Kulturhuset I Yttejärna 15 April 2023

Lecture by Assoc. Prof. PhD Artur Granstedt

Agricultute to create a green future

Regenerativt Ekologiskt Kretsloppsjordbruk
Ecologic Recycling Agriculture (ERA)

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AG

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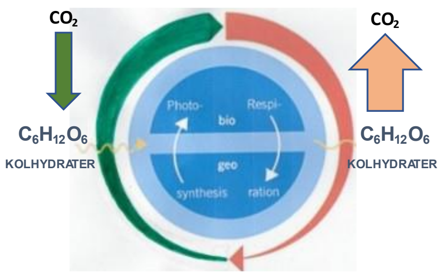
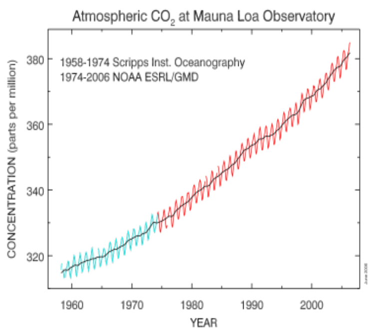
Im am standing here in front of the map of our biodynamic experimental farm Skilleby, which is today also a part of the Biodynamic Farm Yttereneby in Järna. During our studies of the farm, the farmer aswell as the farm is the teacher and we as researchers follow and learn from them. There is too much information for me to explain everything in this short time, however I have a compendium which summarises the important point of my research. You may also be interested in my book Morgondagens jordbruk and the English version Agriculture for the future and coming soon is the expanded version of an earlier book “Biodynamisk odling i forskning och försök” (Biodynamic agriculture in research and trials) which is currently in press.

Endast fotosyntesen binder kol
(all övrig aktivitet frigör kolet igen)
Klimathotet beror på obalans i kretsloppet
(förbränningen större än fotosyntesen)

Only photosynthesis binds carbon (all other activity releases the carbon again)The climate threat is due to an imbalance in the cycle (combustion greater than photosynthesis)



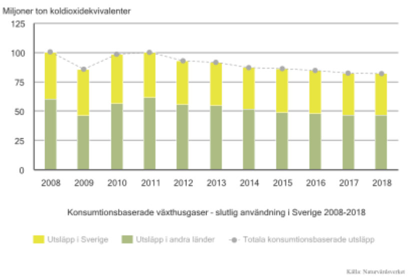
Ch. D. Keeling managed to mobilize enough resources so he could begin measuring the CO2 content of the atmosphere in 1958 at the Mauna Loa Observatory, Hawaii



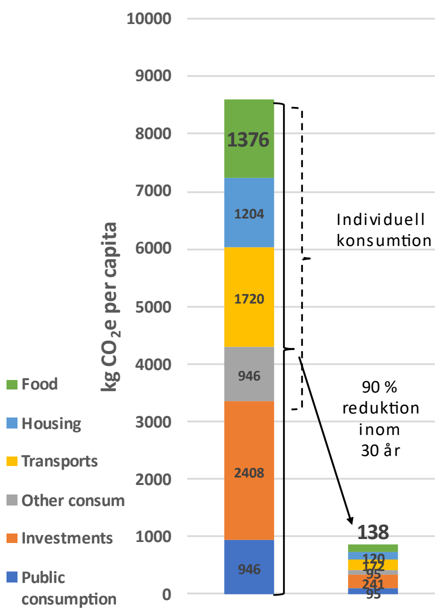
Agriculture and forestry are the only sectors where we can rebuild up new resources, catch the sun-light and the carbon, -- all other human activities are consumption, destroying and burning up resources. The challenges is that we are destroying more than we are rebuilding of new resources and we are each year moving further in the wrong direction as a whole society. Carbon emissions, CO2 emissions and global warming are all increasing. But the opposite is possible through the reformation of both agriculture and our consumption behaviours, which I will show you.

63 % of the Emissions from consumption is imported with emissions in other countries.

Andel inhemska och importerade CO_2-utsläpp

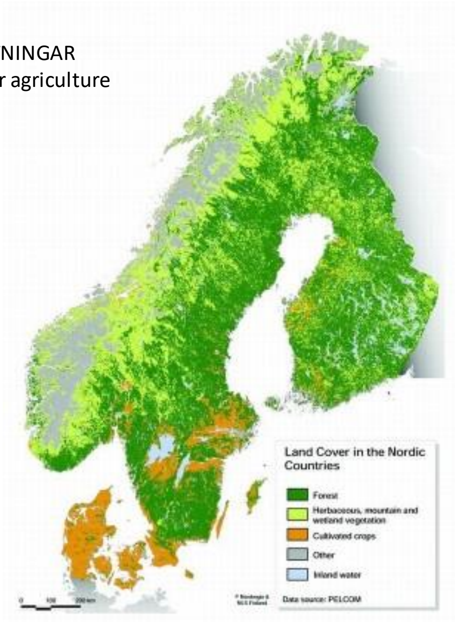


Källa: Naturvårdsverket 2022.
http://www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaser-konsumtionsbaserade-utslapp-Sverige-och-andra-lander/



However this is not the case in today's society as agriculture is using up fossil resources and destroying the resources which agriculture should infact build up. A large part of global warming from the consumption standpoint is imported products with emissions in other countries, and so in the food sector - half of the food and most of the agrochemicals is imported with emissions in other countries. Climatic consequences with deforestation and soil degradation from the production of the imported fodder from other countries as well the environmental consequences for the diversity of use of chemical is not included in the Swedish official statistic consequences of our food consumption. Within thirty years we have to reduce with 90 % all sectors including the agriculture and food sector. We can never stop the increasing global warming without a total change of both the agriculture system and to this related profile on our food consumption -and this within this short time.

