AARHUS UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE
DCE – DANISH CENTRE for ENVIRONMENT and ENERGY

28 May 2019

Organic soils and their CO_2-emissions

Steen Gyldenkærne and Mogens Greve, Aarhus University

Ongoing projects

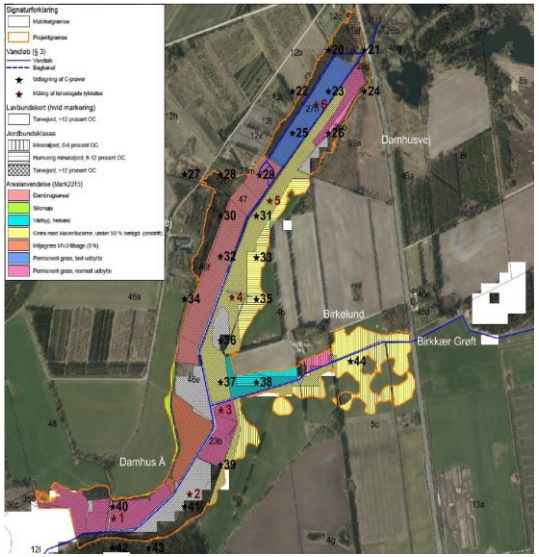
- New estimation methodology for perennial wooden areas not qualifying as forest – hedges (not horticulture)
- LiDAR flown in 2006 and 2014/15
  - Estimation of volume, m^3/m^2
  - Change in volume between 2006 and 2014/15
  - 2006 resolution 1.6 m * 1.6 m
  - 2014/15 resolution 0.4 m * 0.4 m
  - Chip volume - measured in chipped hegdes - ≈ 0.01 m^3/m^3

Ongoing projects

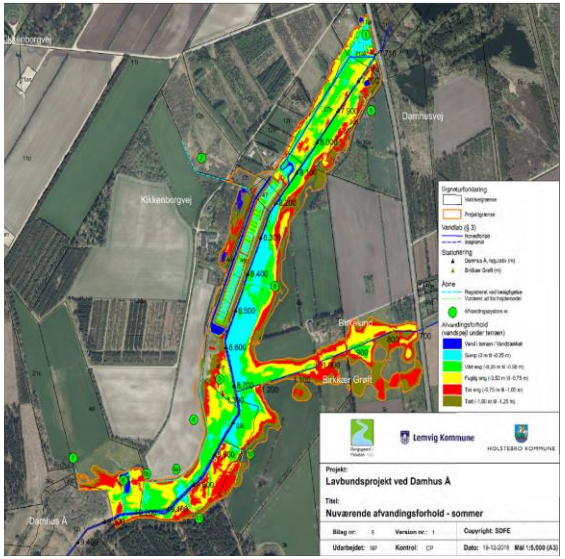
› Wetland restoration

- Partly financed by Pillar 2 – EU subsides
- Currently app. 120 project applications

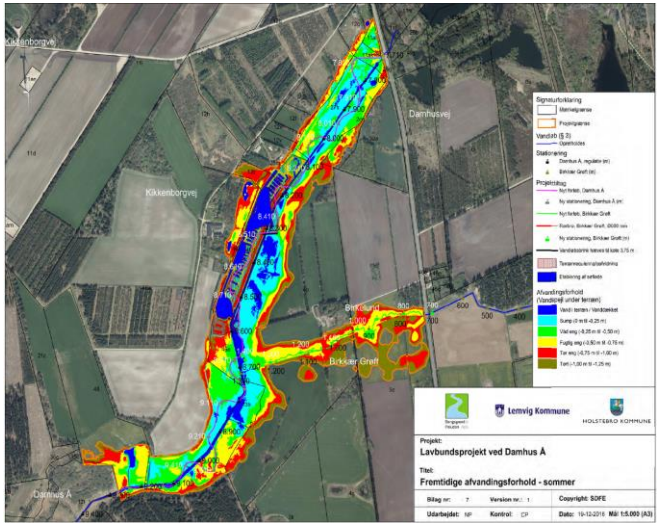
Current land use



Current water table



Future water table



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- Organic soils
- Something about measurements
- Danish data
- CAP, Common Agricultural Policy
  - Good Agricultural and Environmental Conditions (GAECs)
  - Statutory Management Requirements (SMRs)
- We are looking for a PhD student
  - Interested in RS
  - Organic soils

