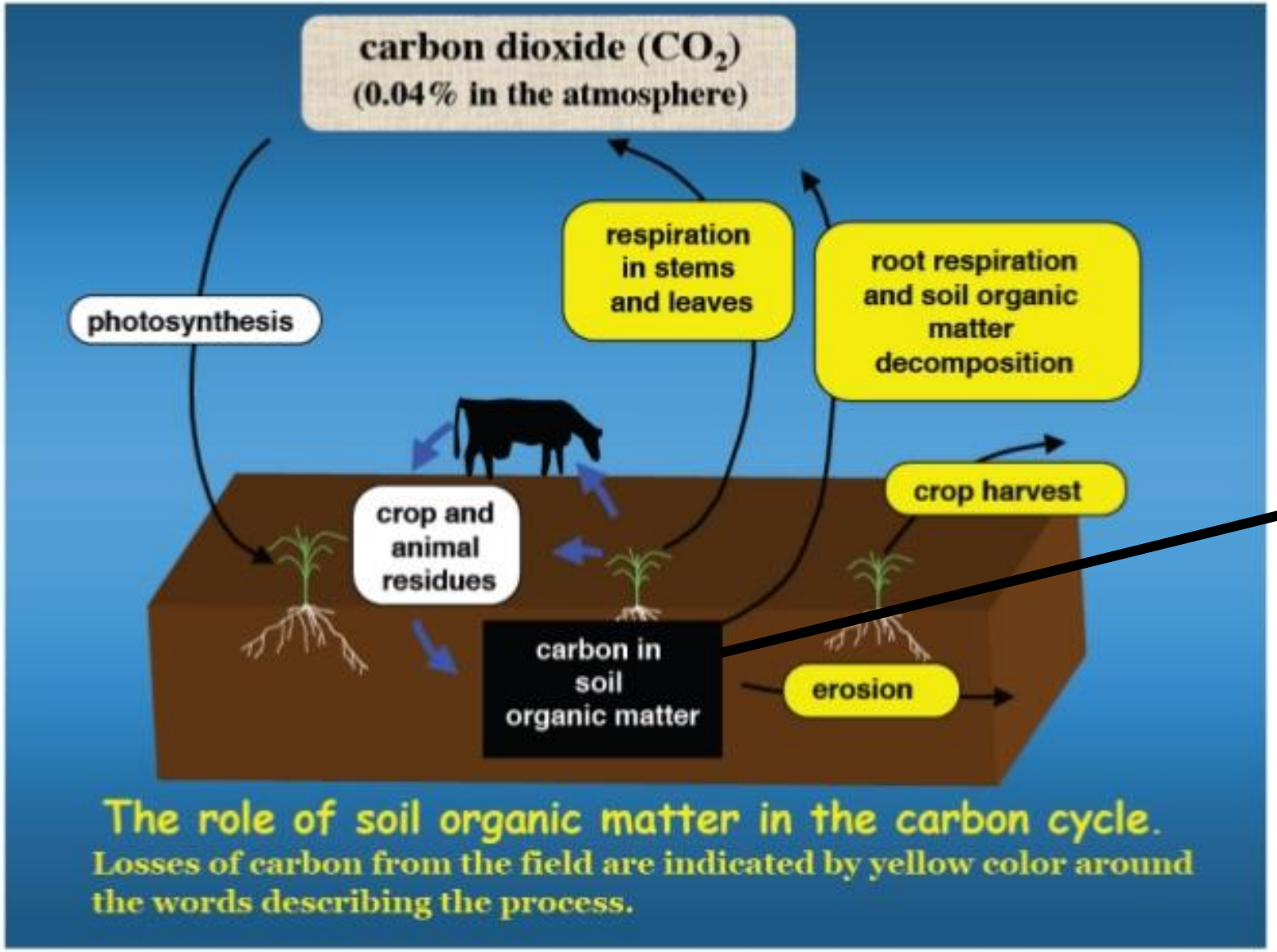
Lunch seminar 11 april 2019

Arranged by Chalmers Area of Advance Energy

AGROVÄST SKIVEKOMMUNE Hushållnings sällskapet SLU AARHUS UNIVERSITY CHALMERS VÄSTRA GÖTALANDSREGIONEN NATURBRUKSFÖRVALTNINGEN

Agenda

- Grasslands´ importance for soil carbon sequestration
- Environmental and health effects from pesticides
- Different foods – different ecotoxic effects
- Innovative solutions needed for our food systems!



Soil Carbon Sequstration, SCS – a Negative Emission Technology (NET)

SCS occurs when land management increases the soil organic content, resulting in a net removal of CO2 from the atmosphere

SCS - Global technical potential as NET
3.8 (2.3 – 5.8) Gt GO2/yr
Fuss et al 2018

SOM is crucial for soil functions

Biological

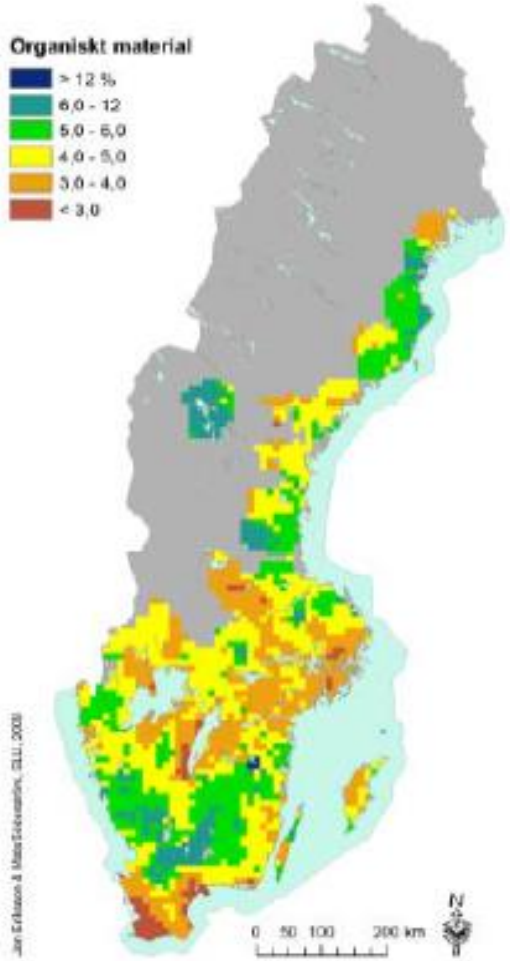
Sources of energy, Reservoir for nutrients, Resilience of plant/soil system

Physical

Structure stability, water holding capacity

Chemical

Contribute to cation exchange capacity, enhance soil pH buffering



Karta 4. Halt organiskt material i matjorden. Data från omdrev 1 och 2 sammanslagna. Antal värden 5 179.
Map 4. Organic matter content in the topsoil. *Data from sampling series 1 and 2 combined (n = 5 179).*