GRUNDFÖRUTSÄTTNINGAR
Basic conditions for agriculture



Our Nordic countries Sweden, Finland and Norway is dominated of forest land compared to Denmark. In our Nordic countries like Sweden very small areas of land is suitable for agriculture depending on soil and natural geographical conditions. In my books I describe more about the historical development of agriculture related to its nature and climate conditions   I mean this knowledges is important to understand the background to the current situation to successful create a future where we again hopefully can survey in peas with the nature with the agriculture and to this related consumption based more local and renewable resources.

Slash-and-Burn Shifting Cultivation during Nodic Conditions

Svedjejordbruk

Eero Järnefelt 1863 -1937

Early agriculture was based on clearing land by burning of natures resources. But with few people and large available land mass in beginning possible.

The changing agricultural landscape–example from Roslagen central Sweden – the hay making agriculture (slåtterjordbruket)

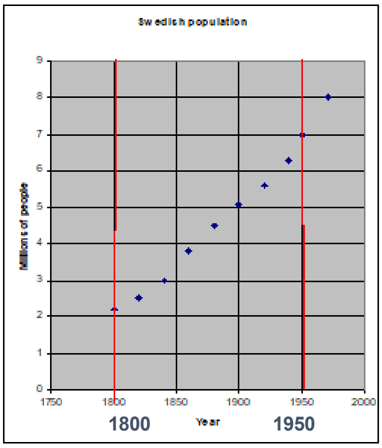
The meadow - the mother of arable land - dominated until

Brusewitz & Emmelin
(With permission)

5/8/2023 AG

This picture made by the painter Brusewitz and the nature geographer Emmelin is a reconstruction of the landscape picture how it look like from a segment of "Roslagen" in Central Sweden during the 17th century. From the iron age, the colder climate made necessary to plan more for the winter to for humans and their animals to survive. Hay making in the agriculture was developed with harvesting, drying during the short summer months to ensure enough fodder stored for cows, goats, and sheep to survive the long winter months. These ruminant animals can eat what we cannot eat, grass, leaves and even bushes and convert this to for us digestible milk and meat protein and energy compounds for us human to survive. These animals also produced the essential manure, this manure was collected and stored during the winter which gave the possibility to produce the cereal crops and root crops on the smaller areas of cultivated arable land. Land was separated with 1) the pasture grass land where the cows and other grass eating (ruminants) was eating the short summertime, 2) the for the long winter time fodder harvested cultivated meadows and 3) the smaller areas of ploughed and cultivated arable land which also become the manure for crop production. This harmonic agriculture, based on cultivated pastureland, sustained the population for thousands of years. However, this agricultural model could not produce enough food in long run for the fast-increasing population during the 18th century. This resulted in the overuse of resources which in turn led to food failure and emigration from the Nordic countries but also new innovations and an agricultural revolution.

Lack of food –
in the end of 18th centuary



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The inhabitants in Sweden increased from **2 millions to 7 million** between 1800 to 1950 before the introduction of artificial fertilizers and pesticides. How was the increased demand for food solved?

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Within countries, the population was increasing and therefore the demand for food was also increasing. In Sweden the increase was from 2 million to 5 million inhabitants within 150 years and this was before the chemical era. My question to students and others has been, how was this possible, as this also meant three times more food and fodder and also an increase in horsepower. This question is to help open their eyes to how important it is with the leguminous plant during not only during this time, but also for our future.

Ley with Leguminosis

was the sunlight driven of the man cultivated nature resource used to create a multiple doubled food production during the 150 years before the introduction of artificial fertilizers and chemicals

- Energy from the sunlight
- Nitrogen and carbon from the atmosphere
- Minerals and water from the ground

