Including emissions from land use change and soil carbon in greenhouse gas balances for animal food products

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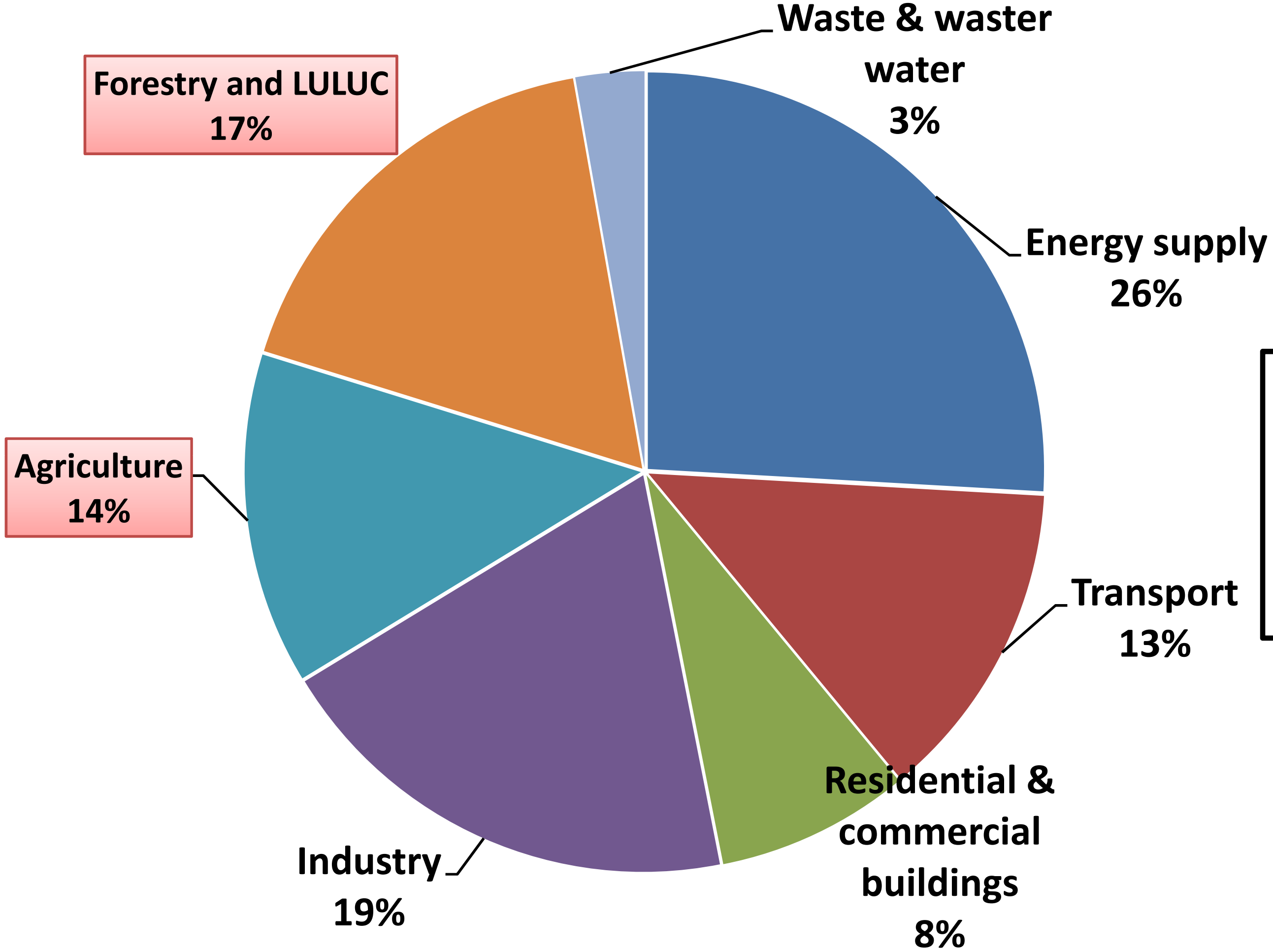
Outline

- Background: emissions and soil carbon sequestration
- How have emissions from land use change and soil carbon so far been included in GHG balances? Some examples
- Modelling soil carbon changes
- Ongoing study: Including soil carbon changes in GHG balances for dairy products
- Conclusions

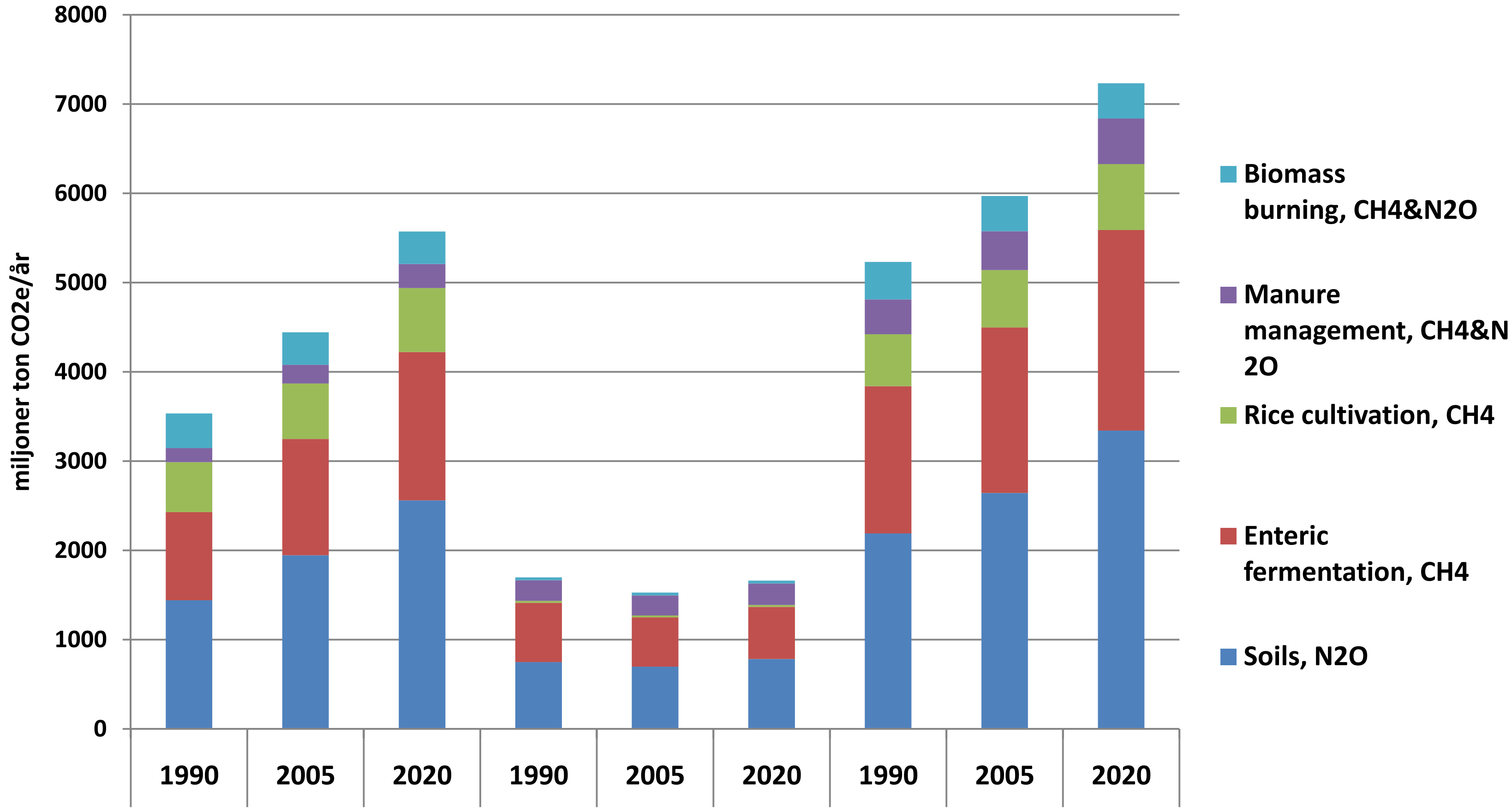
Global greenhouse gas (GHG) emissions in 2004



