

Projekt Green Valleys

Crop rotation effects and calculations of carbon balances in project

Christel Cederberg

Info till Vgregionens klimat-och mathandläggare

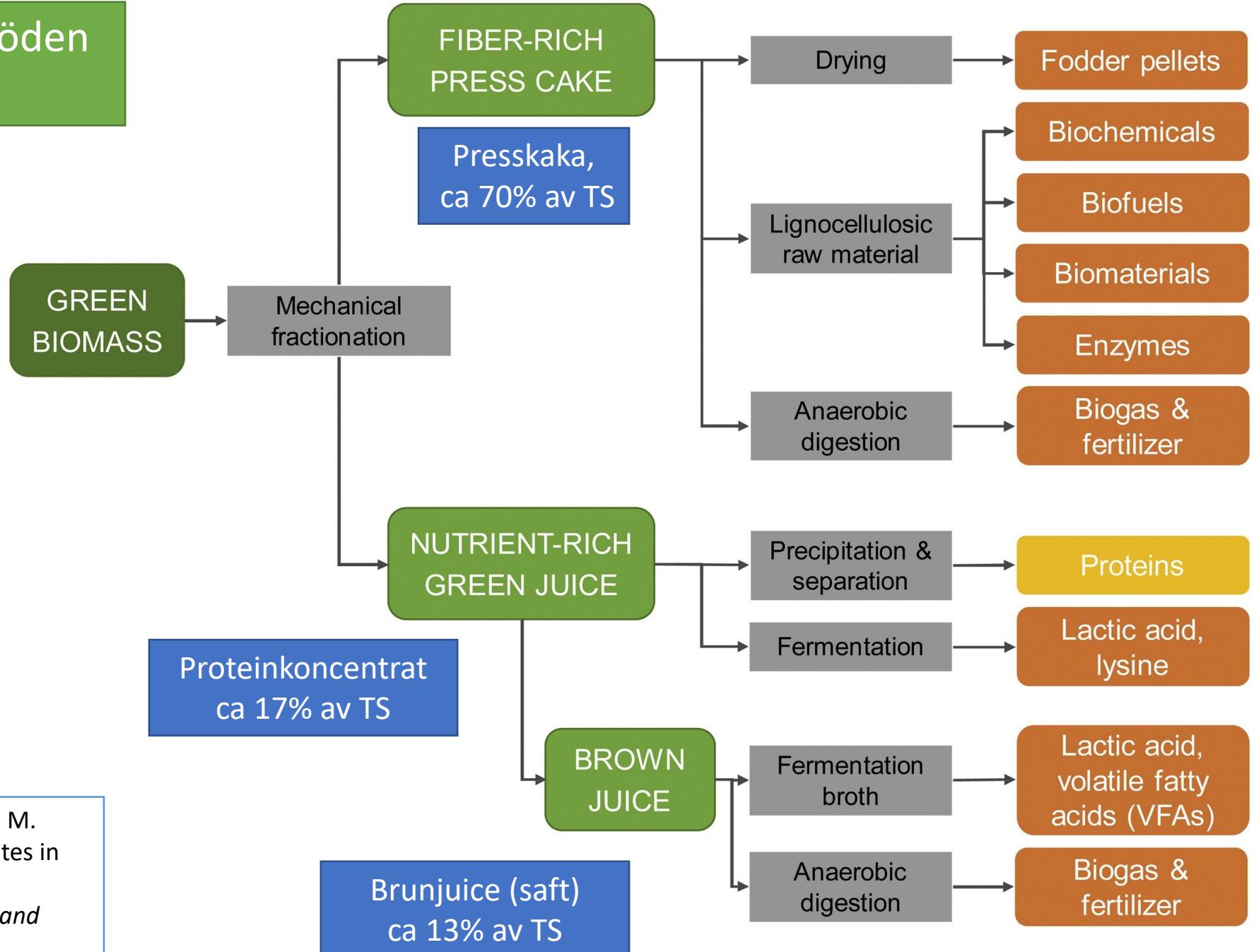
4 maj 2021

agenda

- Grass-based biorefineries – products and some pictures
- Crop rotation effects on SOC
- Carbon balance when introducing a grass based biorefinery – first results!
- Förlängning GV-proj
- Formas ansökan Hållbar livsmedelsproduktion

Gräsbioraffinaderier – flöden och möjliga produkter

Produkter ut från 1 ton torrsubstans grönmassa



Källa: Santamaría-Fernández, M., & Lübeck, M. (2020). Production of leaf protein concentrates in green biorefineries as alternative feed for monogastric animals. *Animal Feed Science and Technology*, 114605.

Test pilot Danmark – Gräsbaserad bioraffinaderi vid Foulum forskningscenter
Department of Biological and Chemical Engineering; Dep of Agroecology



Foto från
möte med
EU-projekt
Go-Grass,
2020

Källa: xxx



Gräs tvättas rent från jord innan det separeras i fast och en flytande fraktion i bioraffinaderiet

Græs vaskes fri for jord, inden det separeres i en flydende of fast fraktion i bioraffinaderiet. Foto: Nikolaj Peder Hansen

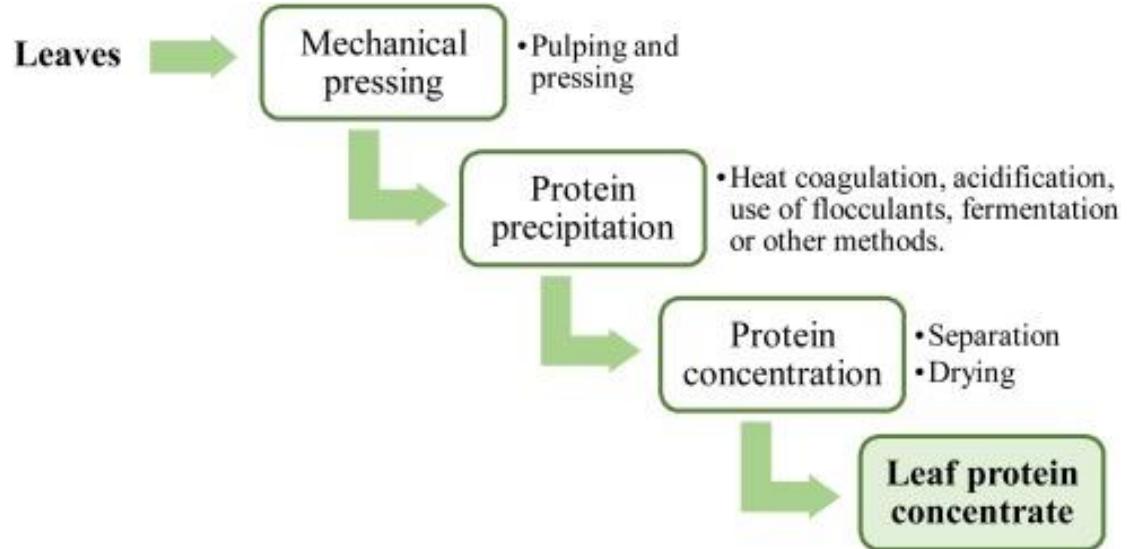


Gräs
Bioraff i
Foulum,
okt 2019,

Foto C Cederberg



*Nærbillede af pulp af græs, som
er presset to gange i
bioraffinaderiet. Foto: Nikolaj
Peder Hansen*



