AARHUS UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE

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Climate regulating service from no-tillage in Danish agriculture – Costs and Effects

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2nd Science for the Environment Conference
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Ecosys Project

› **Aim:** Provide test cases for national analyses of ES mapping and economic valuation to provide input to the development of an operational framework for assessment of ES.

› **Selected Services**:

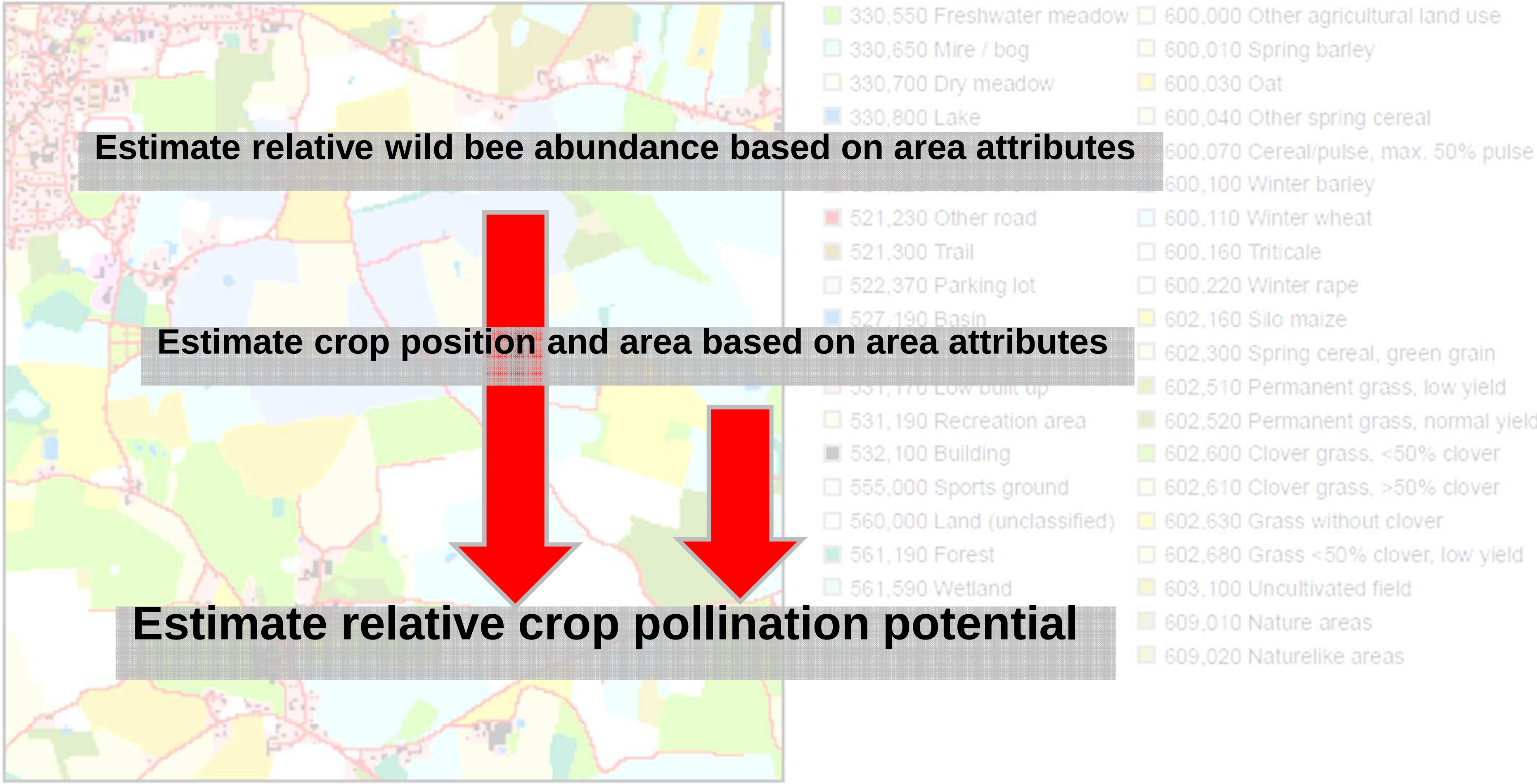
– Provision (Food)
– Regulatory (**Climate**, **Fresh Water Quality**, **Pollination**)
– Cultural (**Recreation**)
– **Biodiversity**