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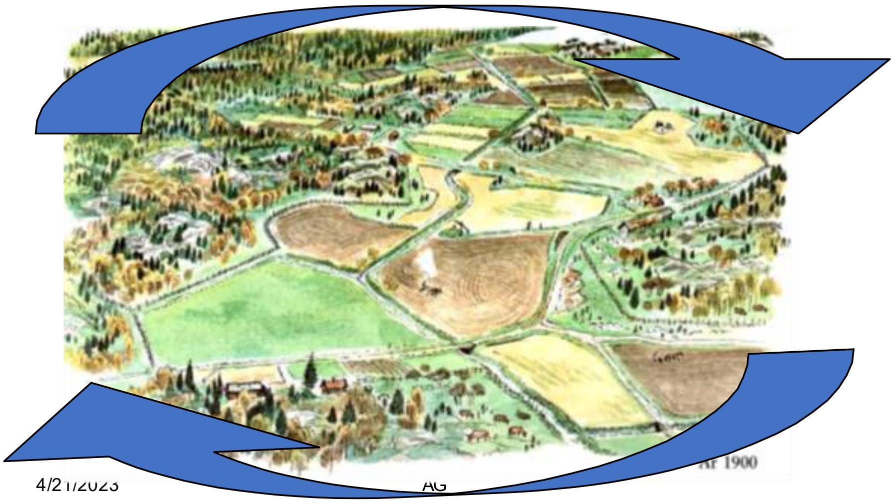
Here the introduction of clover seeds was a revolution for the agriculture and food production. This was well known for the old Greek culture, Parser culture and Rome culture (Virgilius, 70-19 f.kr), but later during the middle age partly forgotten. (Kjaergaard, 1994, An Ecohistorical interpretation…).Today we have become the scientific knowledge about the symbiosis with bacteria in the root nodules by the legume plants. We have learned that the root nodules the bacteria have the capacity to fixate the nitrogen from the atmosphere with help of energy from the plant, trough the deep roots special characteristic for perennial legumes like red clover and Lucerne pick the plant mineral nutrients from the deep part of the soil profile. Legume plants also have symbiosis with mycorrhiza, root fungus with a wide "hyfe" system penetration the soil around the plants which also activate micro organisms in the rhizosphere around the roots stimulating weathering processes. This agriculture was also based on the already from older time well established integration between mainly ruminant animal production and now with the multifunctional crop rotations. The recycling of nutrients between crop and animal production and crop rotations with nitrogen fixation deep rooting plants was doing this agricultural revolution possible.

The same landscape after the agricultural revolution 1900



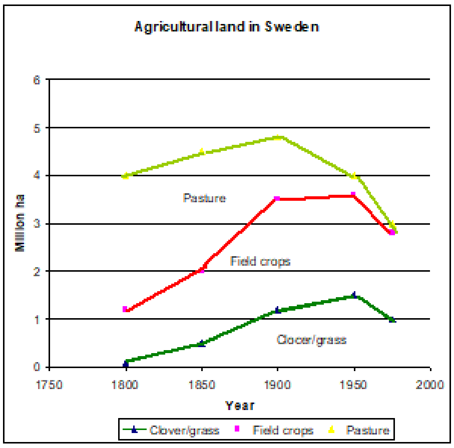
This golden era of an recycling with both crops and animal diverse agriculture was living until the first part of the last century and also described in the above reconstructed landscape picture from now on the same place but about the year 1900. We have instead of the small village the now established three individual farms, each with their own crop rotation going around with the different crops on the fields.

The clover became the crop of the field and the food of the animals that could fertilize the field

4/20/2023

The golden era for agriculture was living until the first part of the last century. Never we had a so high production based on local renewable resources and also with high diversity in the agricultural landscape.
This is more expanded and in detail described with references in my book Agriculture for Future (Morgondagens jordbruk, Granstedt, A. 2018)

Arable land with clover grass in the crop rotation increased and natural meadow land decreased



Crop rotations with symbiotic nitrogen fixation leguminous (clover grass land ley 2 -3 years followed of 2 – 4 years cereal and other crops)

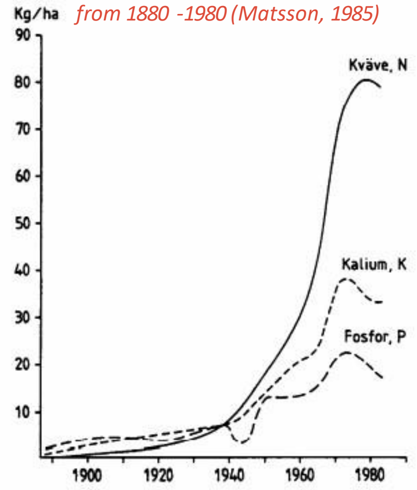
Integration of crop and animals on the whole farm area (before partly separated)

Technical improvements to utilize the nature given production potential and with help of horse power.