Setting the scene: Emissions from organic soils (CO_2 and N_2O)

Submissions	2017, total kt CO2-eq, ex. LULUCC	Organic soil, kt CO2	Organic soil, N2O, kt CO2-eq	Pct
Total	2380839	101080	13457	4.8%
ISL 2019 v1	4755	6977	25	147.3%
LVA 2019 v2	11306	4758	809	49.2%
LTU 2019 v1	20417	6087	520	32.4%
FIN 2019 v4	55334	11379	1500	23.3%
SWE 2019 v1	52660	8391	832	17.5%
IRL 2019 v2	60744	8984	672	15.9%
DNK 2019 v1	49226	3601	477	8.3%
NOR 2019 v1	52713	2480	375	5.4%
EST 2019 v1	20880	911	130	5.0%
DEU 2019 v1	906611	35908	2838	4.3%
LIE 2019 v1	194	6	1	3.3%
NLD 2019 v1	193260	4829	702	2.9%
CHE 2019 v2	47159	556	65	1.3%
POL 2019 v2	413781	2740	2540	1.3%
SVN 2019 v3	17453	92	9	0.6%
GBR 2019 v1	474346	1120	1070	0.5%

Submissions	2017, total kt CO2-eq, ex. LULUCC	Organic soil, kt CO2	Organic soil, N2O, kt CO2-eq	Pct
AUT 2019 v2	82261	304	50	0.4%
HRV 2019 v2	25020	92	10	0.4%
ROU 2019 v3	113796	350	24	0.3%
GRC 2019 v1	95421	244	25	0.3%
BGR 2019 v1	61367	0	155	0.3%
ITA 2019 v1	427708	913	95	0.2%
FRA 2019 v1	471028	220	522	0.2%
HUN 2019 v2	63788	62	0	0.1%
BEL 2019 v1	114540	75	9	0.1%
CYP 2019 v6	8945	0	0	0.0%
CZE 2019 v1	128675	0	0	0.0%
ESP 2019 v1	340231	0	0	0.0%
LUX 2019 v1	10236	0	0	0.0%
MCO 2019 v2	87	0	0	0.0%
MLT 2019 v4	2152	0	0	0.0%
PRT 2019 v2	70546	0	0	0.0%
SVK 2019 v4	43316	0	0	0.0%

Defintion of organic soils

- Organic soils are identified on the basis of criteria 1 and 2, or 1 and 3 listed below (FAO 1998) (from the 2013 Wetland Supplement):
  - 1. Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.
  - 2. Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).
  - 3. Soils are subject to water saturation episodes and has either:
    - a. At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay; or
    - b. At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay; or
    - c. An intermediate proportional amount of organic carbon for intermediate amounts of clay.

EF from 2013 IPCC Wetland Supplement

Land use category	Climate/vegetation zone	EF, ton C/ha/yr
Cropland, drained	Boreal/temperate	7.9
Grassland, drained	Boreal	5.7
Grassland, drained, nutrient-poor	Temperate	5.3
Grassland, deep-drained, nutrient-rich	Temperate	6.1
Grassland, shallow-drained, nutrient-rich	Temperate	3.6

Grassland EF is lower than Cropland

Deep-drained has higher EF than shallow-drained

Measuring C content i soil samples

- Take a soil sample with a stick
  - Dry it
  - Remove stones
  - Grind it
  - Sieve it
  - Take a subsample of xx gram
  - Add acid if nescessary to remove $CaCO_3$
  - Burn it, where you are measuring the emitted CO_2
  - Estimate the Carbon content in %
- Result: % Carbon, gram/gram

An organic soil

Imagine this is an organic soil, >12 % OC

Top layer: 20 cm thick
OC: 24 %

What is the carbon content if it is ploghed to 40 cm?