- Extraktion av protein från blad undersöktes under 2:a världskriget (särskilt UK) för att få fram protein som direkt mänskoföda. Ej accepterat hos konsumenter, bitter och "gräsig"
- Utkonkurrerat av sojabönan mm
- Mekanisk pressning, sätta till vatten för mer proteinutnyttjande
- Utfällning protein, ex värme koagulering, mjölkssyrjäsning...
- Slutligt proteinkoncentrat efter torkning
- Utfodringsförsök i DK: gräsproteinkoncentrat kan ersätta soja i foderstat för gris och värphöns. Kyckling ej fullt ut (men mycket få försök så här långt)

Soil Organic Matter (SOM) –
Soil Organic Carbon (SOC)

Major land degradation processes



Two adjacent soil samples from Kansas US
Left – cropland annual crops / Right – native grassland (prairie)

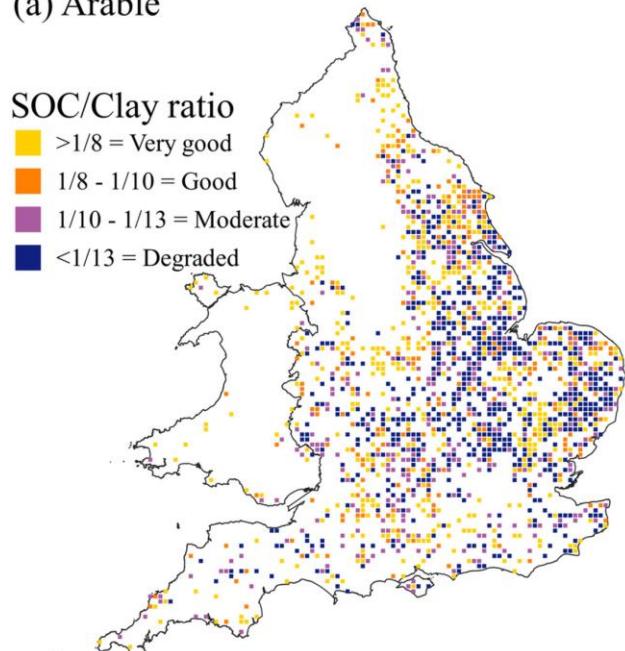
- Wind & water erosion
- Organic matter decline
- Compaction / Hardening
- Pollution

World croplands have
lost 20-60% of their
carbon prior to
cultivation

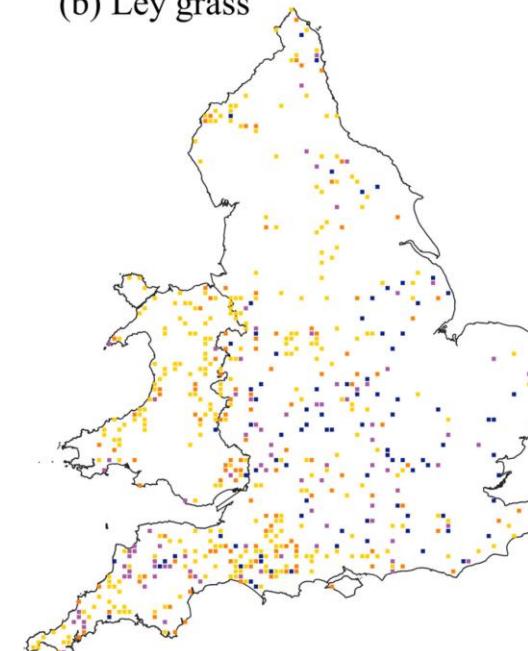
IPCC 2019. Report on climate change and land

(a) Arable

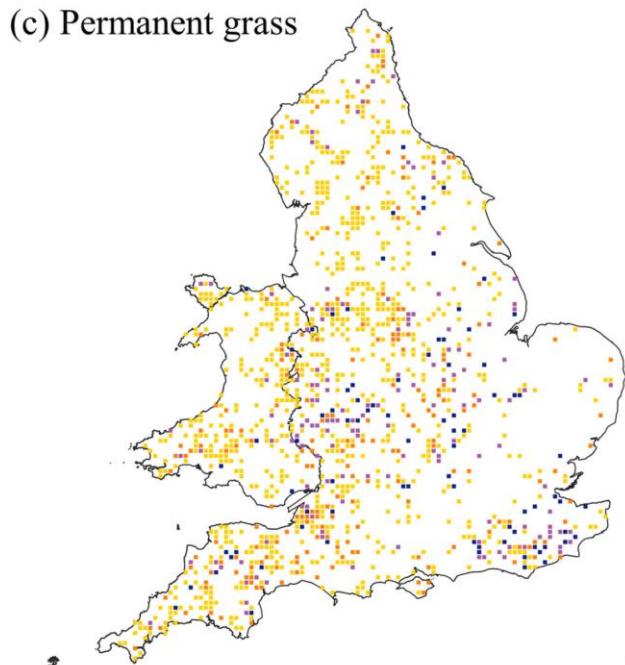
SOC/Clay ratio
■ >1/8 = Very good
■ 1/8 - 1/10 = Good
■ 1/10 - 1/13 = Moderate
■ <1/13 = Degraded