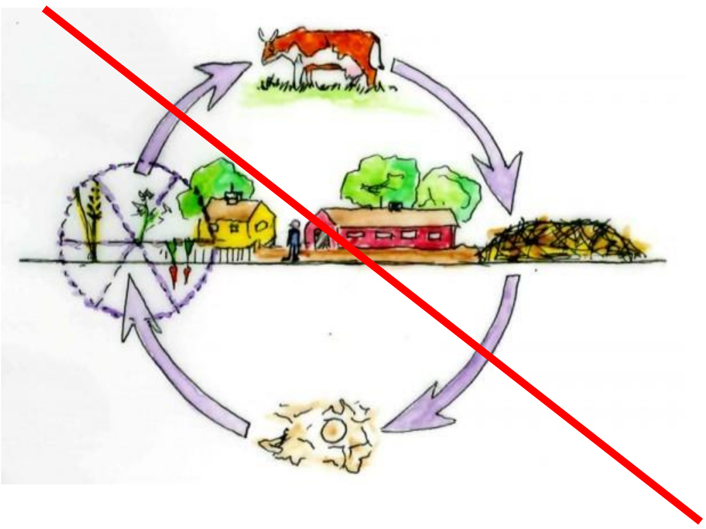
4/21/2023 artur.granstedt@beras.eu AG

At the end of the 18th century, the plowed field was estimated at just over 1 million ha, while the meadow land was almost three million ha. The introduction of crop rotations with clover grass in two or three years followed of cereal and other crops reversed this, the plowed arable area increased at the expense of the meadow land. The cultivated area was at its greatest at the beginning of the 20th century. The land reforms, better tools, stronger horses and the digging out of wetland beds were important prerequisites. The cultured land with grass and legumes gave four- or five-times higher yields than the previous meadow land, gave more fodder to the animals, increased production of meat and milk and at the same time more manure back to the field and which in turn enabled increased production of grain and nutrient-demanding crops such as potatoes as before had great significance for the food supply.

Used nitrogen (N), phosphorus (P) and potassium (K) kg/ha as fertiliser in Swedish agriculture from 1880 -1980 (Matsson, 1985)



The Haber-Bosch method made it possible to industrially fix the air nitrogen and farm without animals and without nitrogen-collecting legumes, the cycles were broken down. The consequence was that what some researchers dubbed the "Nitrogen Cascade" occurred with devastating consequences for watercourses, lakes and oceans, soil, vegetation and even in the atmosphere (Galoway et al 2004). Ammonia along with saltpetre was also used in the manufacture of ammunition during World War I. The criticized “Nobel prize winner” Fritz Haber is also known as the father of the gas war.



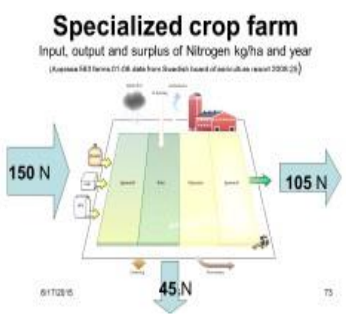
With increased use of mineral fertilizers, the need for farms to get their own manure decreased. More and mor farm was converted to stockless farms without cattle manure. Other farms were taking over the animals and increased the amount of animals, now based also with imported fodder from the now specialised crop farms. Also imported fodder from other countries, special soy fodder increased during this time. I certain regions the animal farms are now more frequent and other regions like central parts and southern parts of Sweden with more open flat land it is more of specialized crop farms. The cycle between crop and animal production on the individual farms was broken. Increasing excess nitrogen is leaching out and eutrophicating the seas from concentrated animal husbandry with too many animals, whose manure does not go back to the arable land where the fodder crops were grown. The manure with plant nutrients, special nitrogen- and phosphorus- compounds was accumulated on the farms with too many manure producing animals and becomes a surplus problem that mainly leaches from the animal farms' land.

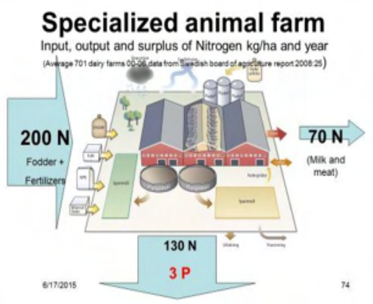
The same landscape 85 years later.

From diverse crop rotation and recycling to specialization

4/21/2023 AG

This picture the same landscape area year 1985 but now with the picture completely changed. The small farms is lost. Here is now specialized grain cultivation without fences or animals and the land is only part of a larger farm. The structural rationalization after 1950 has progressed strongly here with the consolidation of the farmland into large spezialised farm units..





The recycling between crop and animal was broken up on stockless farms which used artifizial fertilisers instead of manure. Other farms was going into specialisation in animal production based on additional fodder recently from the specialised stockless crop farms and also additional imported fodder with the consequences of surplus out in the environment also together with pesticides residues. Area with dead bottoms was increasing and is today in the same extend.