Swedish monitoring program on status for arable soils concerning content of organic matter, pH, nutrients and trace elements conditions (>2000 sampling points)

Soil Org Matter, %

6,0 - 12
5,0 - 5,99
4,0 - 4,99
3,0 - 3,99
<3

Soil sample data from the Swedish monitoring program of arable soil.
Naturvårdsverkets rapport no 6349

Effects of farm types on Soil Organic Matter and thus Soil Carbon

Arable soils in Västra Götaland

(NV monitoring program)

Farm type	n samples	% Organic Matter
Cattle farms	126	**4,3**
Arable farms	190	**3,8**
Pig farms	35	**3,5**

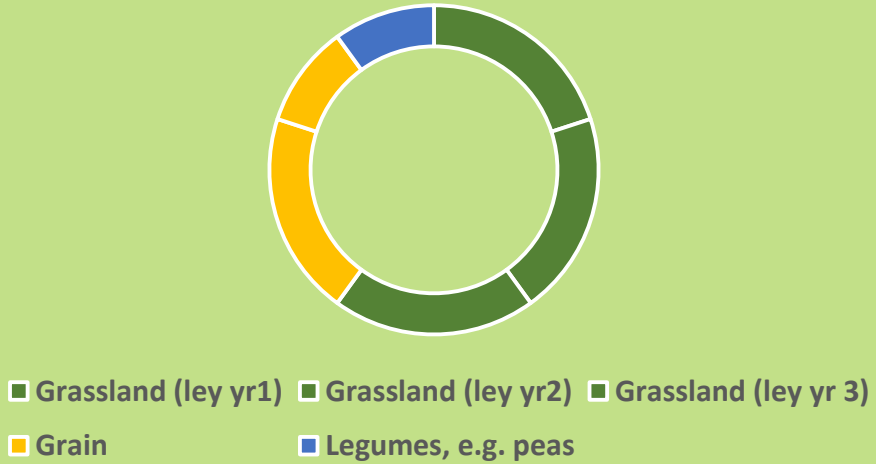
Approx 58% of SOM is C

Diff C stock in top soil (0-25cm)

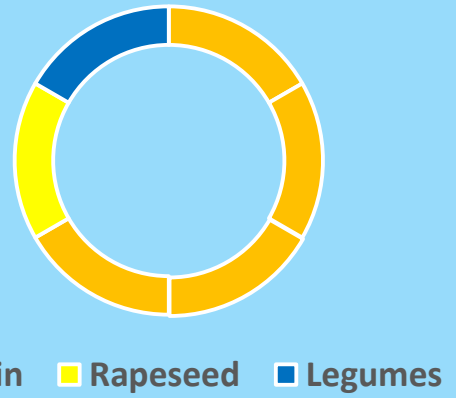
Cattle farms vs Arable/pig farms

Approx 12 ton C/ha

Typical crop distribution on cattle farms

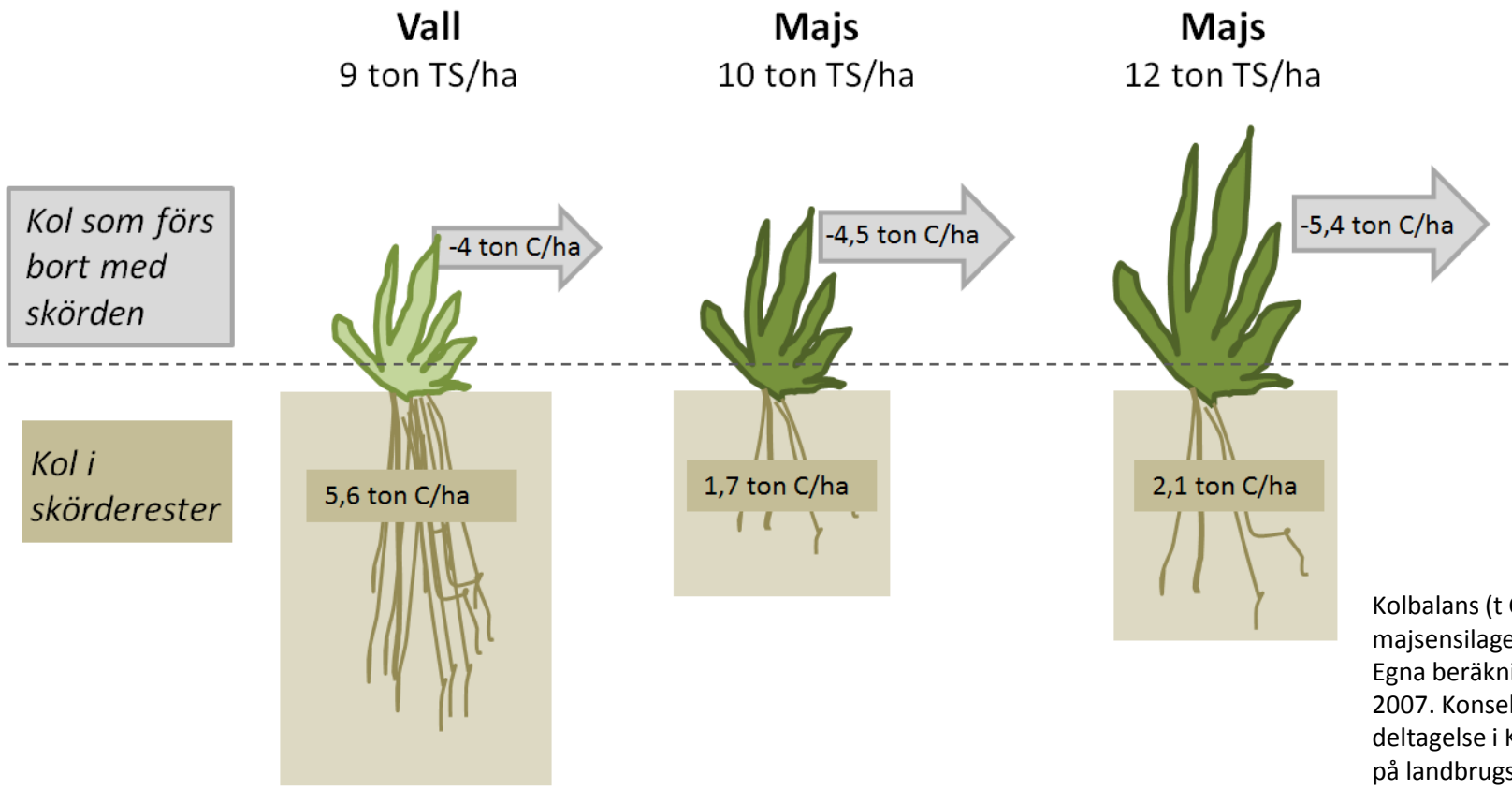


Typical crop distribution on arable farms or pig farms



Soil sample data from the Swedish monitoring program of arable soil. Naturvårdsverkets rapport no 6349