Total 49 Gton CO2e

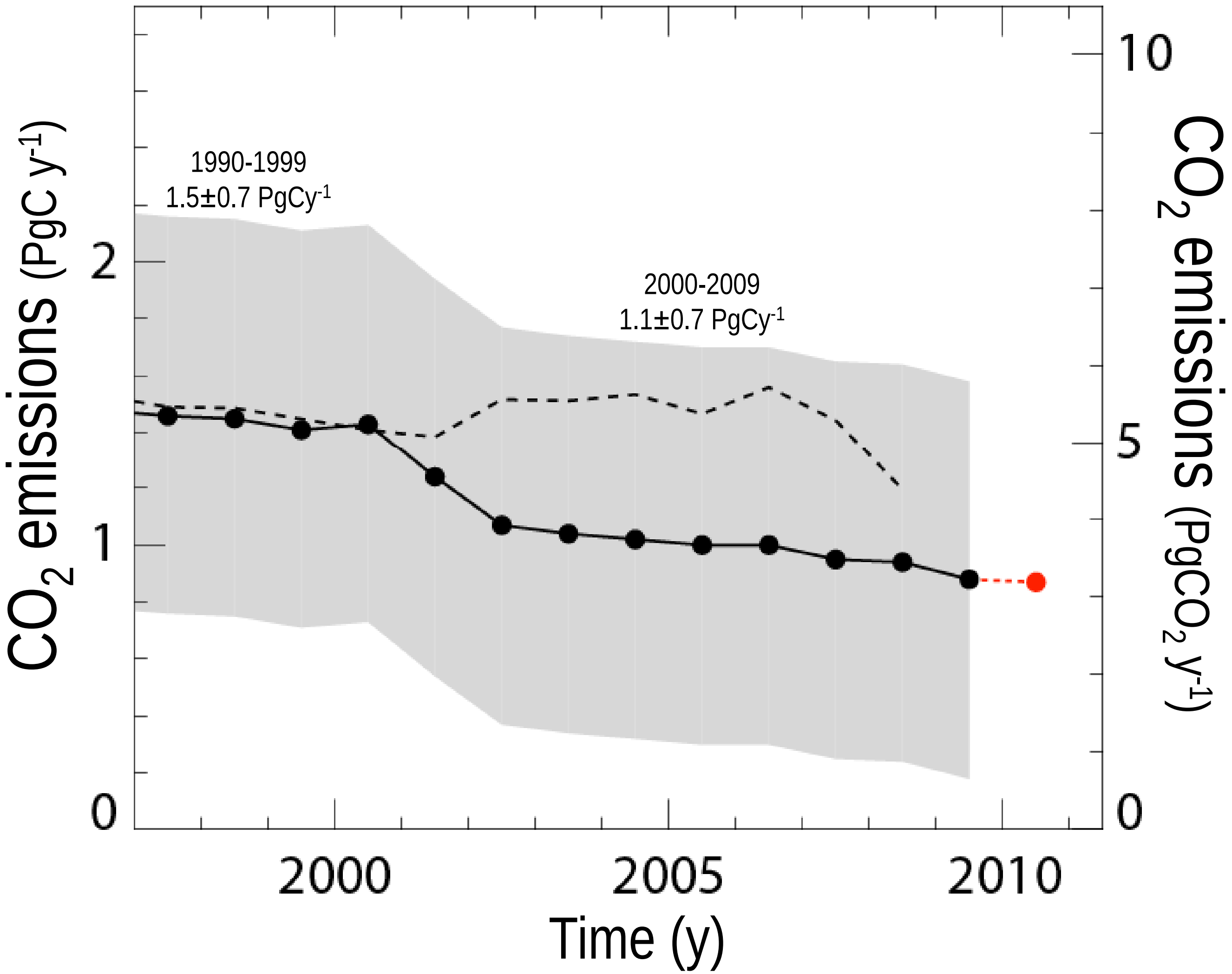
Barker et al, 2007 .,Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

Agricultural GHG emissions 1990-2020
(no LULUC)



Källa: Smith et al 2007. *Agriculture, Ecosystems and Environment* 118: 6-28.