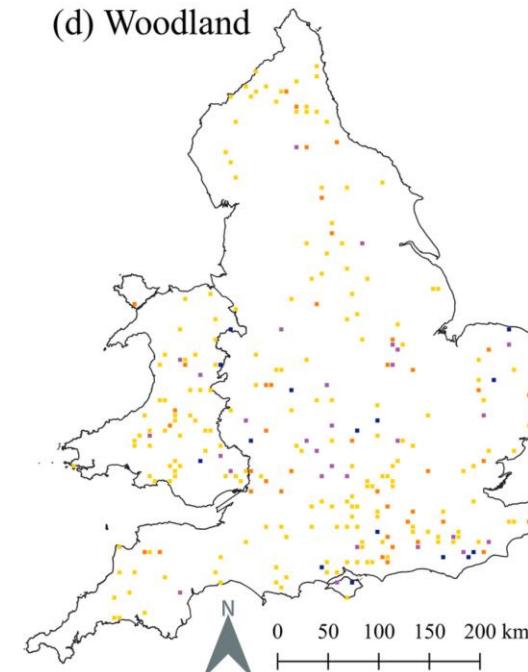
(b) Ley grass



(c) Permanent grass



(d) Woodland



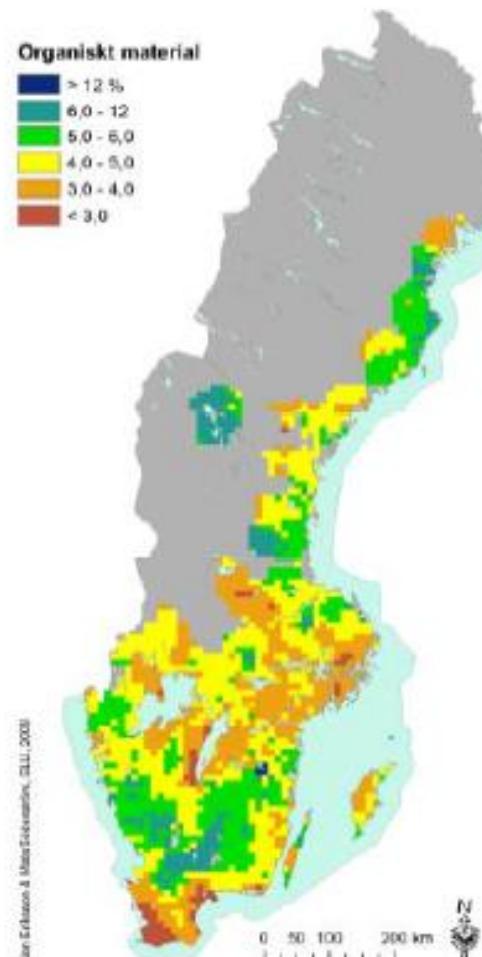
What is a good level of soil organic matter? An index based on organic carbon to clay ratio

European Journal of Soil Science, First published: 12 June 2020,
DOI: (10.1111/ejss.13012)

Calculated index based on data from
English&Wales soil monitoring program

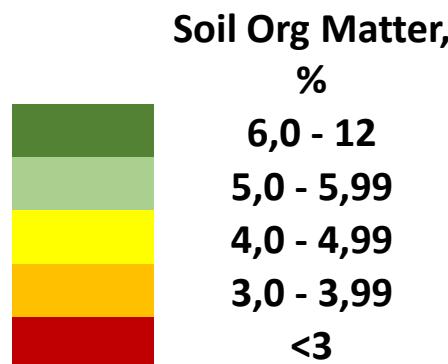
3,45 % org matter ~2% org C
Assume 20% clay
 $2/20 = 0,1$ är good to moderate

2,58% org matter ~1,5% org C
 $1,5/20 = 0,075$ degraded



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 sample data from the Swedish monitoring program of arable soil.

Naturvårdsverkets rapport no 6349

Crop rotation effects on Soil C Sequestration SCS

SYSTEMATIC REVIEW PROTOCOL

Open Access



How do selected crop rotations affect soil organic carbon in boreo-temperate systems? A systematic review protocol

Magnus Land^{1*}, Neal Robert Haddaway¹, Katarina Hedlund², Helene Bracht Jørgensen², Thomas Kätterer³ and Per-Erik Isberg⁴

Abstract

Background: Soils are important global carbon pools that are under threat from intensive land use through a variety of agricultural practices. Sustainable management of agricultural soils may have the potential to mitigate climate change through increased carbon sequestration and increase their fertility. Among management practices to increase carbon sequestration, crop rotation designs have often been tested on yield effects in long-term agricultural experiments. However, in these studies, soil organic carbon (SOC) was monitored but not always the key objective. Thus, here we provide a method for a systematic review to test the effects of common crop rotations on SOC sequestration to provide evidence on the most sustainable management regimes that can promote SOC storage.

Methods: This systematic review incorporates studies concerning selected crop rotations (rotations-vs-monocultures, legumes-vs-no legumes, and perennials-vs-annuals) collated in a recently completed systematic map on the effect of agricultural management on SOC, restricted to boreo-temperate systems (i.e., the warm temperate climate zone). Some 208 studies relevant for this systematic review were identified in the systematic map. An update of the original search (September 2013) will be undertaken to identify newly published academic and grey literature. Studies will be critically appraised for their internal and external validity, followed by full data extraction (meta-data describing study settings and quantitative study results). Where possible, studies will be included in meta-analyses examining the effects of the different rotational practices. Implications of the findings will be discussed in terms of policy, practice and research, and the nature of the evidence base.

Keywords: Agriculture, Conservation, Rotational, Leguminous, Land management, Climate change, Land use change, Carbon sequestration