Grasslands (leys) leave more C in residues to build up SOM



Kolbalans (t C/ha) vid odling av gräsensilage och majsensilage.
Egna beräkningar baserat på Gyldenkærne S et al 2007. Konsekvenser og muligheder ved Danmarks deltagelse i Kyoto-protokollens artikel 3.4 på landbrugsområdet. Arbejdsrapport fra Miljøstyrelsen nr. 5, Copenhagen,

Possible measures to increase soil C in Swedish arable land

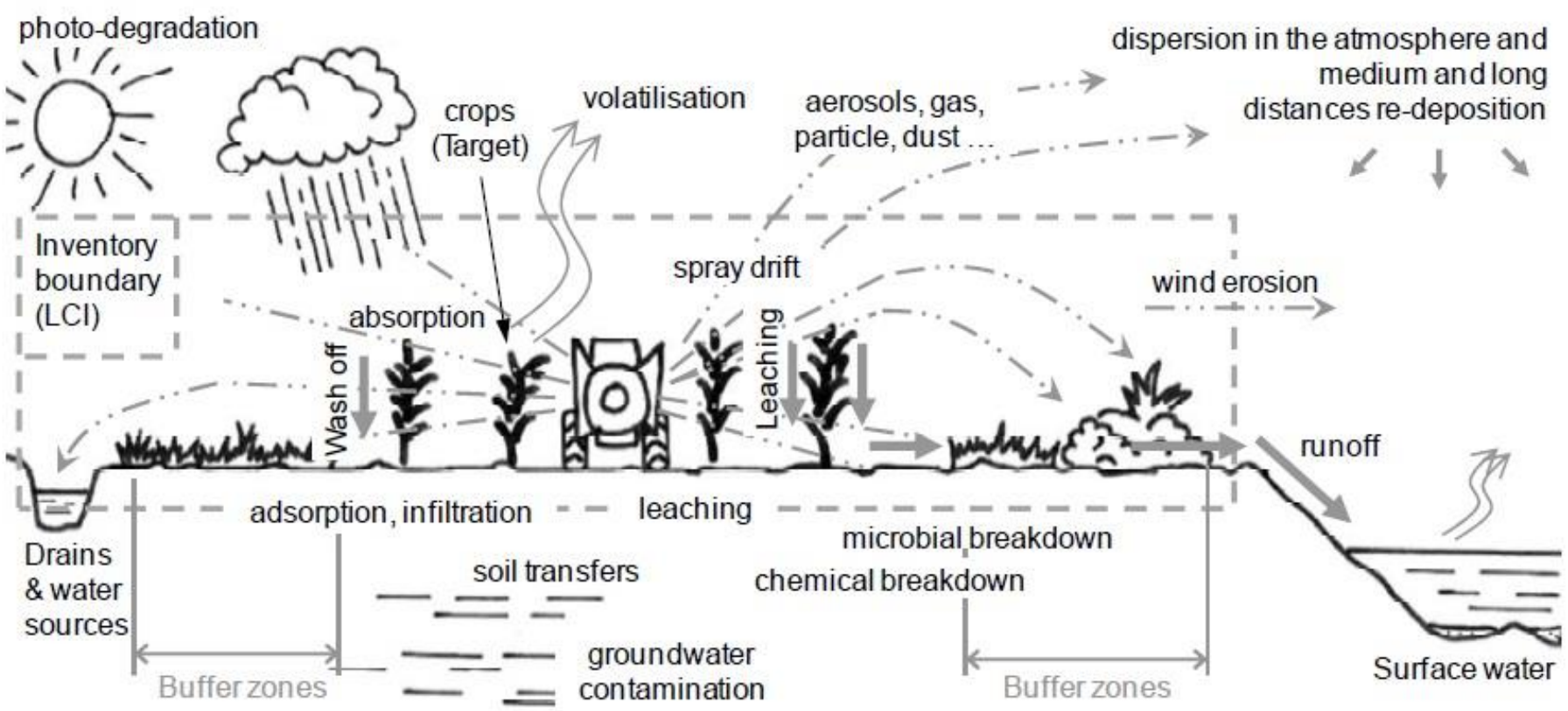
	Potential C sequestration, kg C/ha * yr
Grassland (leys, buffert zones with grass etc)	**645**
Salix	**450**
Catch crops	**330**
No tillage	**0**

Bolinder M, Freeman M, Kätterer T. 2017, Sammanställning av underlag för skattning av effekter på kolinlagring genom insatser i Landsbygdsprogrammet. SLU – uppdragsrapport till Jordbruksverket

Pesticides in agriculture and food production

Large gaps of knowledge in use, risks and effects – especially in developing countries

Pesticides – transports and breakdown



Bildkälla: Van Zelm et al. 2012

Impacts from pesticide use

Human toxicity

- Risks and effects from handling and use – especially in developing countries

Pesticide regulations, knowledge on safe handling – much neglected in developing countries

Goiás, Brasilien, 2011 (Photo C Cederberg)

Java, Indonesien 2009 (Photo C Azar)