CO_2 emissions from deforestation are decreasing



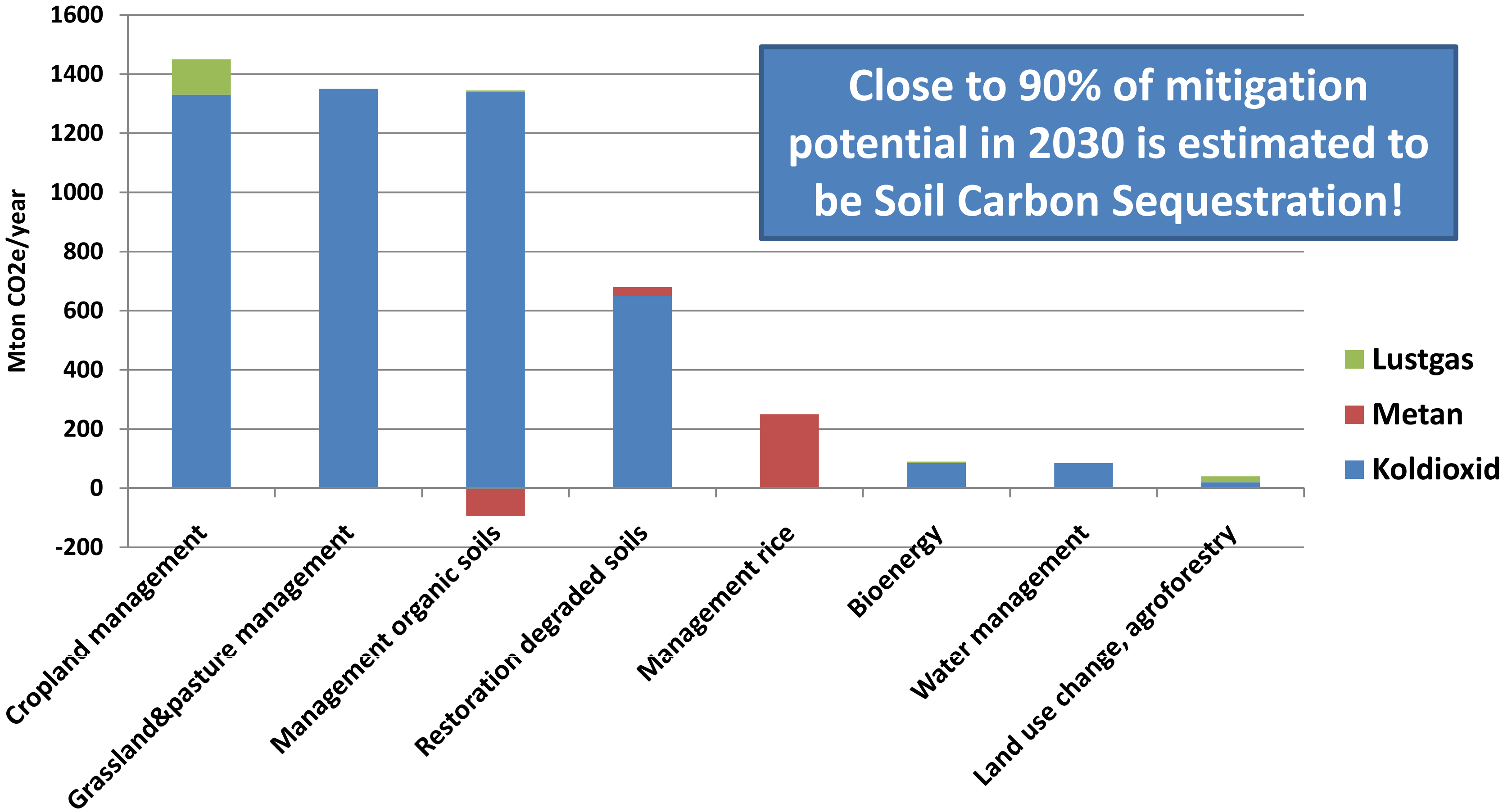
1990s
Emissions: 1.5±0.7 PgC

2000-2005
Emissions: 1.3±0.7 PgC

2006-2010:
Emissions: 0.9±0.7 PgC

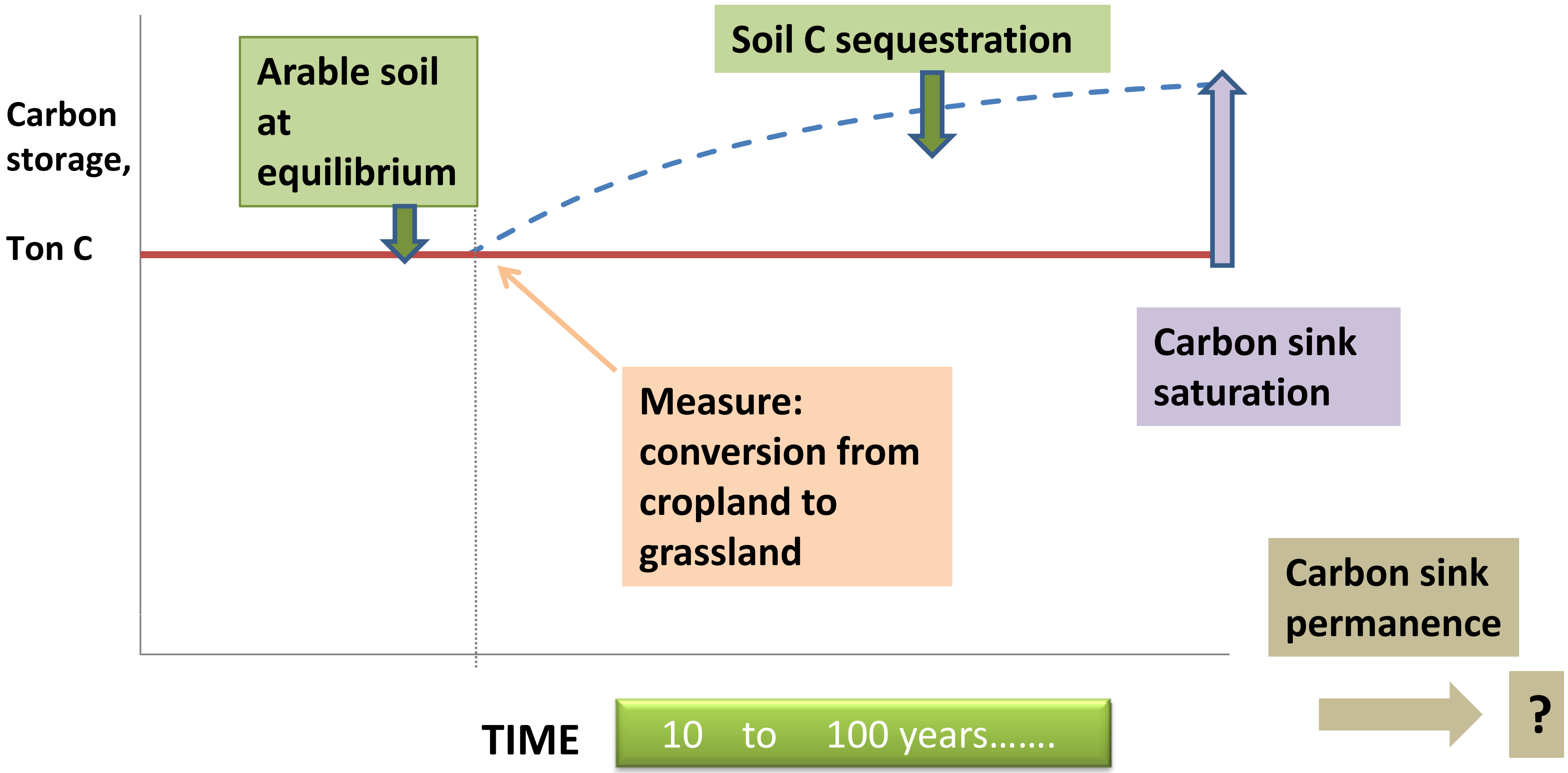
Friedlingstein et al. 2010, Nature Geoscience; Data: RA Houghton, GFRA 2010