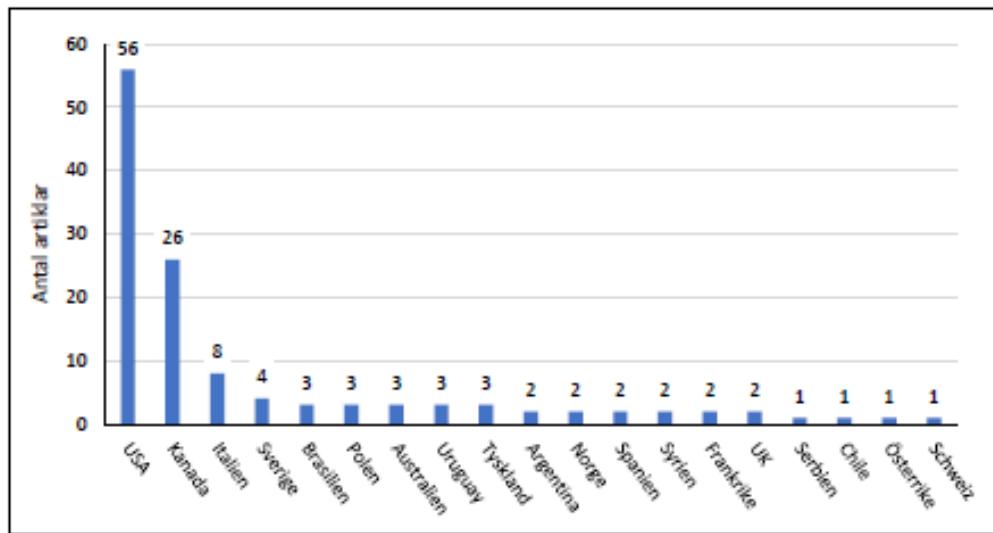
FORMAS

Växtföljders påverkan på inlagring av organiskt kol i jordbruksmark

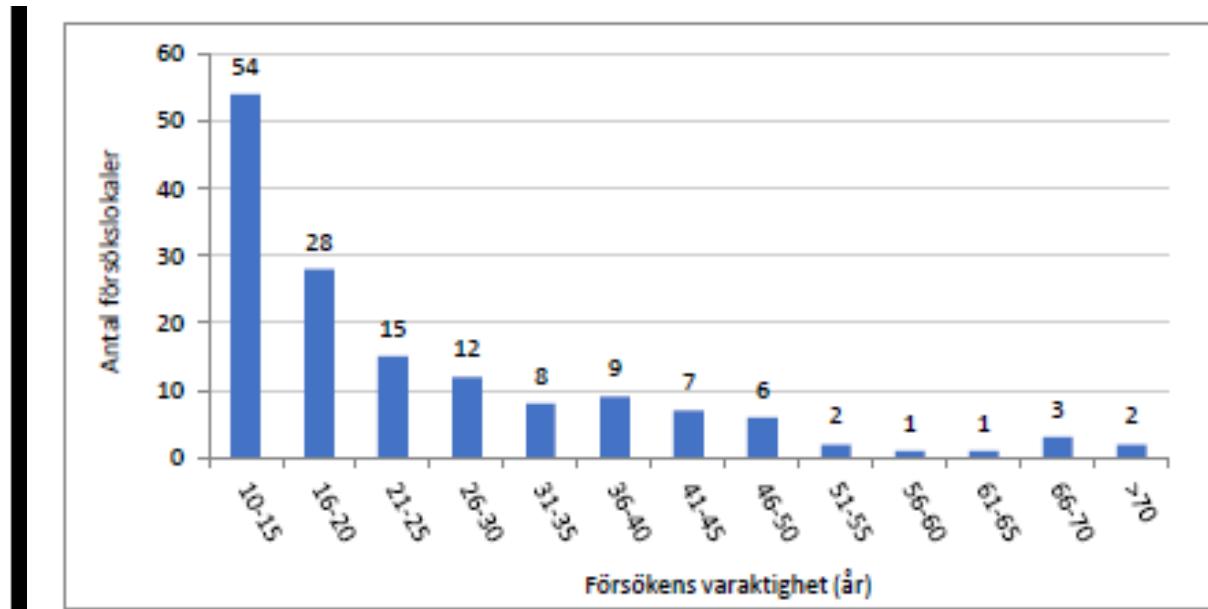
En systematisk översikt och samhällsekonomisk analys



125 studies fulfilled set criteria according to the protocol



Figur 5. Antal artiklar med studier från olika länder.



Figur 9. Frekvensen av olika varaktighet på försöken.

Växtfölders påverkan på inlagring av organiskt kol i jordbruksmark

En systematisk översikt och samhällsekonomisk analys



Compare varied crop rotation (cereals, sugar beets, rapeseed) with monoculture cereal – no effect on SCS

Compare varied crop rotation with a leuminous and no tilling with monoculture cereal – small effect on SCS

Compare varied crop rotation with perennial 2 yr and more, clear and high effect (clear diff in concentration 3,7 g C/kg jord)

Measured SOC sequestration SE ("långtidsförsöken eller bördighetsförsöken")



- 4 yr rotation with cereals (only) was changed into ley-arable rotation with 3 yrs grass-clover and 1 yr cereal, two sites
- Lönnstorp, Lomma, Skåne 15% clay ("baltiska morän")
- Lanna, (nära Bjertorp) Västergötland, 43% clay
- Start 1980 – data until 2015

Börjesson, G., Bolinder, M. A., Kirchmann, H., & Kätterer, T. (2018). Organic carbon stocks in topsoil and subsoil in long-term ley and cereal monoculture rotations. *Biology and Fertility of Soils*, 54(4), 549-558

SOC change 35 years long field experiments

Lönnstorp och Lanna

	Lönnstorp Skåne		Lanna,Västergötland	
	Mono-cereal	Ley rotation	Mono cereal	Ley rotation
Initial C stock, tC/ha 0-20 cm	45,8	44,4	54	54,8
Final stock	39,1	56,5	48,7	60,7
Average SOC change, tc/ha*r	-0.19	0.35	-0.15	0,17
Total diff through change, t C/ha*yr	+0,54		+0.32	

Börjesson, G., Bolinder, M. A., Kirchmann, H., & Kätterer, T. (2018). Organic carbon stocks in topsoil and subsoil in long-term ley and cereal monoculture rotations. *Biology and Fertility of Soils*, 54(4), 549-558

Modelled with C tool in Denmark by Marie and colleagues, I will explain this table on Thursday

Fodder crop	C input to the soil (kg C ha ⁻¹ year ⁻¹)	Scaling to input from reference crop (kg C ha ⁻¹ year ⁻¹)	Potential soil C (100 years) sequestration (kg C ha ⁻¹ year ⁻¹)	C (100 year) sequestration (kg CO ₂ ha ⁻¹ year ⁻¹)	Potential soil C (20 years) sequestration (kg C ha ⁻¹ year ⁻¹)	C (20 year) sequestration (kg CO ₂ ha ⁻¹ year ⁻¹)
Barley, 100% straw removal	1773	-2197	-220	-807	-461	-1692
Barley, 0% straw removal	2651	-1319	-132	-484	-277	-1015
Wheat, 100% straw removal	3456	-514	-51	-187	108	-396
Wheat, 0% straw removal	4682	712	71	260	150	548
Grass-clover, silage	5956	1986	199	730	417	1529
Grass-clover, grazed	6741	2771	277	1016	582	2134
Maize silage	1370	-2600	-260	-953	-546	-2002

How we are including Soil Carbon Sequestration in Green Valley modelling and calculations?