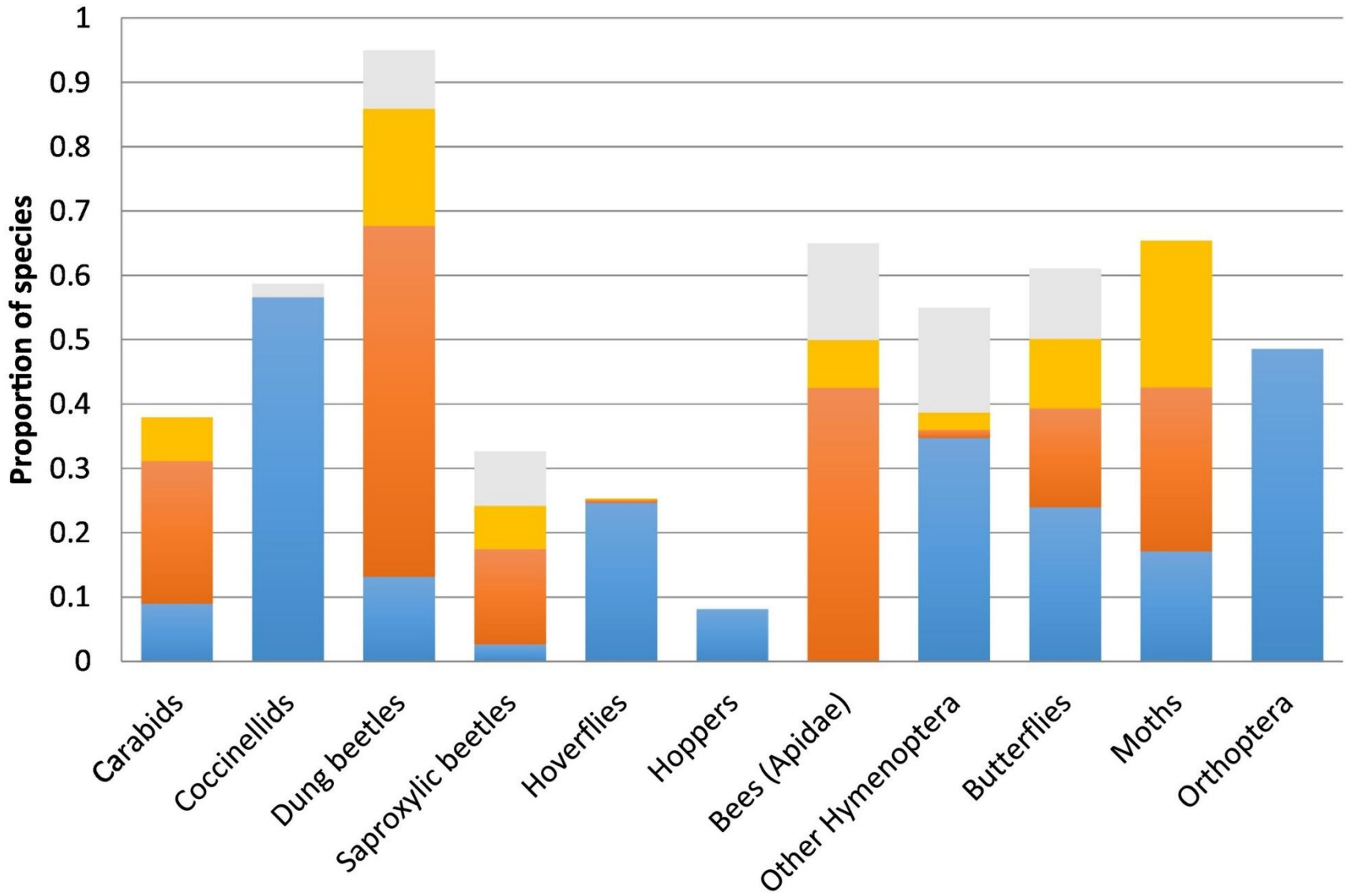
Impacts from pesticide use

Human toxicity

- Risks and effects from handling and use – especially in developing countries
- Pesticide residuals in food
- Pesticide contamination of groundwater and surface water - and potentially drinking water

Ecosystem toxicity

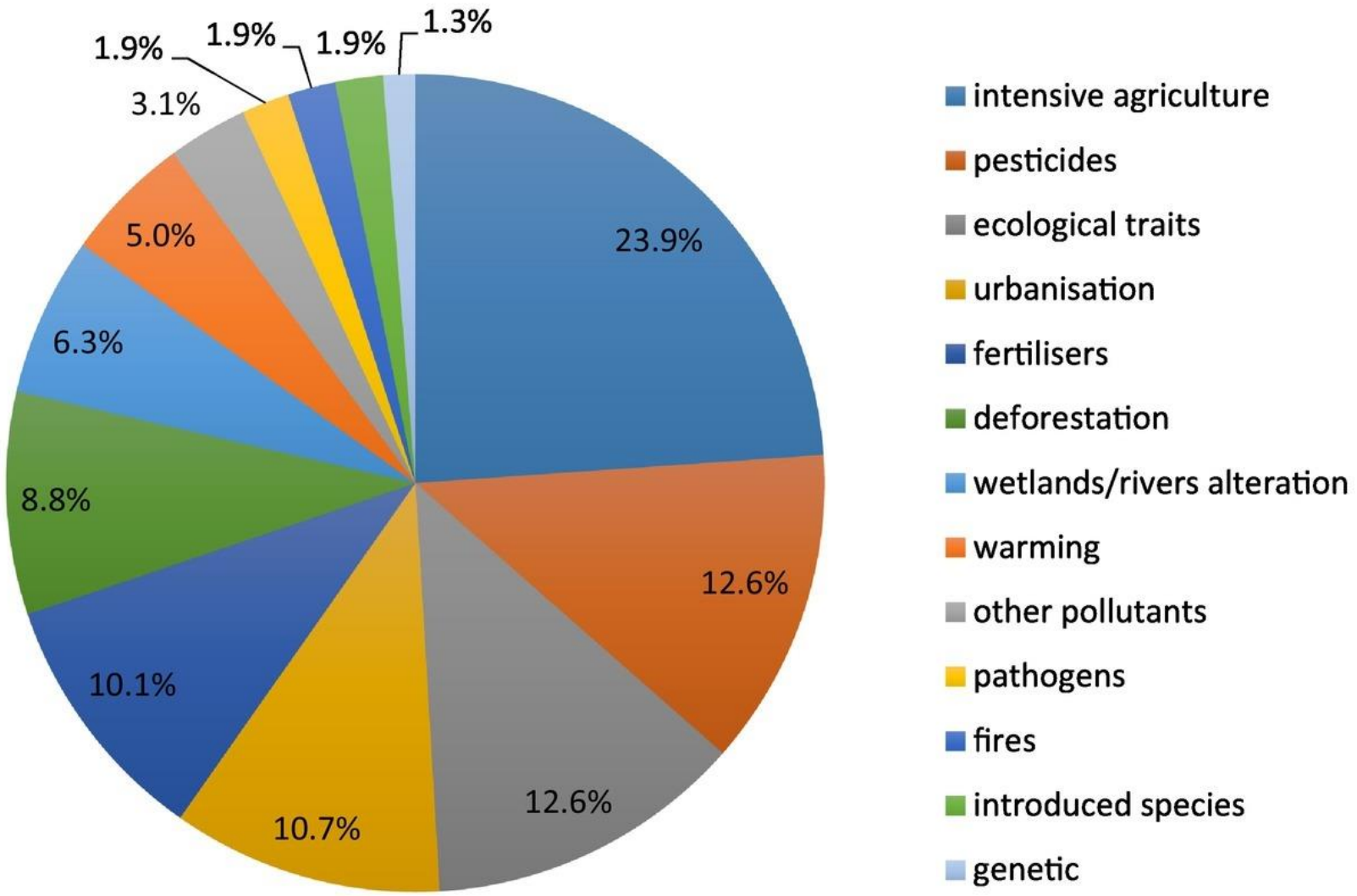
- Direct by killing non-targeted organisms e.g. insects
- Indirect by changing feed sources etc