Källa enl tillstånd SMHI
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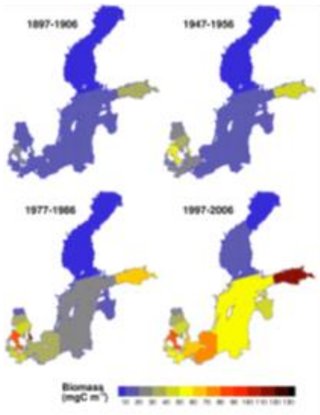
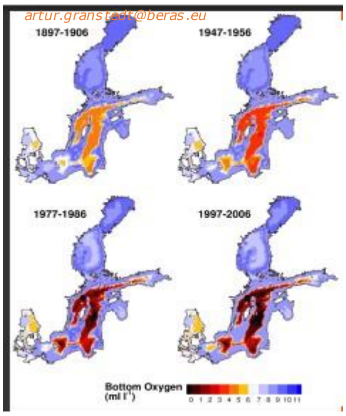
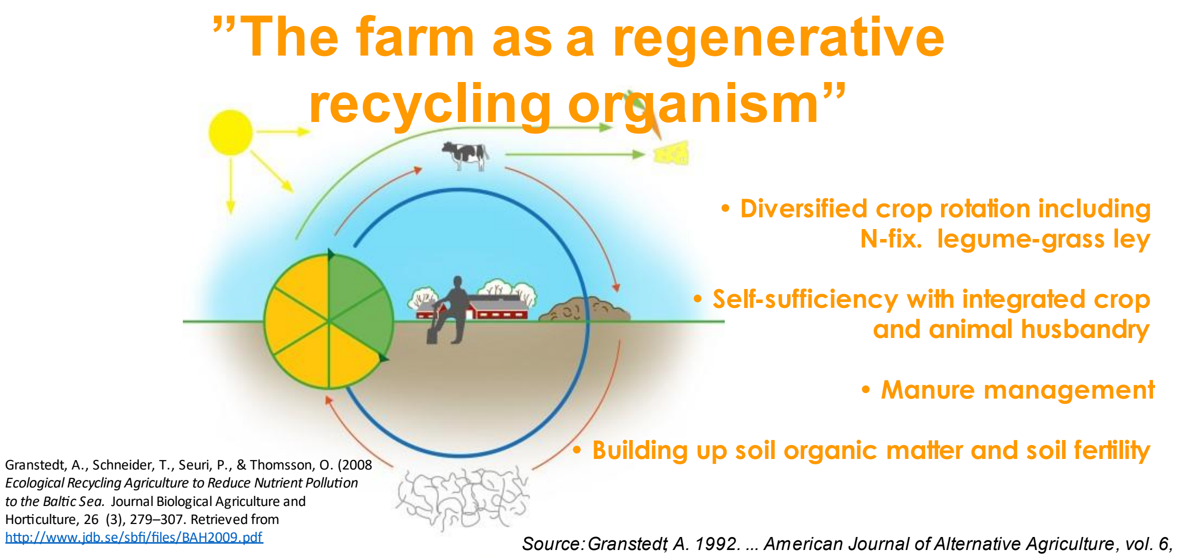




The surplus of Nitrogen and Phosphorus increase with increase of algae blooms and after decomposition finally decreased oxygen in water and areas with dead bottoms was increasing.



The ecological recycling agriculture to day is not to go back but is *developed further* from the situation *before* the use of artificial fertilizers and pesticides and imported fodder but use of the best of the latest developed technique and agroecological scientific knowledge. This building further but with the principles of integration of crop and animal production on each farm or farms in cooperation which work together as a whole system. Each part carries a part of a whole that is more than the parts. Biodynamic farming is developed in attention also on the spiritual side in the life .

1 Diversified crop rotations

with humus building perennial root deep nitrogen-fixing ley crops (green) compensating soil mineralization and crops that require more nutrients (yellow)

2. Integrated animal husbandry

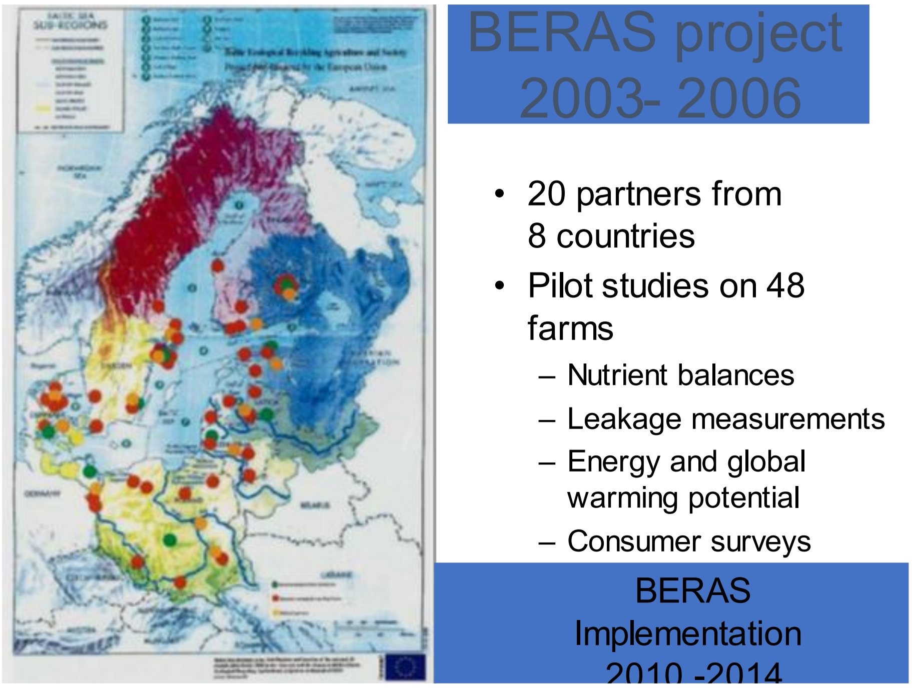
adapted to the own fodder production on the individual farm or farms in closed recycling collaboration