- Above 12 %
- 12 % (organic)
- Below 12 % (not organic)

Surface-water-gley developed in glacial till, Northern Ireland

https://en.wikipedia.org/wiki/Soil

› We have to rethink the way we estimate CO_2 emissions from organic soils

- In Wetlands we assume that there is no CO_2 if the average water table is 10 cm below the surface
  - › C build-up is equal to the degradation in the unsaturated zone

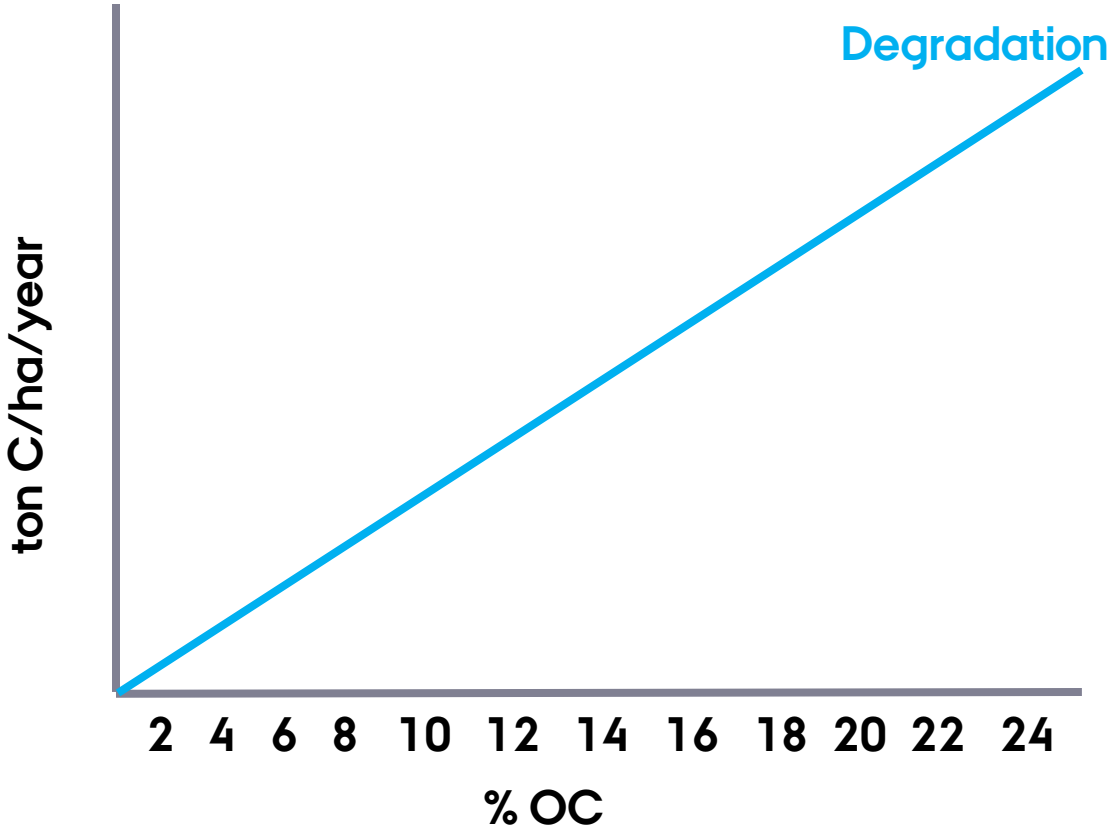
$$\Delta C = C_{input} - C_{degradation}$$

- This concept is used when modelling C turnover in land
- We should think using this concept to drained organic soils too