Review of 73 historical reports of insects decline

- Almost half of insect species are rapidly declining
- A third is threatened by extinction

Sanchez-Bayo & Wyckhuys, 2019
World decline of the entomofauna: A review of its drivers
Biological Conservation 232, 8-27



Main factors associated with insect declines

Review of 73 historical reports of insects decline, main drivers of species decline

- Habitat losses and conversion to intensive agriculture and urbansation
- Pollution, mainly by pesticides and fertilisers

Sanchez-Bayo & Wyckhuys, 2019
World decline of the entomofauna: A review of its drivers
Biological Conservation 232, 8-27

Impacts from current pesticide use

Human toxicity

- Risks and effects from handling pesticides – especially in developing countries
- Pesticide residuals in food
- Pesticide contamination of groundwater and surface water - and potentially drinking water

Ecosystem toxicity

- Direct by killing non-targeted organisms e.g. insects
- Indirect by changing feed sources etc

Safe-guarding man-made resources

- Increasing resistance among weeds, fungis and insects and increasing difficulties to develop new pesticides

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Freshwater ecotoxicity impacts from pesticide use in animal and vegetable foods produced in Sweden

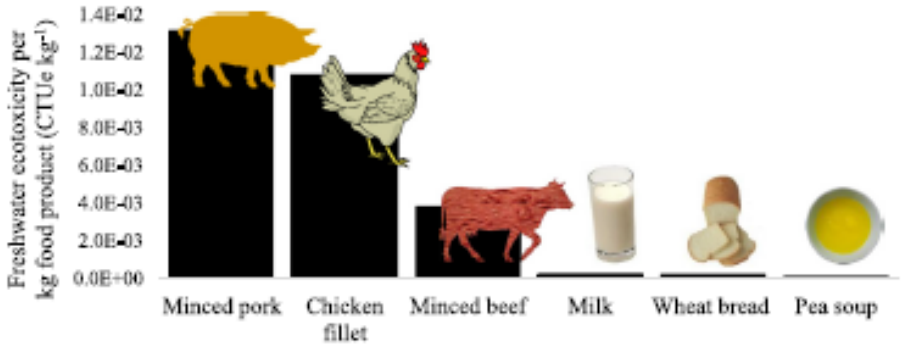
Maria Nordborg [a,*], Jennifer Davis [b], Christel Cederberg [a], Anna Woodhouse [b]

[a] Department of Energy and Environment, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden
[b] SP Technical Research Institute of Sweden, Food and Bioscience, SE-402 29 Gothenburg, Sweden

HIGHLIGHTS

- Animal-based food products have much larger impacts than plant-based food products.
- Impact potentials per kg pork > chicken > beef > milk > bread > pea soup.
- Chicken fillet and minced pork have larger impacts than minced beef and milk.
- Soybeans dominate the impact potentials of chicken fillet and minced pork.
- Replacing soybeans with local feed crops can reduce the impacts considerably.

GRAPHICAL ABSTRACT



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ABSTRACT

Chemical pesticides are widely used in modern agriculture but their potential negative impacts are seldom considered in environmental assessments of food products. This study aims to assess and compare the potential freshwater ecotoxicity impacts due to pesticide use in the primary production of six food products: chicken fillet,

Example of a study using new LCA-methods to include ecotoxicity impacts from pesticide use

To evaluate potential toxical effects due to pesticides – example of freshwater toxicity with USETOX model in LCA

Emissions of pesticides to air & water due to … type av substance, application method, soil, weather etc..

Many situations och scenarios

Impact indikator (characterisation factor, CF, i LCA) depends on substance – extremly many chemicals…. USETOX gives these CF:s

The metric CTUe (Comparative Toxic Units) is based on an estimate of ”Potentially Affected Fractions” (PAF) of species in (freshwater) space and time per unit emission.

Different food products requires different crops and thereby different pesticide use and impacts from pesticides

Food product	The crop(s) required to produce the food product
Bread	Wheat
Peas	Pea
Minced pork	Wheat, oats, barley, soybean, rapeseed
Milk	Grass-clover grassland, oat, barley, soybean
Minced beef	Grass-clover grassland, oat, barley, soybean
Chicken fillet	Wheat, soybeans, rapeseed

Crop	Production region
Rapeseed	Sweden
Wheat	Sweden
Barley	Sweden
Oats	Sweden
Grass/clover	Sweden
Peas	Sweden
Soybeans	Brazil

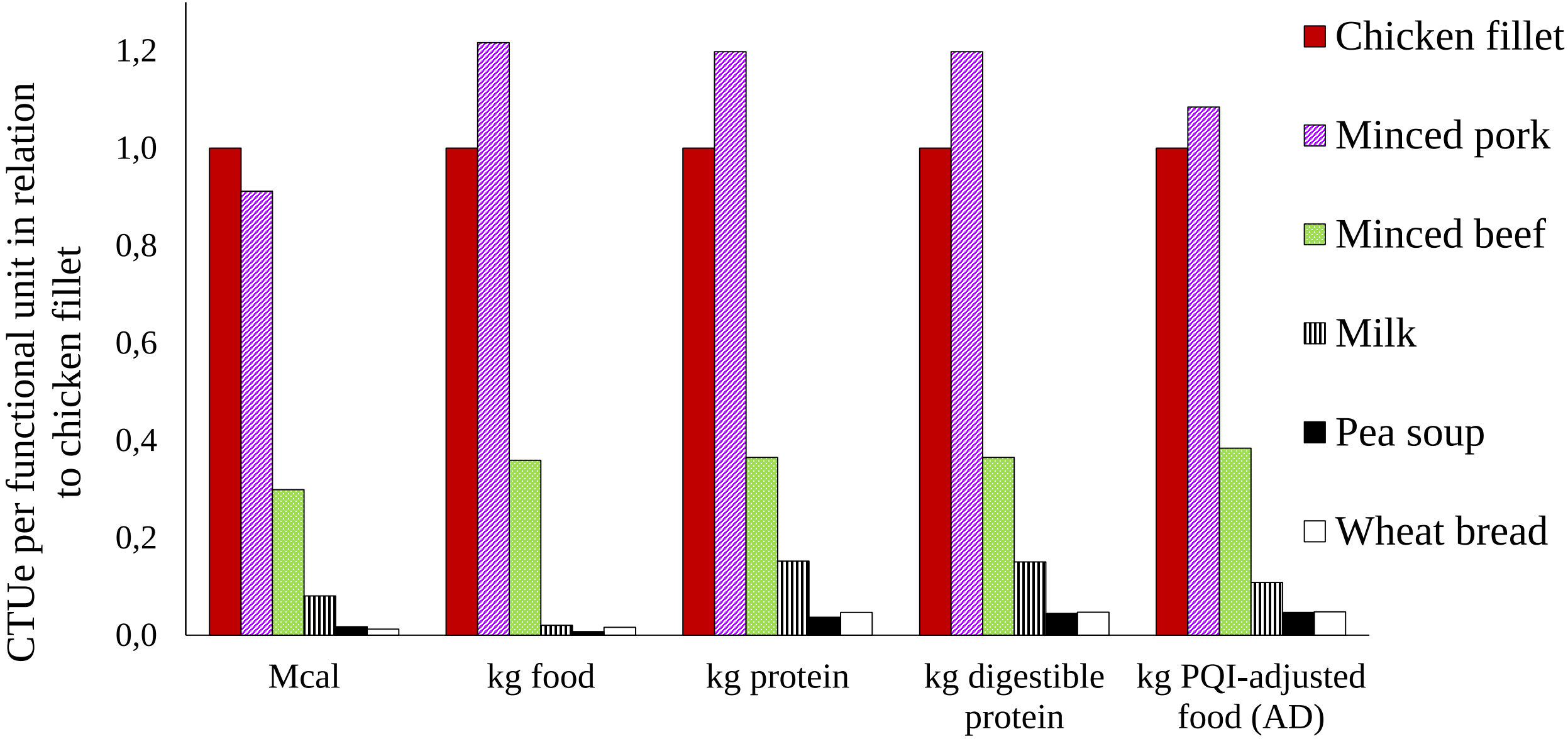
Nordborg, M, Davis J, Cederberg C, Woodhouse A. 2017. Freshwater ecotoxicity impacts from pesticide use in animal and vegetable foods produced in Sweden. *Science of Total Environment (581-582), pp 448-459*