3. Manure management

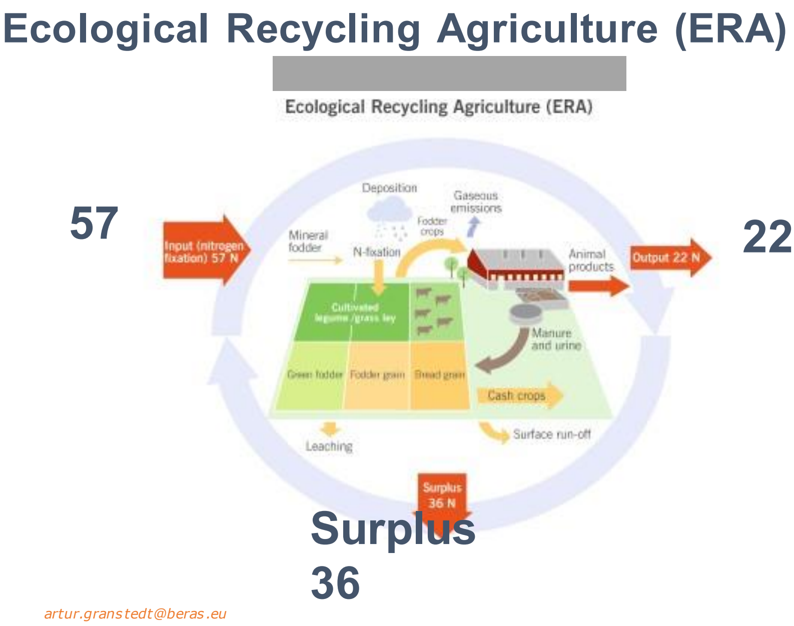
recycling on farm scale level with minimum losses of organic matter and nutrients

4. Soil building

benefit soil organisms in the field, build soil fertility and organic matter.



In the BERAS (Baltic Ecological Recycling Agriculture and Society) project partially financed by the EU, the current situation in agriculture was analyzed, in terms of plant nutrient management in the various Baltic Sea countries, as well as the plant nutrient management on a total of 42 selected ecological recycling type farms, representative of different growing conditions in the entire Baltic Sea area. The project was based on Artur Granstedt's doctoral thesis (Granstedt, 1990) and subsequent scientific reports with case studies of conventional and organic farms in the Baltic Sea region .



The image shows the nitrogen flows as an average for all farms within the Baltic Sea project BERAS and on the model farm Skilleby in Järna. The nitrogen surplus was then 54% lower and leaching 70 -75 % than the average for Swedish agriculture corresponding to the actual study period 2002-2004.

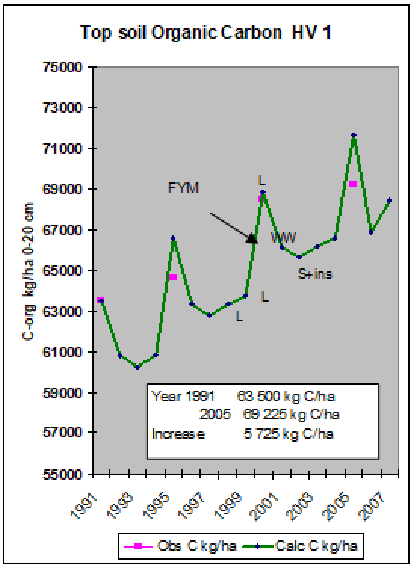
Mixed ley with red clover and grass and a plot with only grass on the experimental farm Skilleby in Järna. The amount of fixed air nitrogen is calculated here as the sum of the total nitrogen content of the aboveground and belowground biomass harvest in the grass and clover-grass plot minus the corresponding nitrogen content in the grass-only experimental plot adjusted for changes in the amount of mineral nitrogen in the soil. In the pit, observations were made of the spread of the roots to a depth of one meter and the presence of the leguminous nodules on the roots of the clover plants.

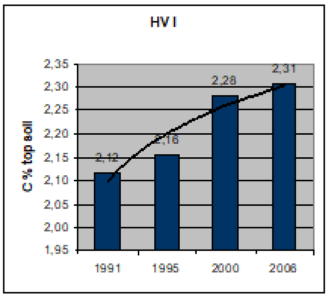
Long term manure experiment

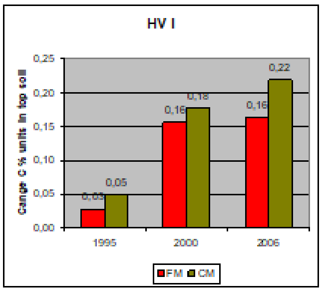
Experimental plan from 1991

Main plot	Treatments winter wheat
F1	Not composted manure 12.5 ton (0 from 1995)
F2	25 ton
F3	50 ton
K1	Composted manure 12.5 ton (0 from 1995)
K2	25 ton
K3	50 ton
Subplot (split plot) +	BD preparation each plot each year
-	Without BD preparation