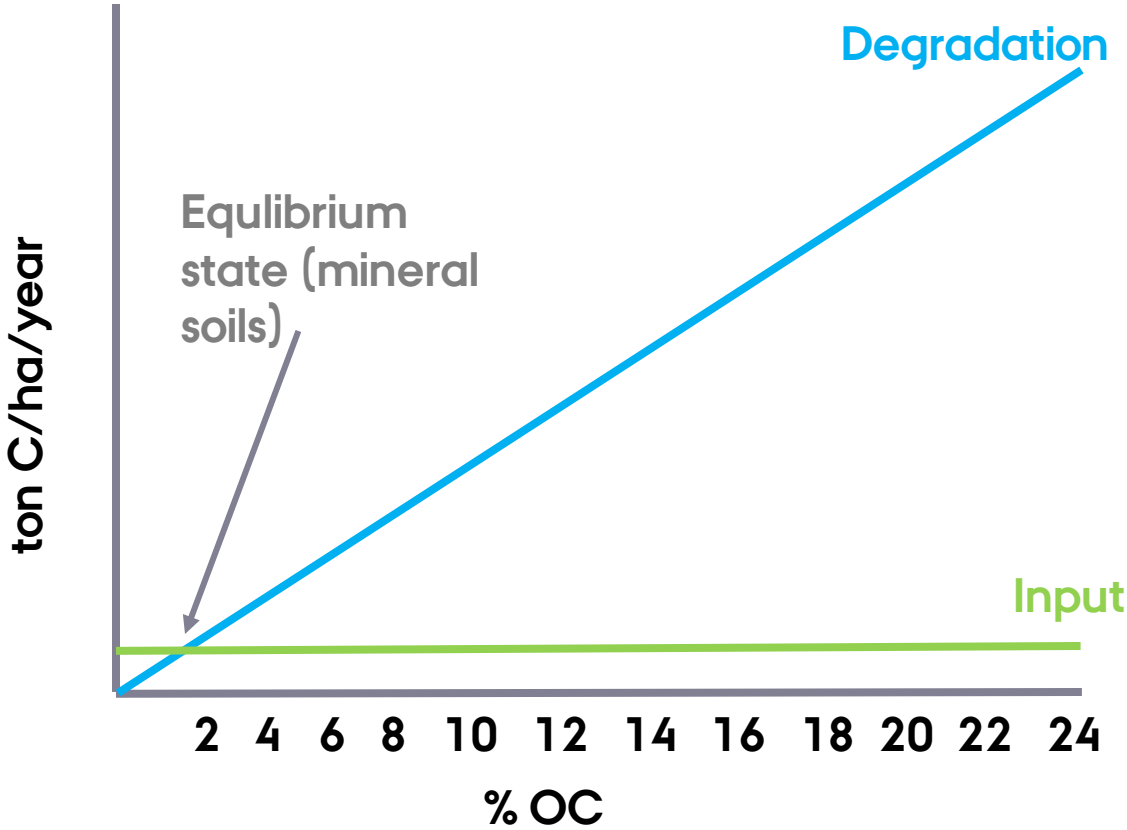
$$\Delta C = C_{input} - C_{deg}$$

C_{input} = dead organic matter + roots + root exudates

$C_{deg, ha}$ = % OC * bulk density (t/m^3) * distance to water table (m) * EF_{deg} (ton/ton) * 10000 m^2