Global technical mitigation potential by 2030 in global agriculture



Smith et al, 2007 Phil Trans R Soc 363:789-813; IPCC 2007

Soil carbon sequestration: Some basics



Important limitations for soil carbon sequestration as a GHG mitigation option

- Carbon sink saturation – soils reaches C saturation after 20-50(100) yrs
- Achieved C sequestration is reversible – the same land use must go on ”forever” to avoid C loss
- Displacement effects – e.g. if peatlands are taken out of production to reduce GHG emissions, foregone food production must take place elsewhere, maybe by ploughing grasslands (releasing carbon) or on deforested land
- Monitoring – verification that a particular measure has increased soil carbon stock is costly

- How have emissions from land use change and soil carbon so far been included in GHG balances? Some examples

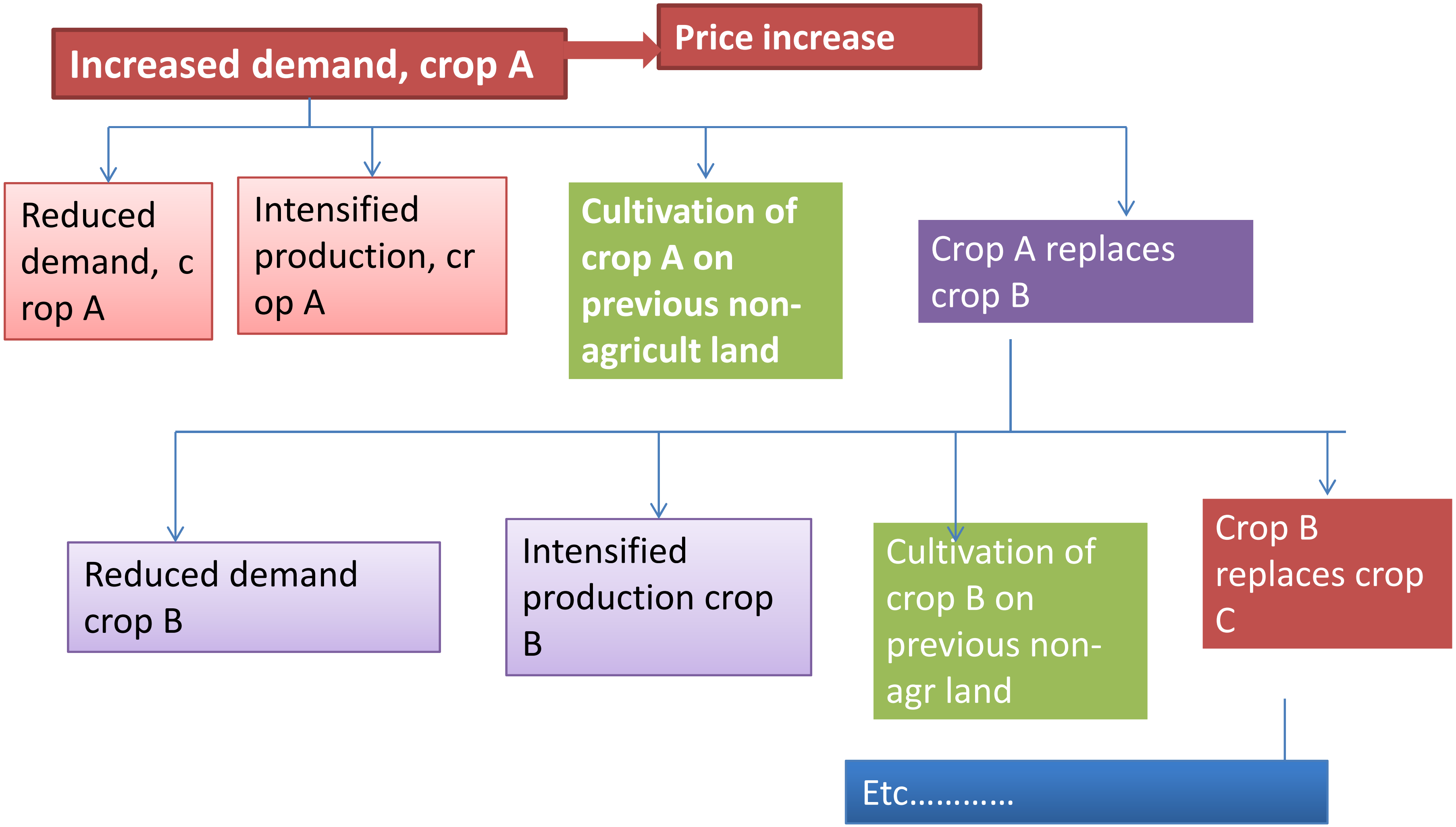
Carbon credit for biofuels versus carbon emissions from land use change

Growing feedstock for biofuels remove CO2 from atmosphere

Growing feedstock for biofuels means a direct and/or indirect carbon cost

By excluding LUC-emissions, analyses of biofuels are one-sided because they used only the carbon benefits of using land but not the carbon costs by diverting land from its existing use (Searchinger et al 2008)

Economic equilibrium modelling to estimate indirect land use change from biofuels



Estimates of indirect land use emissions from biofuels vary wildly

Reference	Year	LUC impact, gram CO2e/MJ fuel	Net impact of biofuel consumption when incl LUC, g CO2e/MJ
Searchinger et al	2008	156-270	127 to 232
EPA (US Renew Fuel Standard	2009	106-130	41 to 52
CARB (California Low Carb Fuel Standard	2009	44-68	15 to -13
Tyner	2009	36	8
EPA final	2010	8-54	-4 to -69
Hertel et al	2010	40	10
Tyner et al	2010	21-32	1 to -9
IFPRI (EU comm)	2010	17	-43