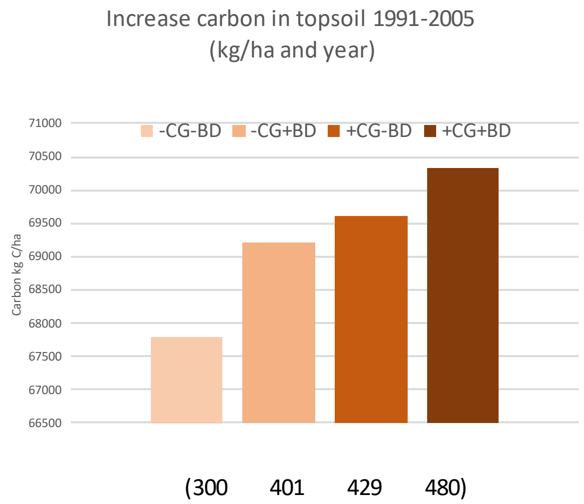
At Skilleby experimental farm in Järna, long-term trials were carried out starting in 1991 on all parcels in the five-year crop rotation comparing three level of manure wihout and with composting without and with biodynamic preparate treatments in a so-called splitplot design that was carried out with four repetitions on plots 1 and 2, two repetitions on plot 3 and three repetitions on plots 4 and 5 in the years 1991 to the year 2010.





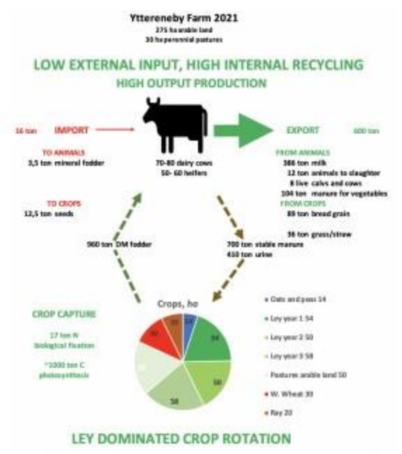


The long-term trials show that with a high proportion of clover grass ley (here three years of ley out of five years in the crop sequence) a strong humus build-up and carbon sequestration in the soil takes place compared to a lower proportion of clover-grass ley. Composting the manure gives a higher humus formation. In specialized cereal farming, the opposite can happen with a breakdown of humus and lost of organically bound carbon. The soil as a possible store of organically bound carbon is confirmed here. As can be seen from the picture (left), this humus build-up takes place in stages in connection with the fodder crops and recirculation of the stable manure, while consumption occurs when straw grain is grown. The increase in humus content corresponded here to an average of 400 kg of carbon per ha and year in the topsoil 0-20 cm (over 1500 kg CO_2 equivalents per ha and year) and 300 kg in the underground soil (60-90 cm). This corresponds to a total of approximately 2 600 kg of carbon CO_2 equivalents per ha and year. It confirms the results from also older comparative trials with biodynamic cultivation.



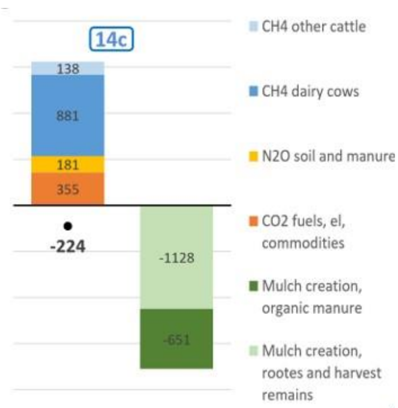
The build-up of organically bound carbon in topsoil on shift 1 during the period 1991 to 2005 corresponded on average to 400 kg C par ha and year, with the highest value for composted manure with biodynamic compost preparations (480 kg/ha / year) and field preparations which can be compared with no composting and without biodynamic preparations (300 kg/ha / year) (Granstedt, A., & L., Kjellenberg, 2017).

Rapport *Framtidssäkrat jordbruk*, 2022

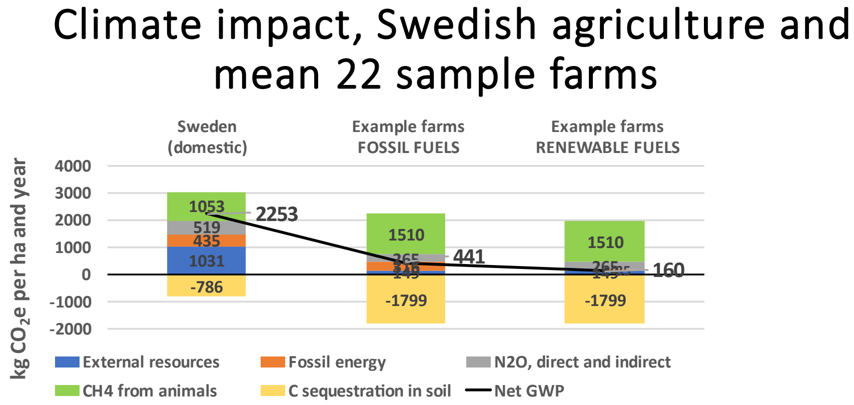


Figur 22b. Flöden av resurser och växtföljd på en ERA-gård. Exemplet Ytterenby gård med 275 ha åker och 30 ha naturbeten år 2021.
Figure 22b. Flows of resources and crop rotation on an ERA-farm. The example Ytterenby farm with 275 ha arable land and 30 ha natural pastures year 2021.