Two parameters are very important for the outcome when calculating soil carbon sequestration rates

- **Initial soil carbon content** in the soil (is it low or high in carbon, cultivation history)
- For how **long time period** are we estimating the soil carbon sequestration

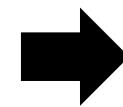
To handle this we will have to calculate with some different input numbers on soil carbon sequestration rates so that we can give a range in how big the soil carbon sink will be in relation to other GHG fluxes

	Low rate (i.e. high SOC status)	Average SCS rate	High rate (i.e. low SOC status)
Time period 20 yrs		500 kg C/ha*yr ley	750-1000?
Time period 100 yrs		250?	400?

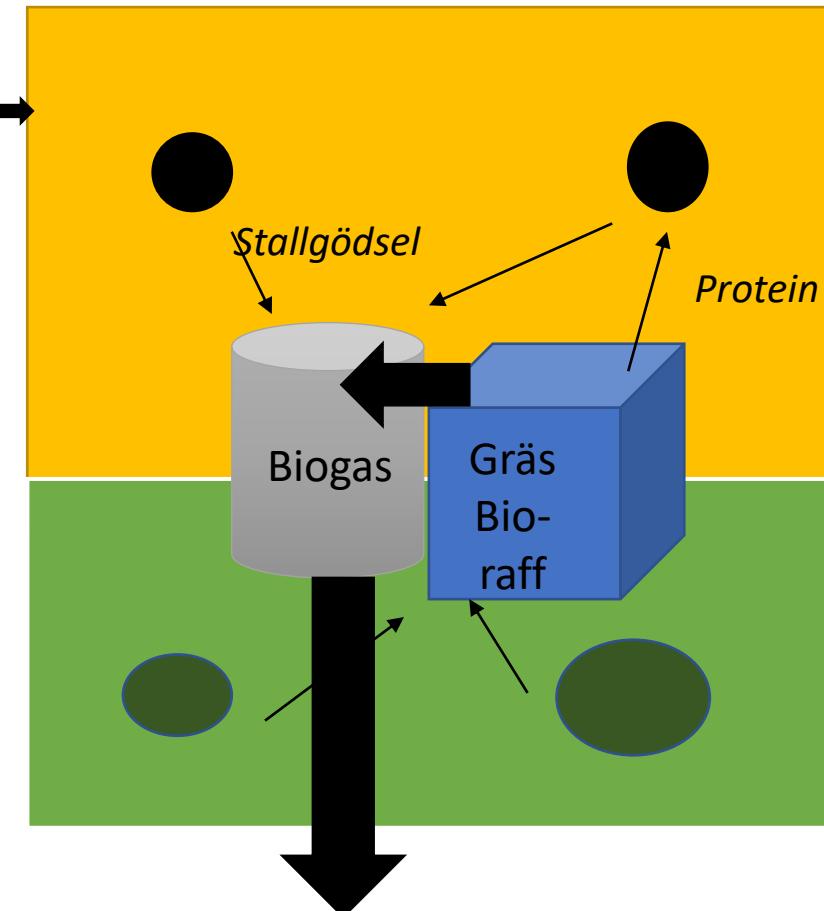
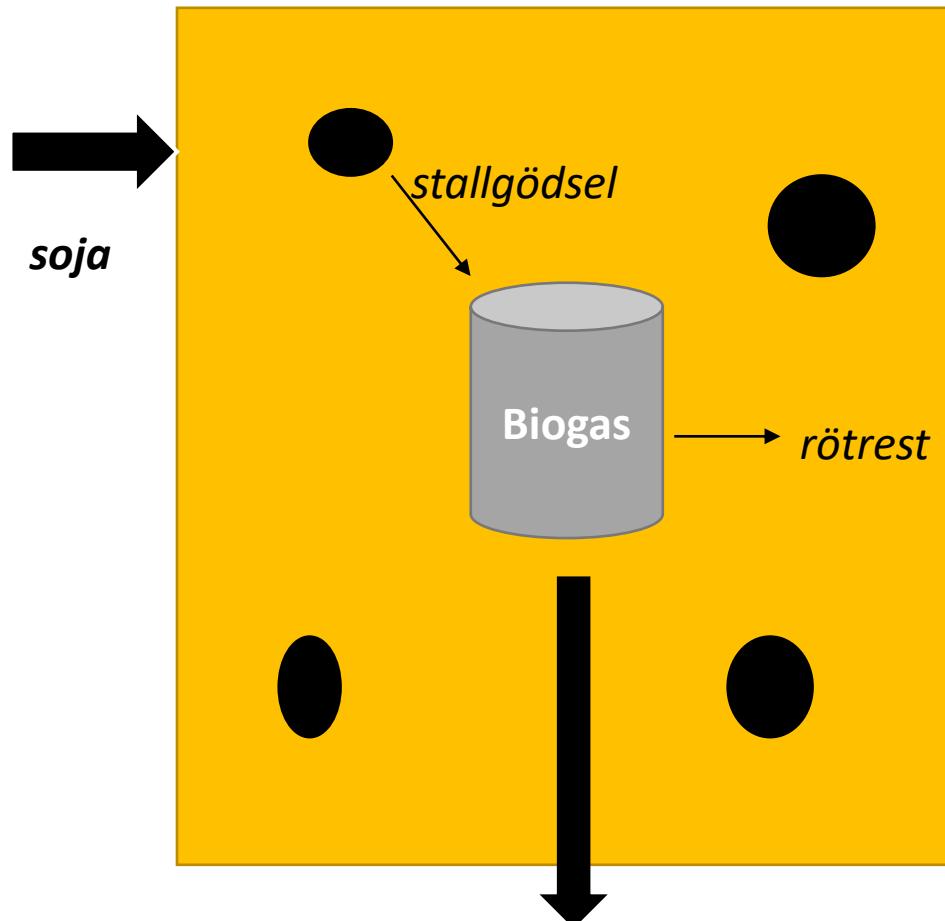
First results on Carbon balances in GV project

Ett exempel på en modell för en större anläggning

Jordbrukslandskap där spannmål och oljeväxter domineras - Svinproduktion domineras - Gemensam (faller) biogasproduktion



Gräs-bioraffinaderi integreras med biogasproduktionen, vall introduceras i växtföljder