European Commission 2010. The impact of land use change on greenhouse gas emissions from biofuels and bioliquids. Literature review

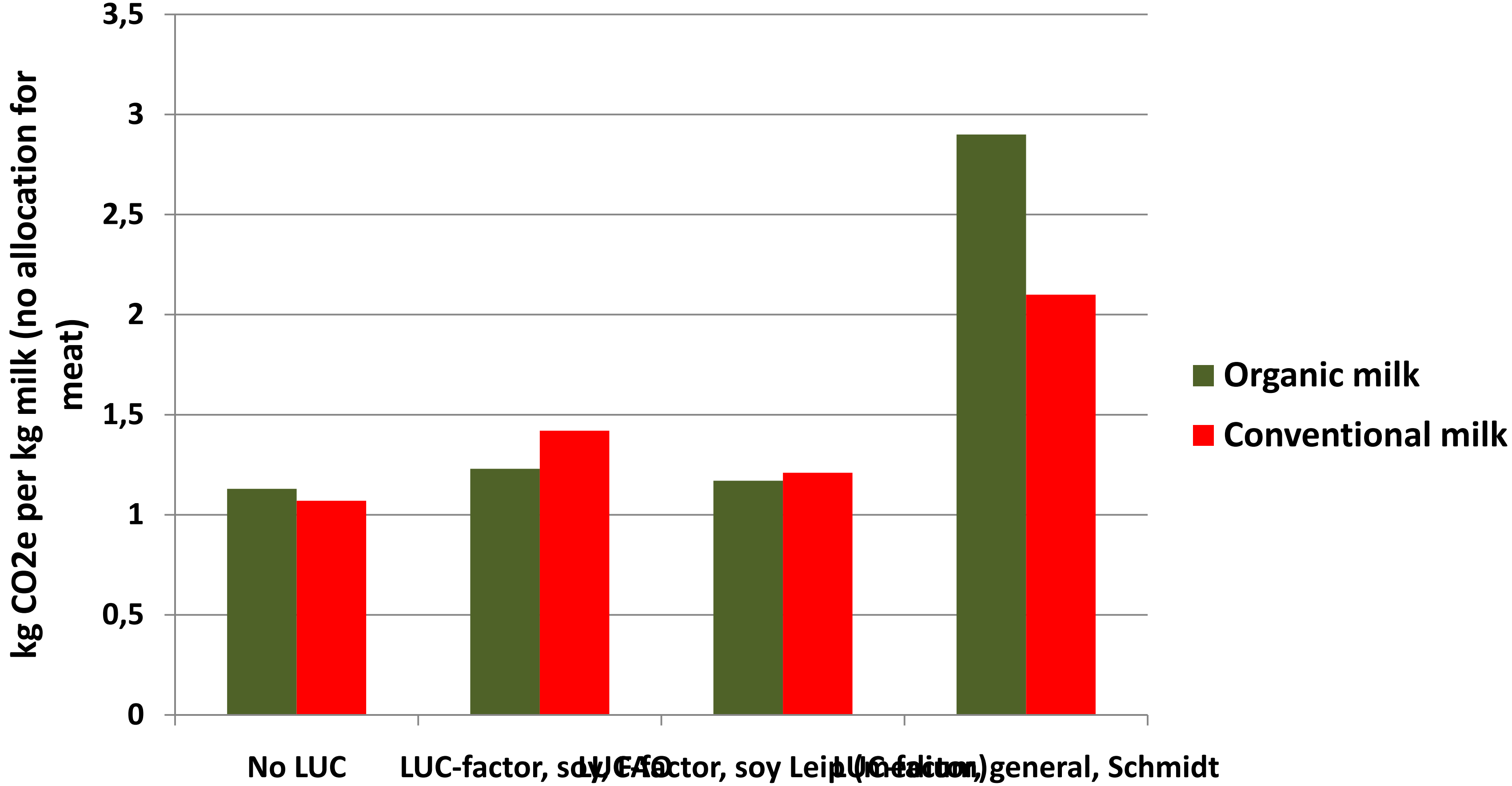
Methods for including land use change in greenhouse gas balances of animal food

- LUC-factor for expanding soybean (FAO 2010)

  (historic values 1987-2007)

- LUC-factors for expanding cropland (Leip et al 2010 (historic values 1998-2008, soybean most important)
- LUC-factor for general land use (Schmidt et al 2011) (distributing all yearly GHG emissions due to LUC on all activities occupying land since any occupation of land results in some LUC)
- LU-factor for occupation of EU cropland (Leip et al, 2010) (carbon sink in natural vegetation foregone due to agriculture)

Impact on milk´s GHG balance when including land use change using different methods



Flysjö et al., 2012. J of Cleaner Prod 28, 132-142.

- Modelling soil carbon changes

Important parameters for estimating soil carbon changes

- Carbon input
  - crop residues
  - Organic material (e.g. manure)
- Initial carbon stock in soil
- Temperature
- Clay content
- Water content
- Carbon/Nitrogen ratio
- Tillage(?)