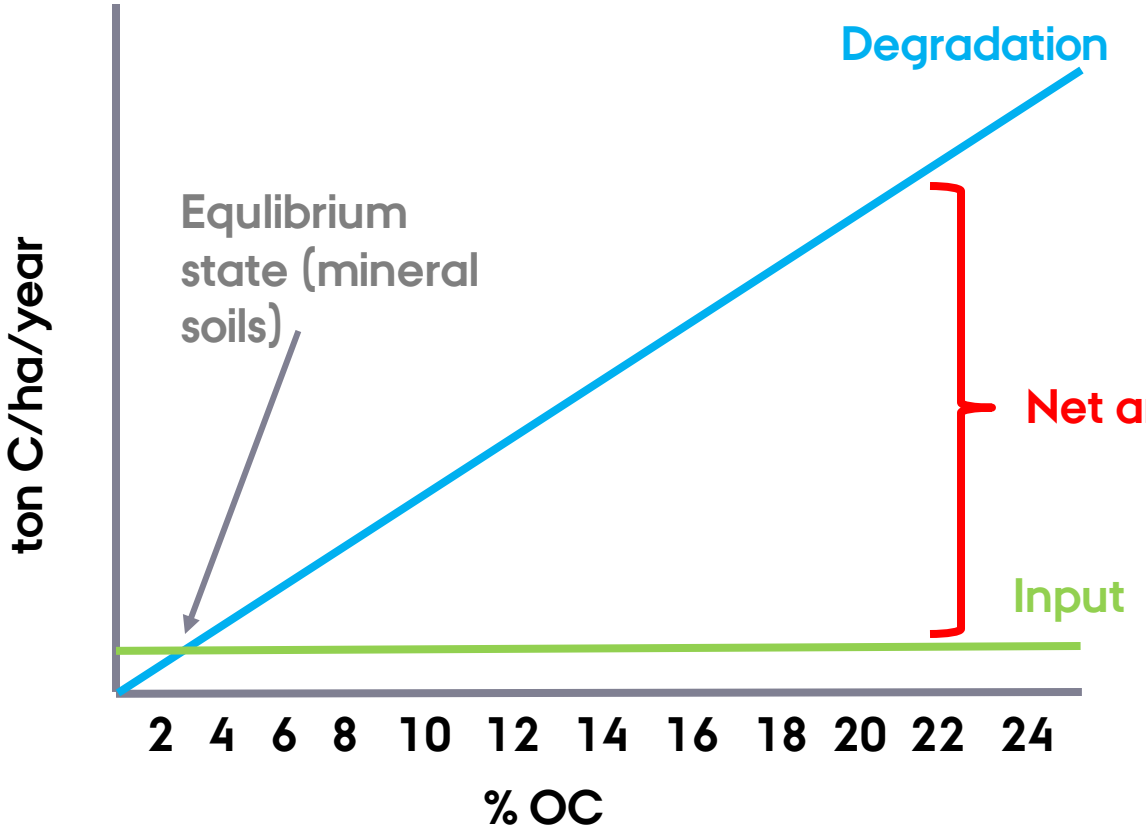


Total degradation depends on the total amount of OC in the aerobic soil compartment



Total degradation depends on the total amount of OC in the aerobic soil compartment

Input is fairly constant between years, you dont have to measure NEE



Total degradation depends on the total amount of OC in the aerobic soil compartment

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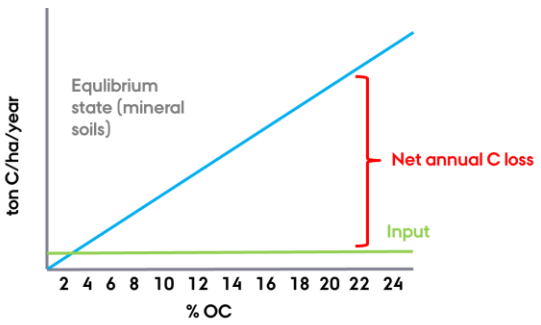
Measuring CO2 emissions



- My feelings
- Only limited need for measuring NEE
  - Average C input from the existing crop is a default value
  - Only soil respiration is needed for soils with large OC contents
  - Eg. SRS2000

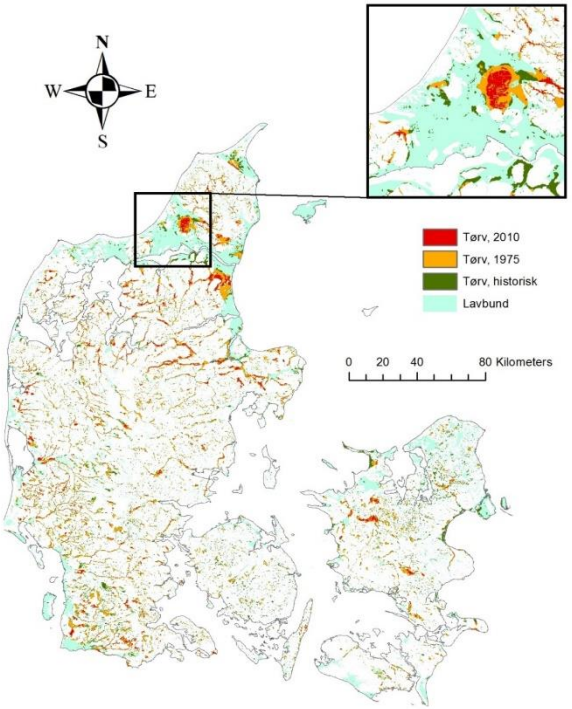
› Are the IPCC EFs wrong ?