Pesticide use in peas, Sweden (Västra Götaland)

Type	Product	Active substance	Dose of product (l ha^{-1} or kg ha^{-1})	AS content (g AS l^{-1} or g AS kg^{-1})	Application frequency (yr^{-1})	Calculated dose per application (kg AS ha^{-1})	Calculated yearly average (g AS ha^{-1} yr^{-1})	Crop type and development stage	Application method [a]	Tillage type	Application month
H	Basagran SG	Bentazone	0.60	870	1.0	0.522	522.0	Peas I	Conv. boom cereals	Conv.	April
I	Fastac 50	Alpha cypermethrin	0.30	50	0.3	0.015	7.5	Peas III	Conv. boom cereals	Conv.	Aug.
H	Roundup Bio	Glyphosate	3.00	360	0.25	1.080	270.0	Bare soil [b]	Conv. boom bare soil	Conv.	Sept.

Pesticid use in soybeans, Brazil

Type	Product	Active substance	Dose of product (l ha^{-1} or kg ha^{-1})	AS content (g AS l^{-1} or g AS kg^{-1})	Application frequency (yr^{-1})	Calculated dose per application (kg AS ha^{-1})	Calculated yearly average (g AS ha^{-1} yr^{-1})	Crop type and development stage	Application method [a]	Tillage type	Application month
H	Gromoxone	Paraquat	1.50	200	1.0	0.300	300.0	Bare soil	Conv. boom bare soil	No till	Sept.
H	Drible	Lactofen	0.30	240	1.0	0.072	72.0	Soybean I	Conv. boom potato	No till	Oct.
I	Fastac	Alpha cypermethrin	0.30	100	1.0	0.030	30.0	Soybean I	Conv. boom potato	No till	Oct.
I	Lannate	Methomyl	0.70	215	1.0	0.151	150.5	Soybean I	Conv. boom potato	No till	Oct.
H	Basagran	Bentazone	0.90	600	1.0	0.540	540.0	Soybean I	Conv. boom potato	No till	Oct.
H	Naja	Lactofen	0.25	240	1.0	0.060	60.0	Soybean I	Conv. boom potato	No till	Oct.
H	Classic	Chlorimuron ethyl	0.04	250	1.0	0.010	10.0	Soybean I	Conv. boom potato	No till	Oct.
I	Premio	Chlorantraniliprole	0.025	200	1.0	0.005	5.0	Soybean I	Conv. boom potato	No till	Oct.
H	Select	Clethodim	0.35	240	1.0	0.084	84.0	Soybean I	Conv. boom potato	No till	Nov.
F	Comet	Pyraclostrobin	0.30	250	1.0	0.075	75.0	Soybean I	Conv. boom potato	No till	Nov.
I	Premio	Chlorantraniliprole	0.025	200	1.0	0.005	5.0	Soybean I	Conv. boom potato	No till	Nov.
F	Opera	Pyraclostrobin	0.50	133	1.0	0.067	66.5	Soybean II	Conv. boom potato	No till	Nov.
		Epoxiconazole	0.50	50	1.0	0.025	25.0	Soybean II	Conv. boom potato	No till	Nov.
I	Premio	Chlorantraniliprole	0.05	200	1.0	0.010	10.0	Soybean II	Conv. boom potato	No till	Nov.
F	Opera	Pyraclostrobin	0.50	133	1.0	0.067	66.5	Soybean II	Conv. boom potato	No till	Dec.
		Epoxiconazole	0.50	50	1.0	0.025	25.0	Soybean II	Conv. boom potato	No till	Dec.
I	Nomolt	Teflubenzuron	0.15	150	1.0	0.023	22.5	Soybean II	Conv. boom potato	No till	Dec.
I	Platinum Neo	Thiamethoxam	0.30	141	1.0	0.042	42.3	Soybean III	Conv. boom potato	No till	Jan.
		Lambda cyhalothrin	0.30	106	1.0	0.032	31.8	Soybean III	Conv. boom potato	No till	Jan.
H	Gromoxone	Paraquat	1.50	200	1.0	0.300	300.0	Soybean III	Conv. boom potato	No till	Feb.