C-TOOL –
3-pooled dynamic soil carbon model

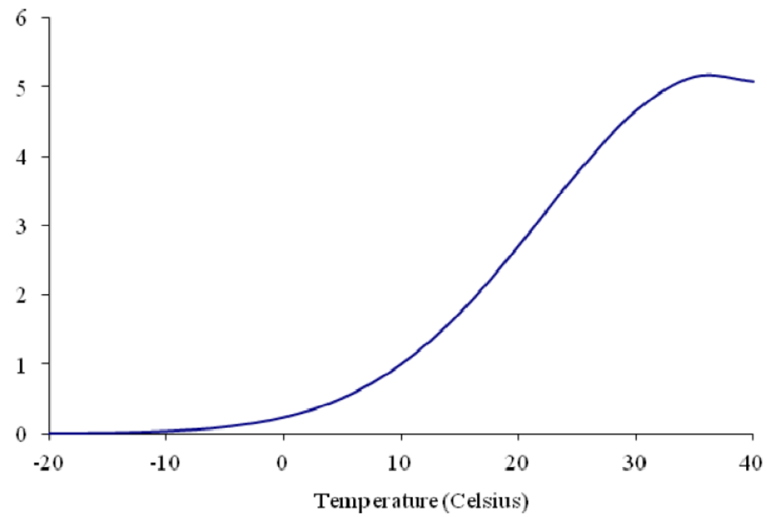
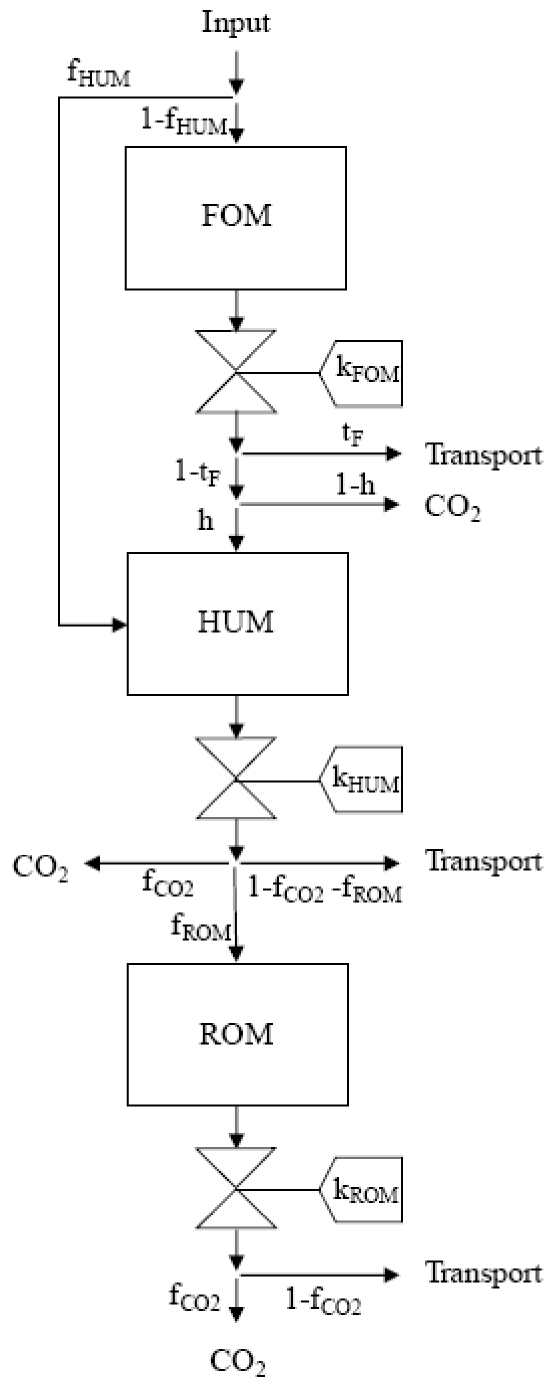
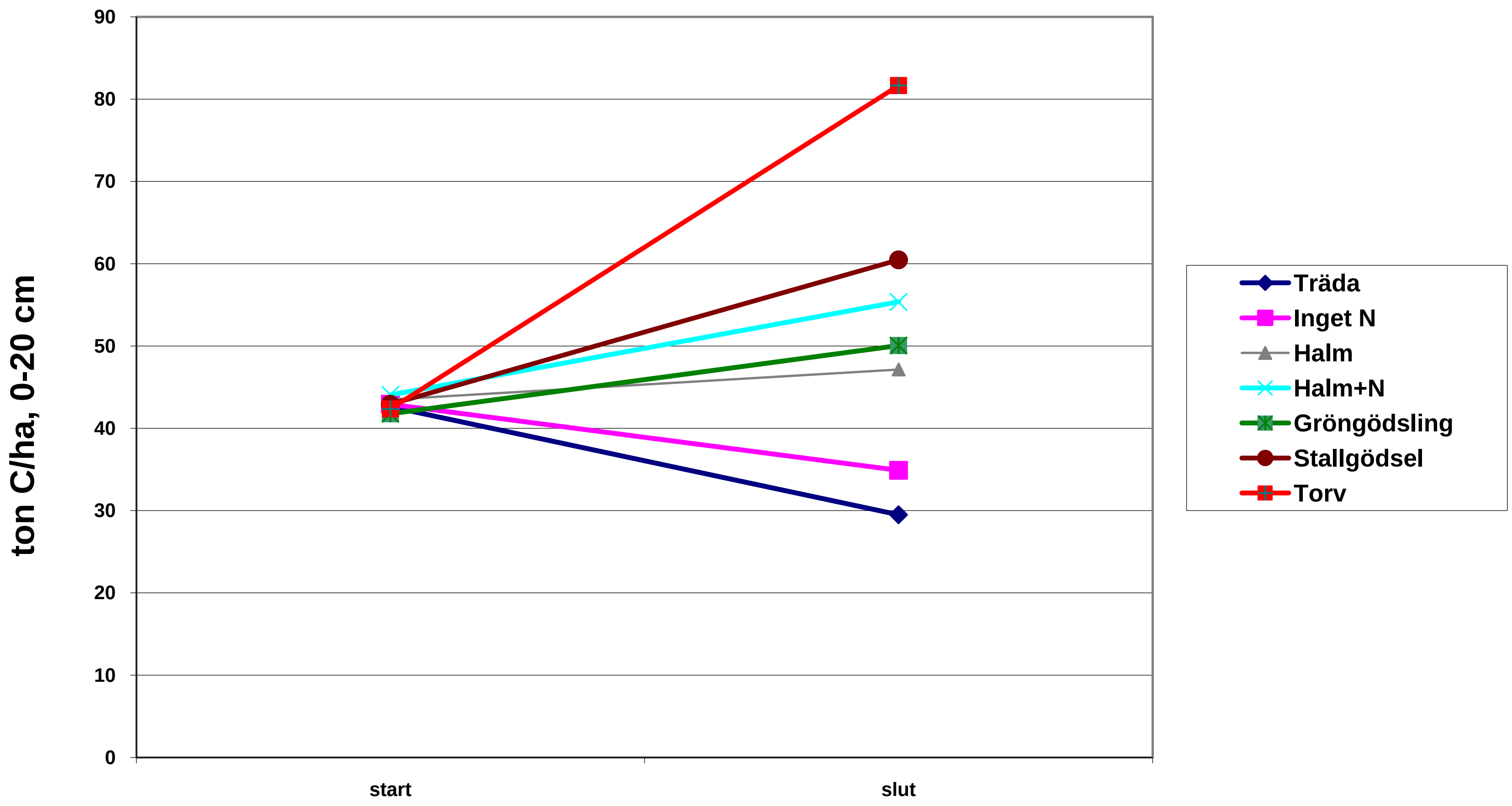


Figure 2. Temperature effect on turnover rates based on Eq. (3)