- No, they are not wrong. They represent the conditions on which they are measured
- But do they include all emissions ?
- What about soils having >12 % OC ?
- And can the estimates be improved ?

The Danish case I

- Denmark is a flat country with a lot of shallow organic soils
- Soil Mapping
  - in 1975: 175,000 ha
  - in 2010: 107,000 ha

Organic soils are disappering



The Danish case II

Area of peatland with different carbon content, 0-30 cm on agricultural soils, 2010

Carbon (%C)	Area (ha)
< 3	App. 65,000
3-6	62,960
6-12	43,789
>12	70,481

The Danish case III

Average carbon content on former peatland above the water table, (ton C/ha) after carbon content in the top soil (0-30 cm).

Carbon (%C)	Obervations (n)	Carbon content C/ha)
0-3	121	112
3-6	259	216
6-12	385	305
12-24	494	353
>24	777	415

› After 30-40 years

- More or less all aerobic organic matter is gone
- Unless you have or are able to drain further
- How much have you left ?
- What is the story-telling on the fate of organic soils ?

The Danish case

- We will probably get funding for investigating this further
- Updated EF and emissions in 2024
- We need data from other countries
- If you have any data sets including:
  - % Carbon
  - Bulk density
  - Distance to water table
  - CO_2 emissions
  - Please send them to me
  - Steen Gyldenkærne: e-mail: sgy@envs.au.dk

Results

- The current Danish inventory is probably underestimating the CO_2 emissions from soils not qualifying as organic soils
- Over time the emission will cease naturally
- Focus will be on soils with large carbon stocks

CAP

- **Enhanced 'Conditionality'**
- Conditionality is an integral part of the future CAP framework and replaces 'greening' and cross-compliance of the current CAP
  - **Climate Change**
  - GAEC 2 – Preservation of carbon rich soils such as peatlands and wetlands (new).

THE FOUNDATION: CONDITIONALITY

- Conditionality is a system of linkage between area- and animal-based CAP payments (in Pillar I or Pillar II) and a range of obligations.
  - When recipients of payments (mainly farmers) do not meet the obligations, the payments may be reduced. These **obligations** originate either in CAP legislation (in the case of "standards for good agricultural and environmental condition" – GAEC) or in non-CAP directives and regulations (SMRs).
  - The new system will effectively merge and streamline two elements in the current CAP – known as "**cross-compliance**" and "**greening**".

Conditionality

› Requirements

- Mnimum spending on the environment and climate in CAP Pillar II will be modified.
- In their CAP plan, Member States **will remain obliged to earmark at least 30% of their EU Pillar II funding to be spent on the environment and climate**
- Member States will be able to transfer extra funds from Pillar I to Pillar II for environmental purposes, if they wish: in addition to the basic 15% which can be spent on any type of Pillar II support, a further 15% will be possible - which must be devoted only to environmental and climate objectives.

Conditionality

› To address these (and other) CAP objectives, each Member State will draw up a "**CAP strategic plan**". In its plan, each Member State will analyse the situation on its territory in terms of strengths, weaknesses, opportunities and threats (SWOT) – as well as its related needs – in respect of these objectives. **It will set quantified targets** against the objectives and design "interventions" (types of action) for achieving them, on the basis of an EU-level menu. The Commission will approve the plan when satisfied with its quality. **Year-by-year progress against the targets will be monitored and the plan will be adjusted as necessary**.

Conditionality

› What does it mean ?

- Very **close corporation** between the Agricultural and Climate ministries **is needed**
- Close monitoring of progress has to be shown in the inventories
- Pillar 1 payment (general area subsidy) to all farmers is moved to pay farmers on organic soils to take them out of rotation
- Farmers on mineral soils are paying the bill

PhD student wanted

› Remotely sensed mapping of water table levels and humidity on Danish organic soils

- Interested in remote sensing
- Looking for water logged organic soils

- Contact:
- Senior Advisor Gregor Levin
- E-mail: gl@envs.au.dk
- Phone: +45 871 58664
- Link: http://phd.scitech.au.dk/for-applicants/apply-here/august-2019/remotely-sensed-mapping-of-water-table-levels-and-humidity-on-danish-organic-soils/