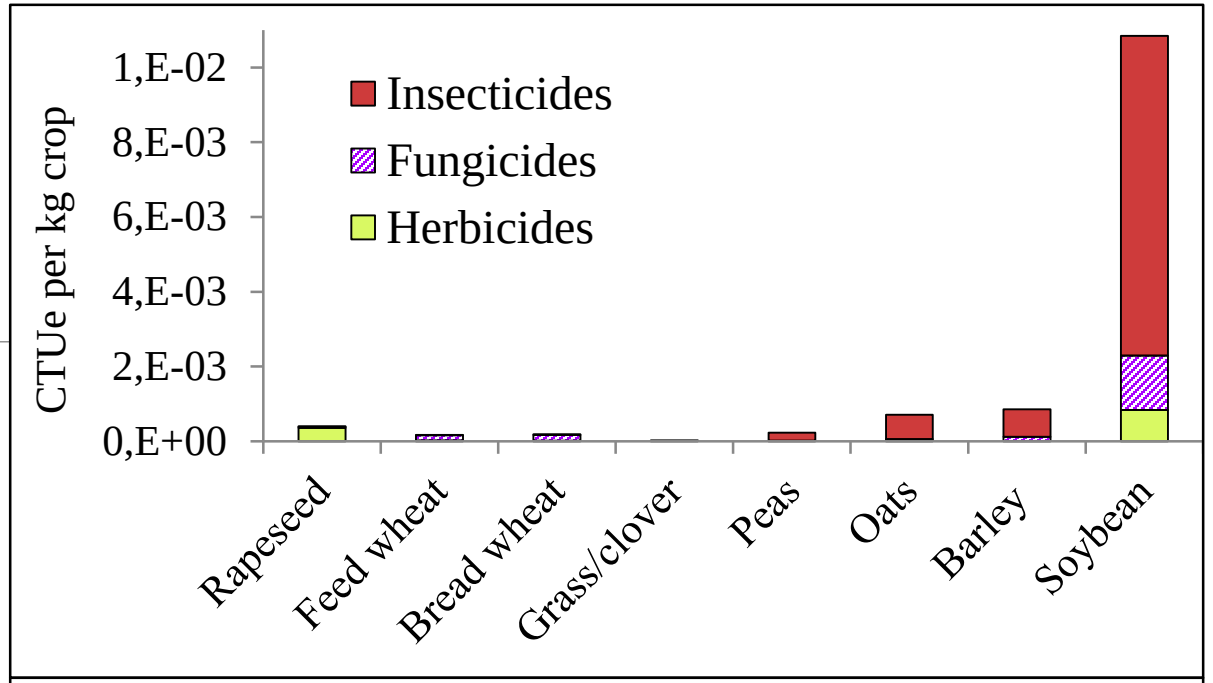


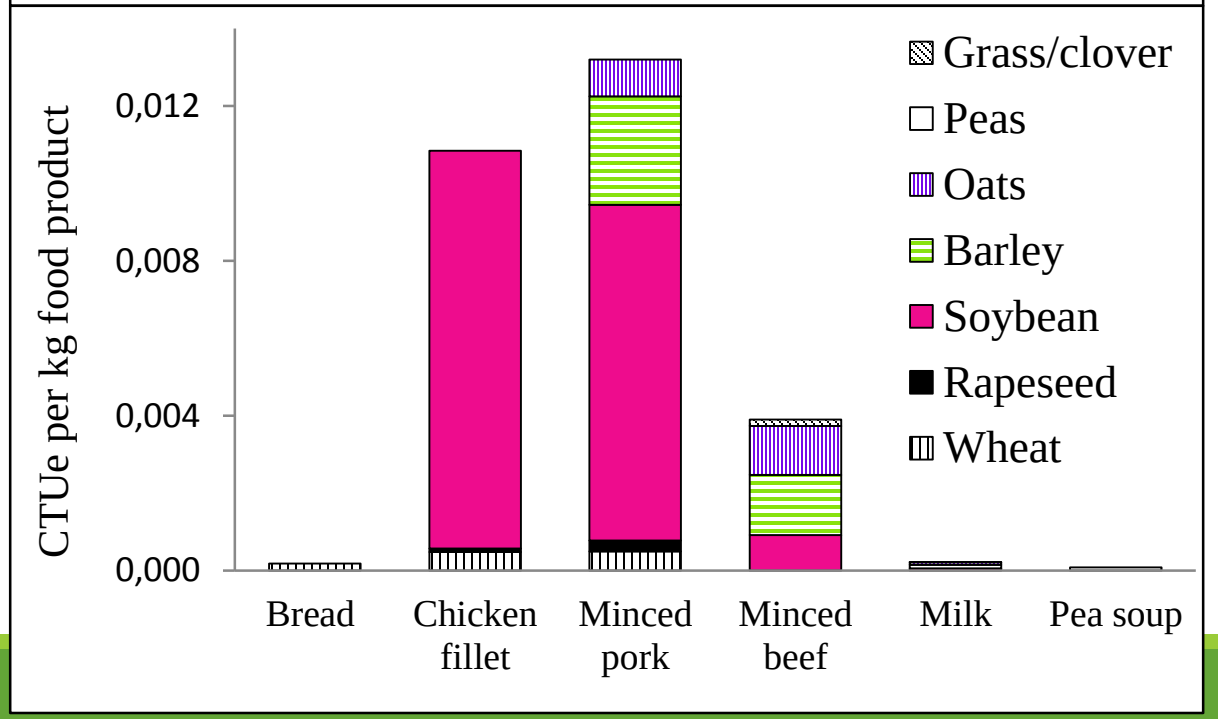
Potential freshwater ecotoxicity for 6 food products as CTUe (Comparative Toxic Units ecotoxicity) per functional unit, in relation to chicken fillet. PQI = protein quality index, AD = average Swedish diet.

Why is pork and chicken worse than beef and milk?

- This result is explained by the feed rations of pigs, cattle and chickens and the associated use of pesticides in the feed crops.