› **Participants**: Hans Estrup Andersen, Thomas Becker, Jørgen Brandt, Berit Hasler, Brian Kronvang, Janus Larsen, Gregor Levin, Louise Martinsen, Flemming Møller, Doan Nainggolan, Steen Solvang, Peter Borgen Sørensen, **Mette Termansen**, Anne Winding, Marianne Zandersen

Subproject: Crop Pollination Services

Basic GIS data (Basemap, Gregor et al., 2012; Jepsen et Levin, 2013)

Main principles for application of the INVEST model (Lonsdorf et al., 2009)



Estimate relative wild bee abundance based on area attributes

Estimate crop position and area based on area attributes

Estimate relative crop pollination potential

Participants: Peter Borgen Jørgensen, Gregor Levin

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Subproject: Recreation Services (in collaboration with DØRS)

› National mapping and valuation of recreation services from all types of green spaces

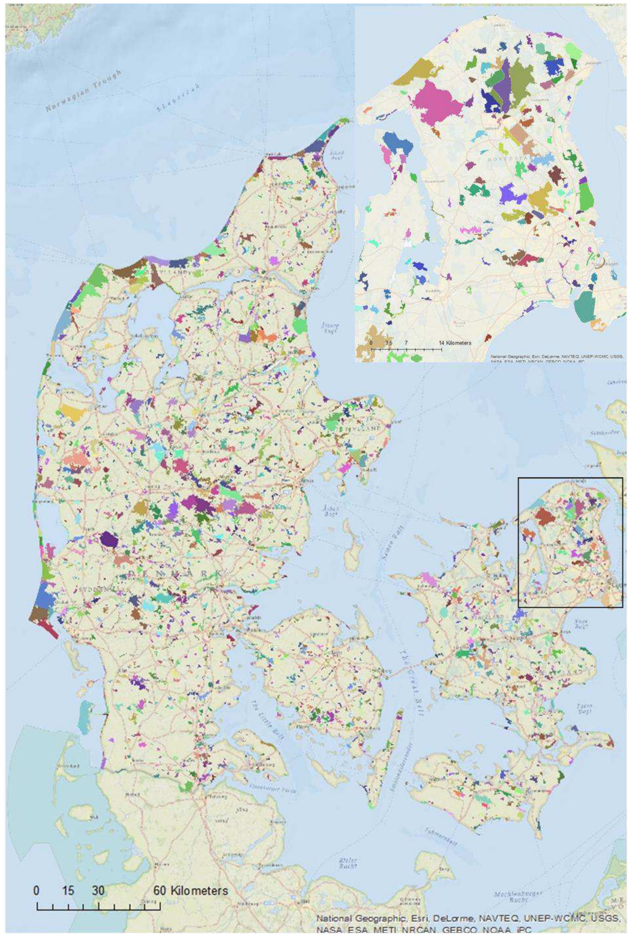
› Survey data: national representative household sample

› Site characteristics:

– Land use: 36 categories of land use; each 10m2 assigned a category (Basemap, Levin 2012)

– Other : noise levels, site ownership, road densities

› Valuation approach: discrete choice framework (Termansen et al. 2004; Zandersen et al. 2007; Termansen et al. 2013)