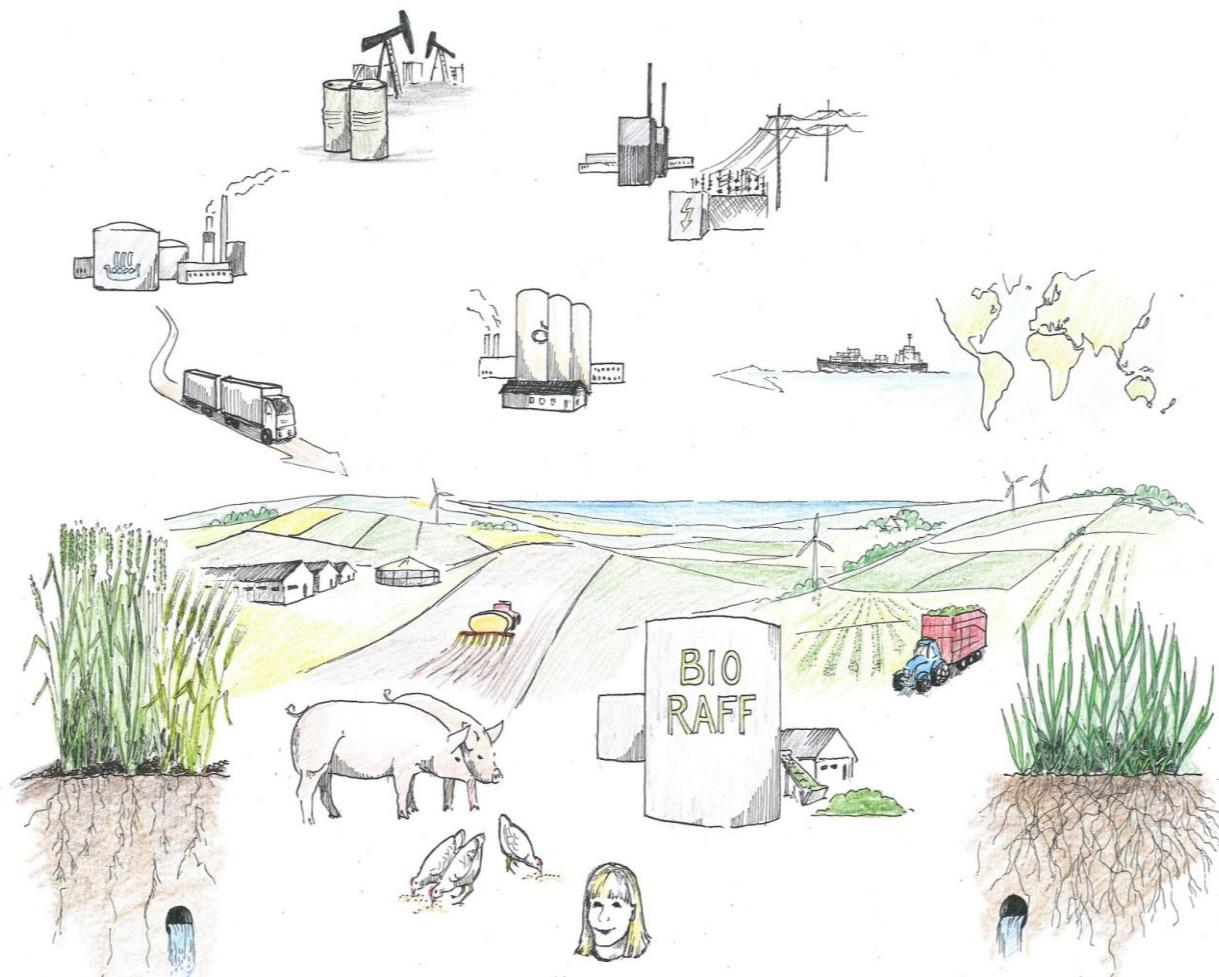
Bioenergi, t ex biodrivmedel

Bioenergi, t ex biodrivmedel

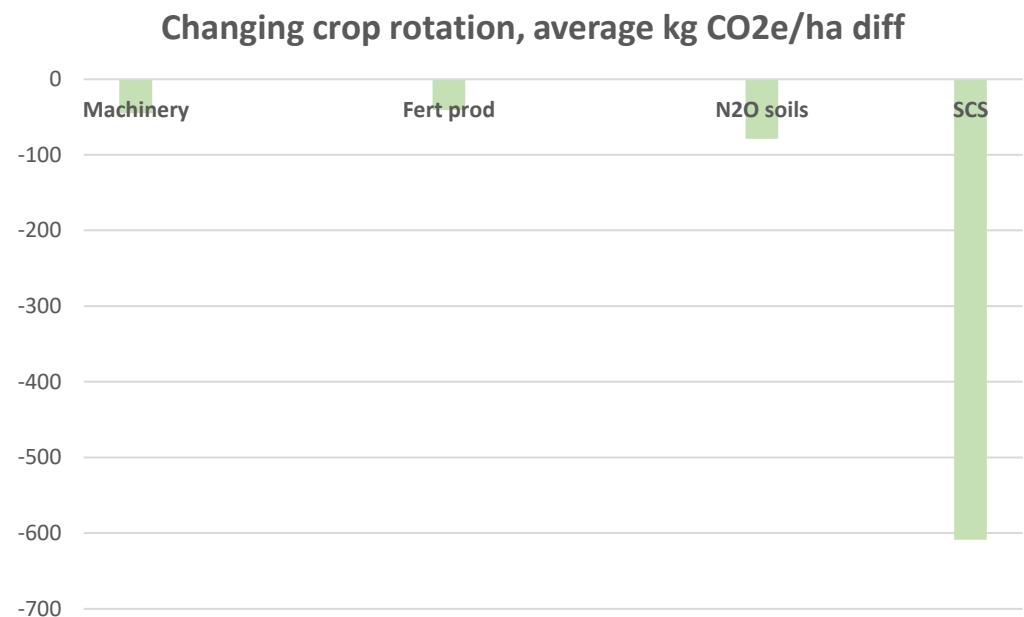
Changing crop rotations, based on typical rotation in VG-region

År	Crop	Reference rotation, 6 yr annual crops	Arable/Ley rotation with 33% perennials	Skörd, t/ha
		Skörd, t/ha	Gröda	
1	Barley	5	Barley	5
2	Oats	5	Ley yr 1 (grass/clover)	9 (dm)
3	W wheat	6.2	Ley yr 2 (grass/clover)	6,7 (dm)
4	W rapeseed	3.2	Höstraps	3.4
5	W wheat	6.7	Höstvete	7
6	W wheat	5.5	Höstvete	5.8

Introducing green biorefineries in a North-European agricultural landscapes dominated by annual crops