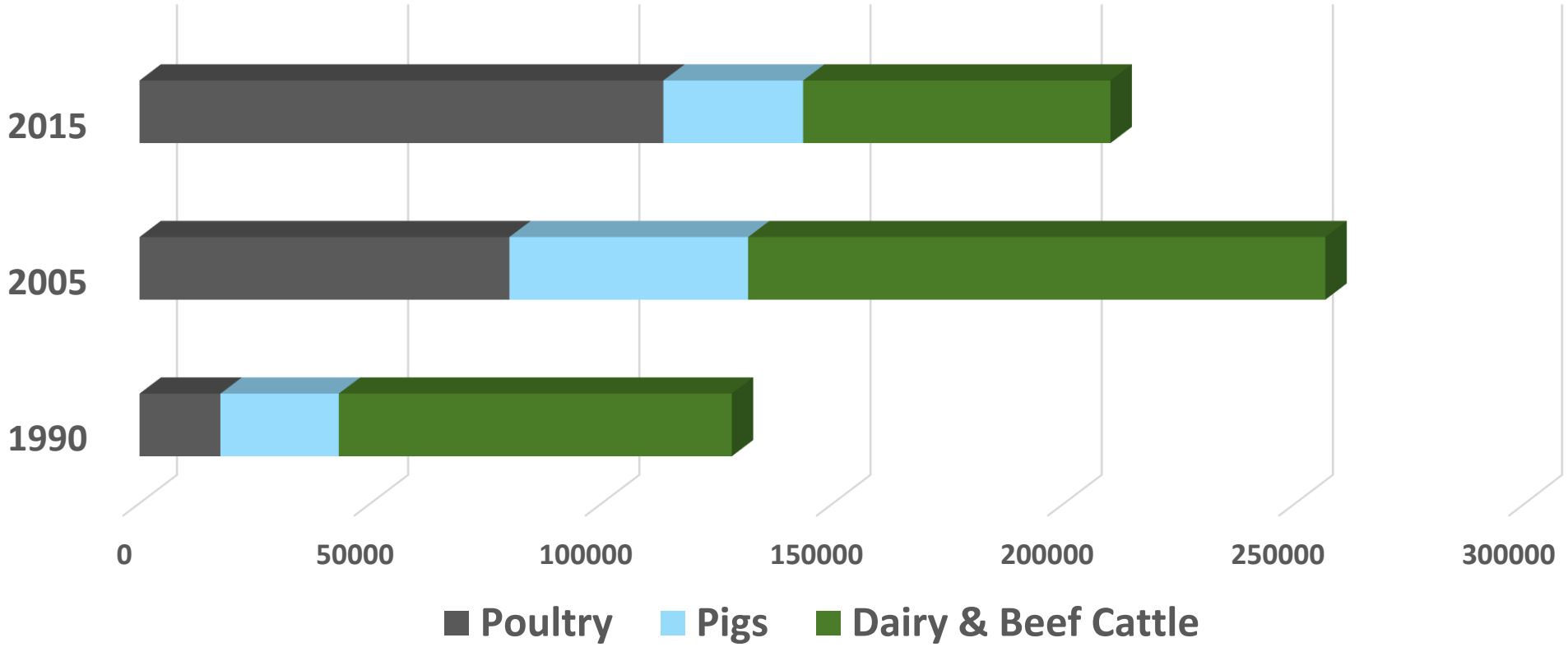
- Beef cattle feed on large amounts of grass/clover, with low impact potentials per kg harvested crop, while **chickens and pigs feed on large amounts of soybeans, with high impact potentials per kg harvested crop**.





Nordborg, M et al. 2017. *Science of Total Environment (581-582), pp 448-459*

Use of soybean products in Swedish animal production - trends



Egen bearbetning av statistik från Jordbruksverkets Foderkontroll

We need innovative solutions to change our food systems for the future!

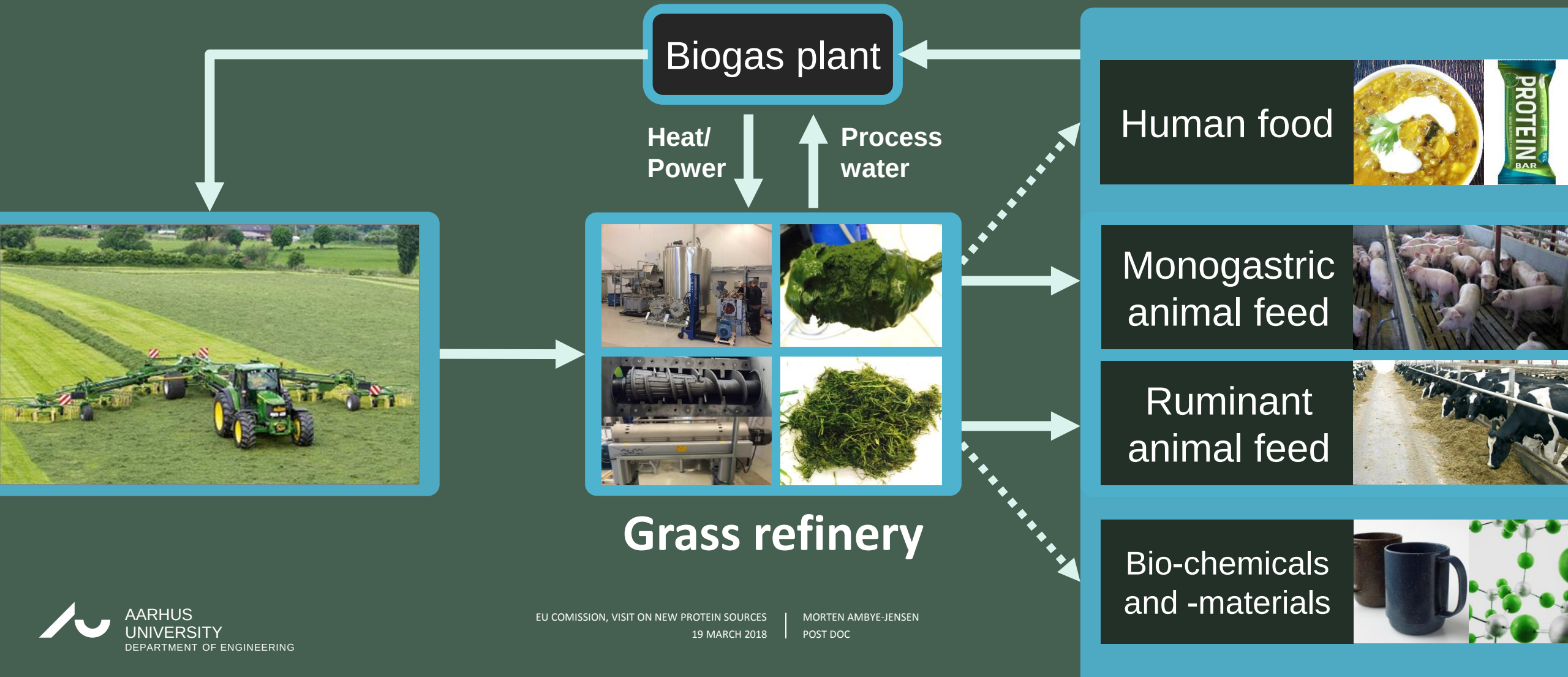
Weed control in conventional cereals

Advanced weed control in organic cereals
Development of new technology

En åtta meter bred Cameleon kombinationsmaskin med kamerastyrda billar användes för sådd och hackning

http://www.lantbruksforskning.se/aktuellt/nyheter/brett-band-med-utsade-bast-nar-radavstandet-ar-sto/

Grassbased biorefinery – test pilots in Denmark to Sweden, platforms for development



Whole system thinking – sustainable biomass production + biorefinery processing for renewable energy and to substitute harmful products

Local conditions important!

Bio-refinery

Oil

C_6

C_5

Syngas

Fibres

Lignin

Fuels

Chemicals Materials

Residual

Food

Feed

Soil conditioner

Fertiliser

Rest

Org. waste

Reactor

Biogas

Syngas

Substituting soy import

Thank you for your attention!