Climate balance calculated for Skilleby-Ytterenby gård 2021

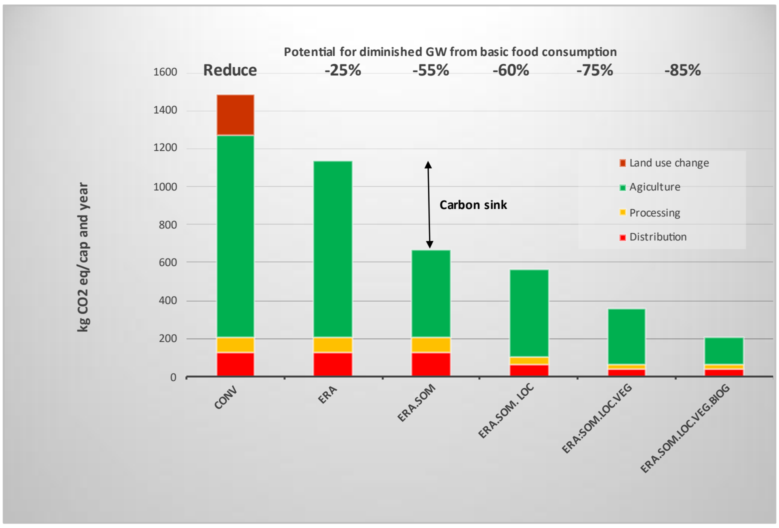


Against the background of the results from many years of research work, the Baltic Sea project BERAS, new research results and the serious current situation, the project Future-secured agriculture started in 2020 which include both nutrient balances and the climatic consequences. Ytterenby-Skilleby farm in Järna 2021, is one the 23 example farms in Sweden. The graphic describes the crops that are grown, supply of feed, seed, uptake of nutrients from air and soil, cycle of feed for the animals and manure back to the ground, and removal with animal and plant foods. This study of the climate balances show that the carbon storage can be greater than the emissions of greenhouse gases calculated in carbon dioxide equivalents (Granstedt and Thomsson 2022). Calculated values for the carbon storage agree with a good margin with data from our long-term experiments at Skilleby with soil samples taken to a soil depth of 90 cm.



Data for the Example farms are mean values for all22 farms. The variation is large, some even net sequestrators, but all show better results compared to the average Swedish agriculture. The main reason for the lower net climate is:
1) 85 % lower use of external resources through more internal recycling
2) 230 % more carbon sequestration in grasslands, including more nitrogen fixation legumes in crop rotationson all arable land

Against the background of the results from many years of research work, the Baltic Sea project BERAS, new research results and the serious current situation, the project Future-secured agriculture started in 2020. The focus here is above all the climate issue but also the nutrient leakage from agriculture. The project is based on documentation and evaluation of selected example farms in Sweden cultivated in accordance with the principles of a regenerative ecological recycling agriculture under the widely different conditions that prevail from northernmost to southernmost Sweden. The figure summarizes the first years' results for the 22 farms. Here, the potential to reduce the climate impact from primary production by 90% is shown. Individual farm studies show that you can get even further with a net storage of carbon in the ground.



In the scenarios based on results from the BERAS project's sample farms (2003-2006) it was taking into account the whole food chain with possible changes in land use, agriculture, processing and distribution: Food from ecological circular farms (ERA) could reduce the climate impact by about -25% with the entire production chain. If the build-up of the soil's organic matter (ERA.SOM) detectable after at least one crop rotation is also taken into account, the climate load is reduced by -55%. Local processing and distribution (ERA.SOM.LOC) further reduce the climate impact to -60%. With also more vegetarian and almost exclusively forage-based meat and milk consumption (ERA.SOM. LOC.VEG.) the load is reduced by -75% and with production of farm-based biogas as fuel produced from the farm's own manure (ERA.SOM.LOC. VEG. BIOG), then the climate burden is reduced by -85% (Granstedt, 2012).

- **An ecological recycling agriculture based on integrated crop and animal production with effective recycling of nutrients and organic biomass and crop rotations with legume - grassland can:**
  1. **conserve basic natural resources**
  2. **rebuild fertile soils and biol diversity**
  3. **protect the Sea from N, P and pesticides**
  4. **reduce the global warming**
  5. **Improve the food nutritional quality**

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Summary:

Results from our long term on farm studies can be summarized in above sentences. An ecological and biodynamic agriculture is based on integrated crop and animal production with effective recycling of nutrients and organic biomass and crop rotation with grass/clover grassland and other legumes. Recycling conserve nature resources, protect the sea from surplus of nitrogen and phosphorus compounds. Combined with legume plants recycling rebuild fertile soils, give carbon sequestration, and reduce negative human climatic impacts. This farming system finally improve the food quality through more and effective recycling of nutrients, higher biological activity in soil and no use of dangerous pesticides.