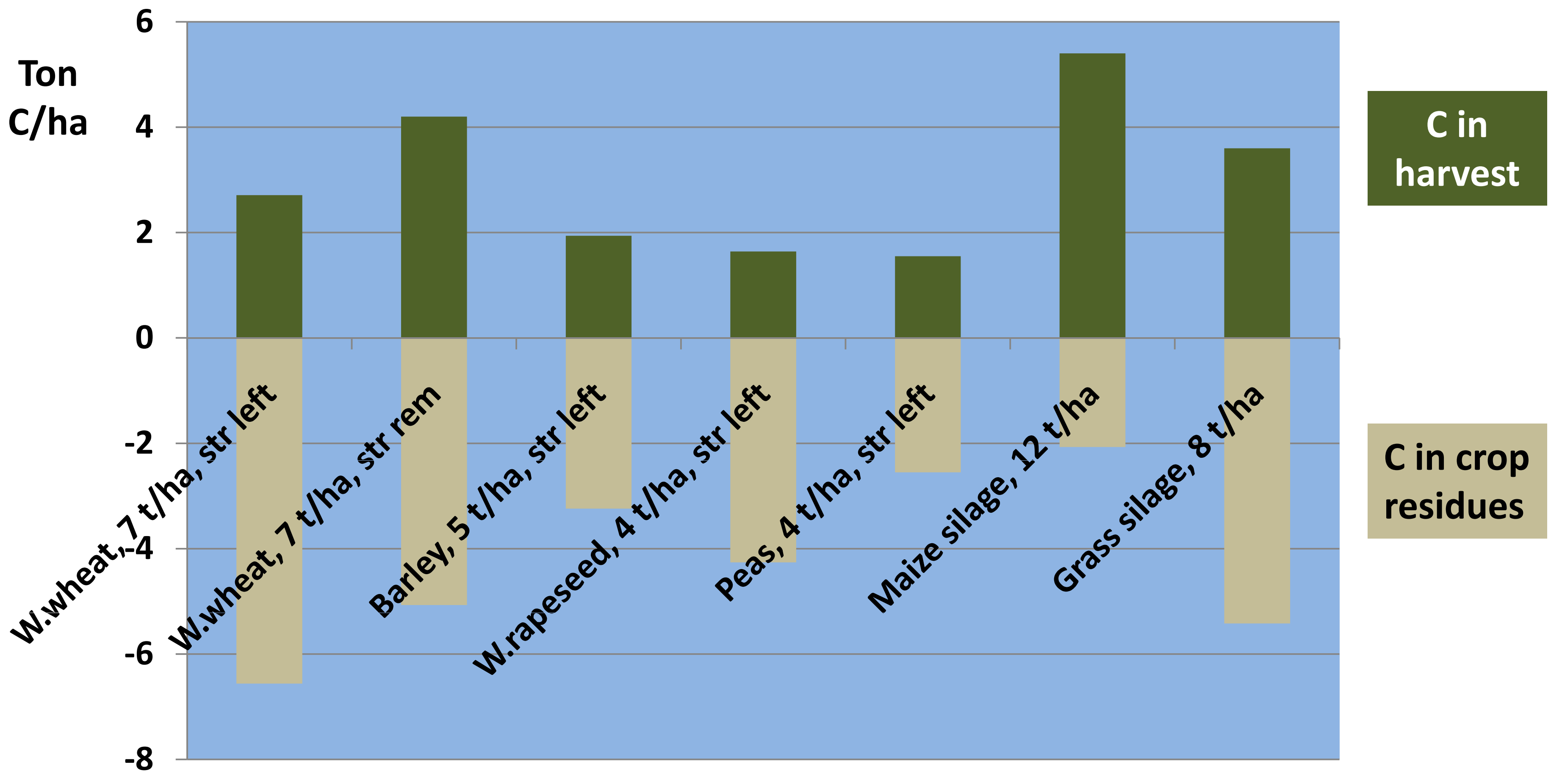


Soil carbon models are calibrated against long-term field experiments: Data from Ultuna, Uppsala 1956-91



Same amount of carbon input for all accept "träda" and "inget N"

Carbon in harvest products and crop residues



- Ongoing study: Including soil carbon changes in GHG balances for dairy products

Ongoing project: comparing milk´s GHG emission including soil carbon changes

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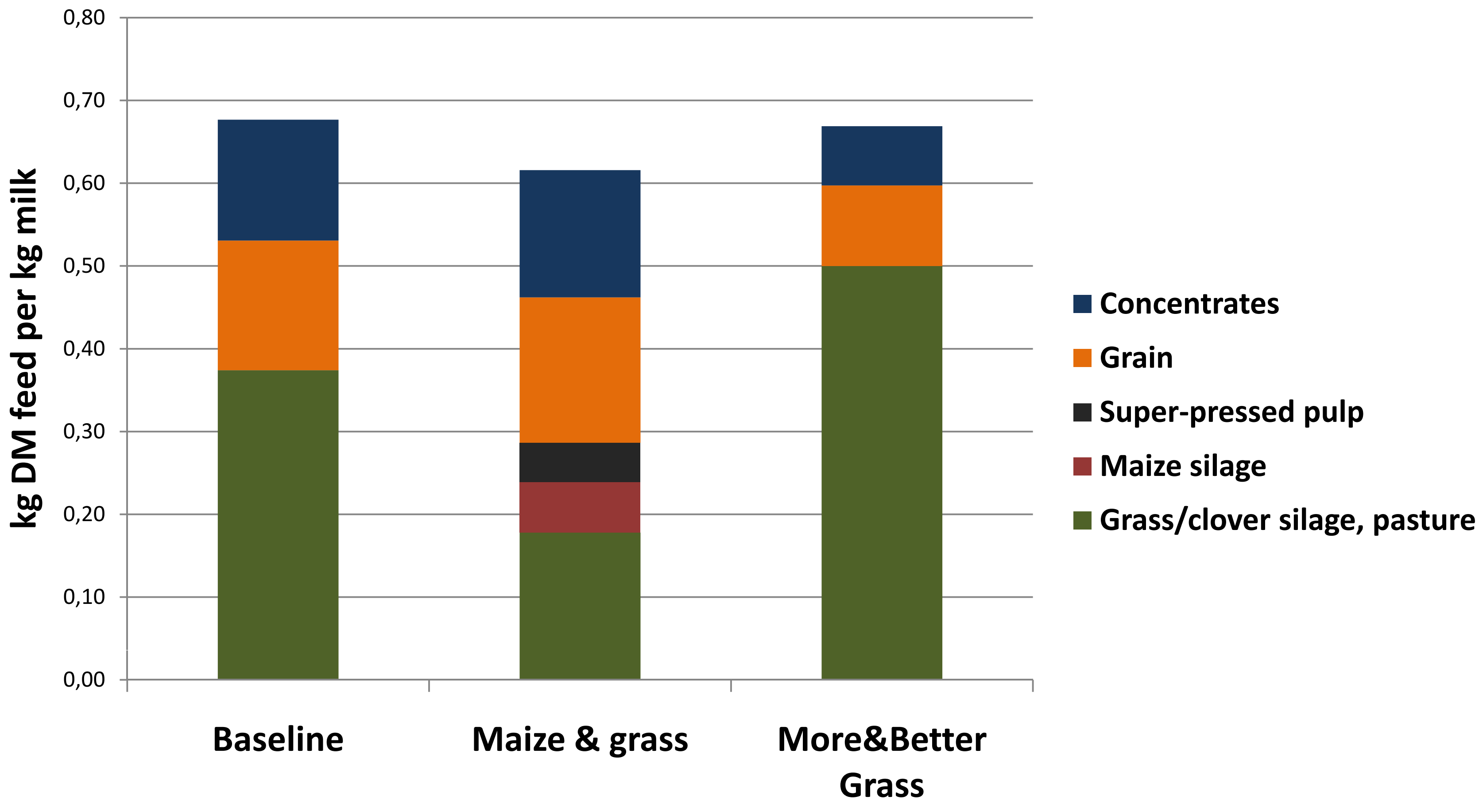
- Comparison of three feed rations for dairy cows producing 9000 kg milk/yr