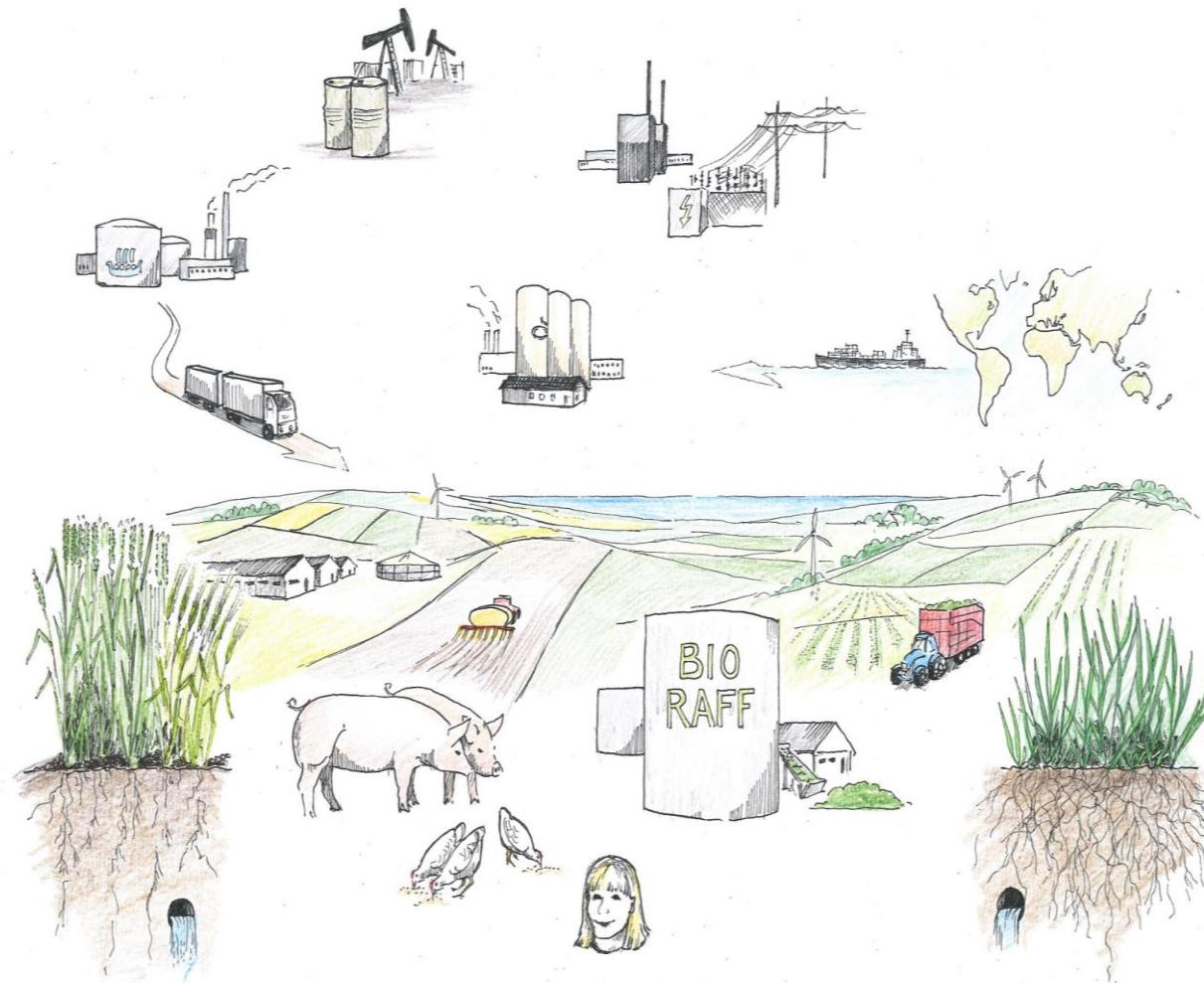


Direct effects for farmers in landscape when changing
6-yr rotation with annuals into ley-rotation
(33% perennials)



Introducing green biorefineries in a North-European agricultural landscapes dominated by annual crops

Indirect effects (background system global soy prod&trade, fossil energy, less grain in EU)



The new crop rotation produce in average 0.45 t/ha proteinkoncentrat which can substitute ~0.45 t soymeal. Average CF 0.77 kg CO₂/kg soymeal to EU
Around -350 kg CO_{2e}/ha in crop rotation (no LUC-emissions)

Biogas production from presskake and brown juice replace natural gas and CO₂-savings
Around -350 kg CO_{2e}/ha in crop rotation

We loose around 1,7 ton grain/ha in average in crop rotation....

EU 28 (före Brexit)



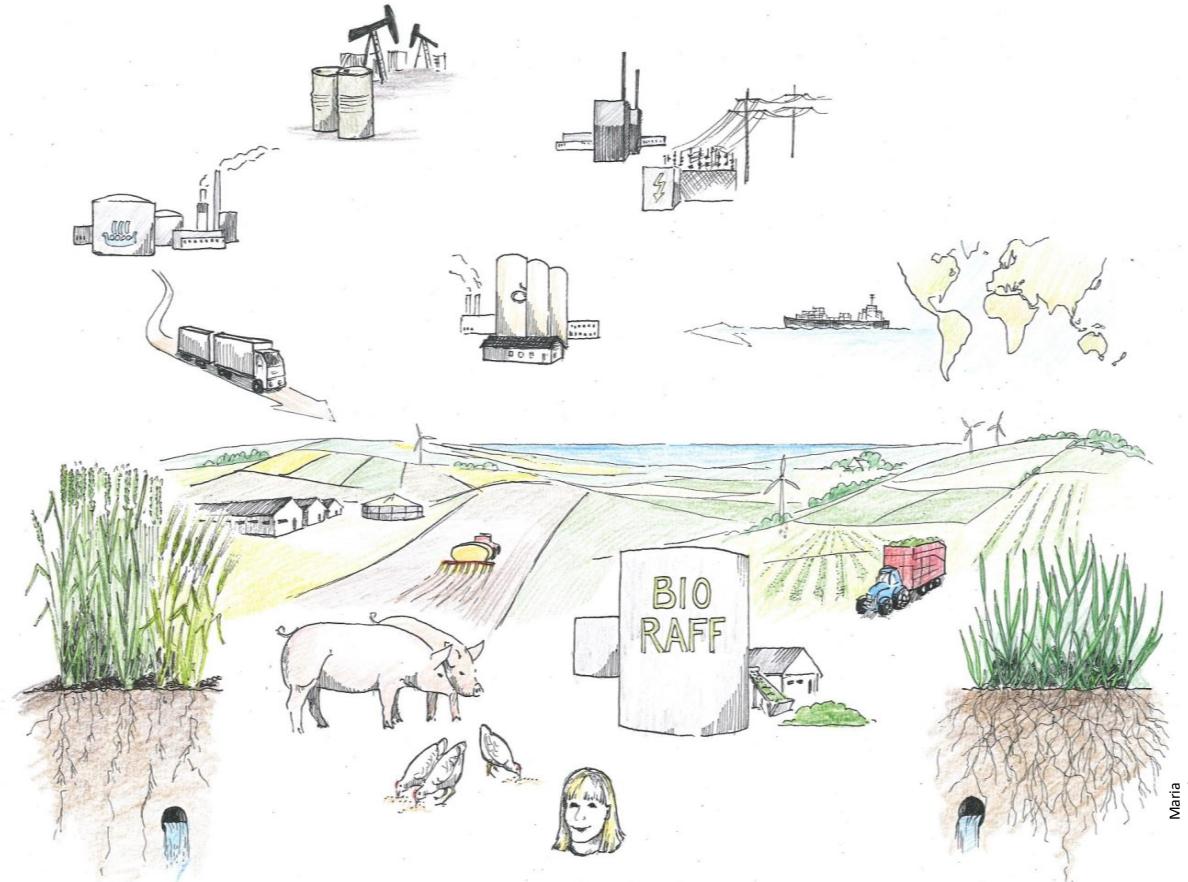
**177 miljon hektar jordbruksmark varav
ca 100 miljoner hektar åkermark med
grödor i växtföljd (saedskifte)**