- Soil carbon changes for the three rations were estimated using C tool

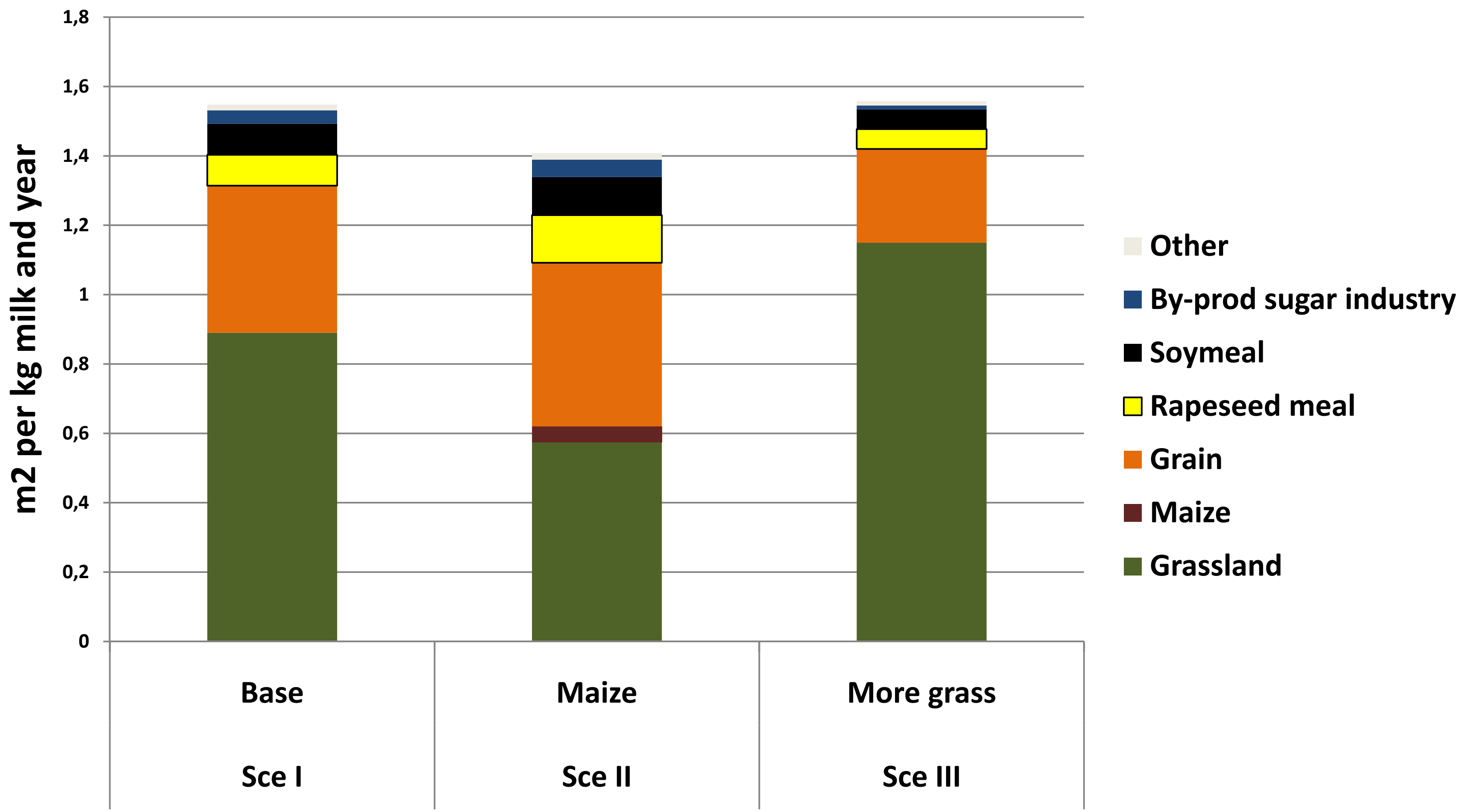
	Baseline	Maize & grass	More grass
	Kg DM per cow*yr		
Grass/clover silage, pasture	3 367	1 601	4 499
Maize silage		549	
Super-pressed pulp		427	
Grain	1 409	1 582	876
Concentrates	1 314	1 383	645
Total	6 090	5 542	6 020

Feed rations according to Liljeholm et al, 2009

Feed intake per kg milk



Land occupation, m2 per kg milk and year



Preliminary results

- Initial soil carbon status is very important for the soil´s carbon sequestration potential
- The estimated soil carbon changes are significant, but not of great importance for milk´s total GHG balance
- Feed rations with more maize silage seem to loose soil carbon
- Feed rations with more maize silage have lower land requirement – the use of this land "surplus" is important for the total GHG balance

Conclusion

- Soil carbon sequestration has potential in climate work but probably overestimated
- High verification costs make it difficult to implement as a climate mitigation option
- Initial soil carbon status is crucial for the soil´s carbon sequestration potential
- Total input of carbon most important for soil carbon sequestration potential
- Reasonably correct data on crop residues from grasslands are needed – big lack of data!

Thank you!