**Netto importör av mark från övriga
världen för mat och bioenergi**

Cirka 35 miljoner hektar, domineras av

- Soja
- Vegetabiliska oljor (för human konsumtion och biodrivmedel)

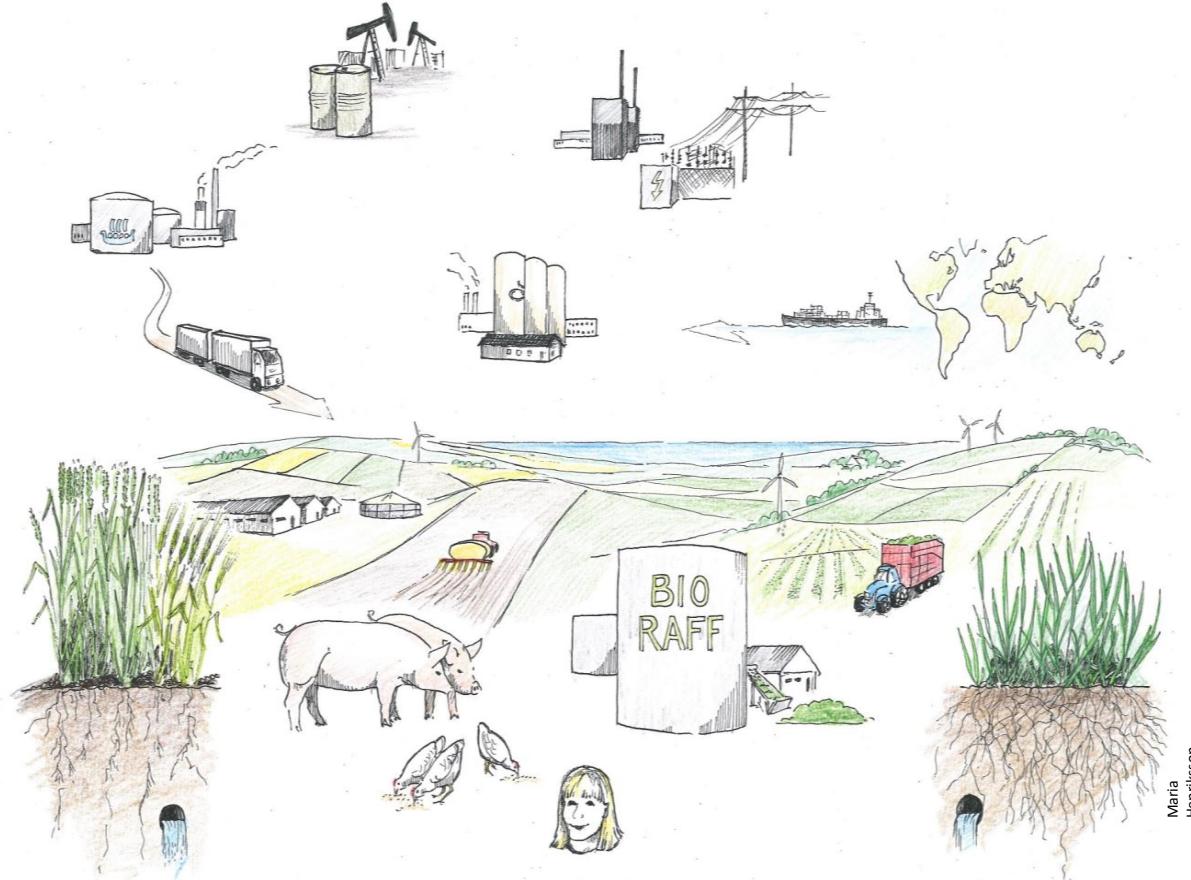
System grass-based biorefineries



Key challenges

- Production grass-clover (luzern) biomass
 - Logistik, transport
- Bioraffinering
 - High proteinyield
 - Drying protein product for market
- Systemanalys – miljömässiga effekter
 - Land use including soil C seq and soil health aspects
 - Important quantification rotation effects
 - Effects on pesticide use, nutrient leaching, diversity in landscapes
- Economy
 - Market
 - Societal

Rapporter på g beträffande systemanalys



Kort arbetsrapport som beskriver hur vi räknar på kolsänkor i projektet – klar i juni

Vi utvecklar flexibel modell som räknar på hela systemet för konceptet bioraff och som användas för gårdsanläggning, i regional skala och nationell skala

Paper 1 – Description of model, what it can calculate and examples of results in terms of land use change, protein and energy production - submit i juni

Paper 2 – adding environmental indicators to above (GHG balance, energy, N emissions, pesticides, some biodiversity indicator - submit i slutet av höst

Paper 3 – (tillsammans med SLF projekt EEVAS) Integrera grass bioraff with org dairy and pigs at farm level

Vinter 22