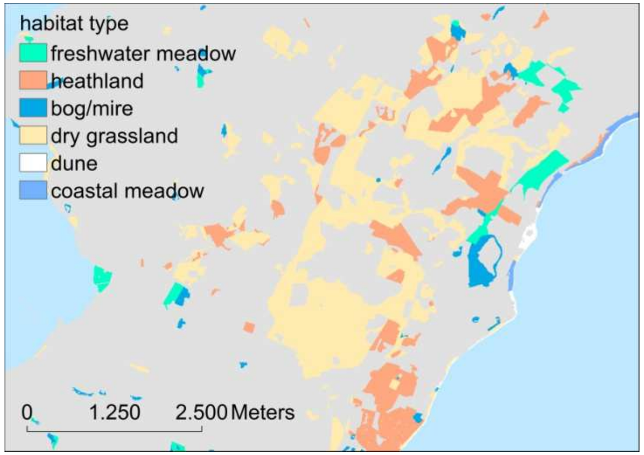


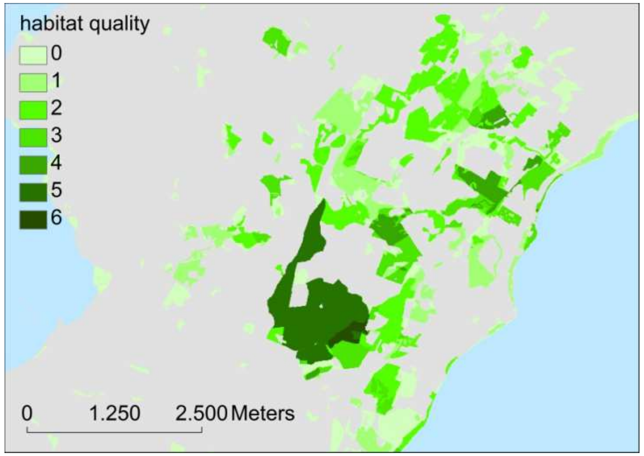
Participants: Mette Termansen, Thomas Becker, Marianne Zandersen

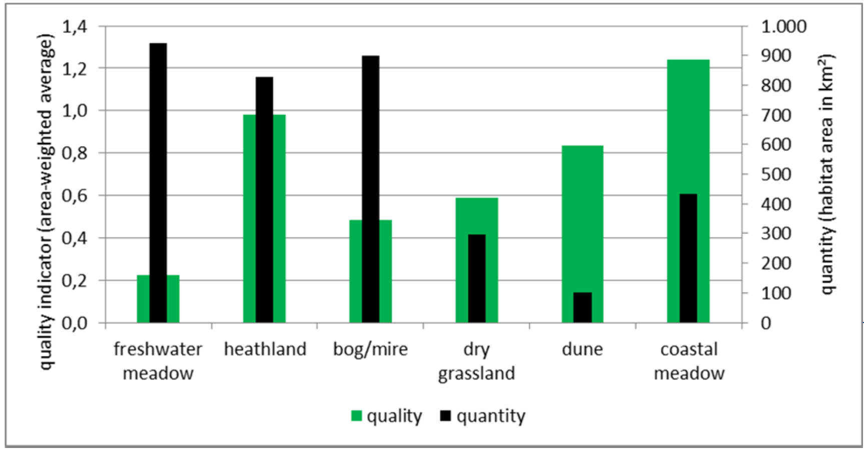
Subproject: Biodiversity

› Two dimensions of biodiversity:

- Habitat quantity
  - Area of habitat types according to national registrations (based on Basemap (Levin et al. 2012; Jepsen et Levin, 2013)
- Habitat quality
  - Indicator reflecting presence of different red-listed and indicator species (based on Danish High Nature Value Indicator (Ejrnæs et al. 2012))







Participant: Gregor Levin

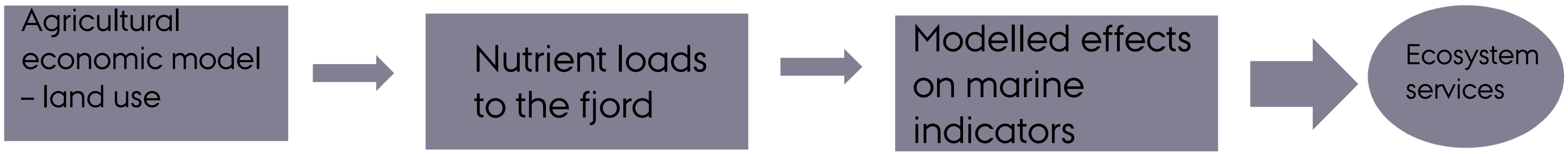
Subproject: Water Quality Regulation

› Two objectives:

– Water resources accounts – recommendations and description of data needs, exemplified by the Odense area

– Mapping and valuation of water ecosystem services in Odense catchment

› Model chain:

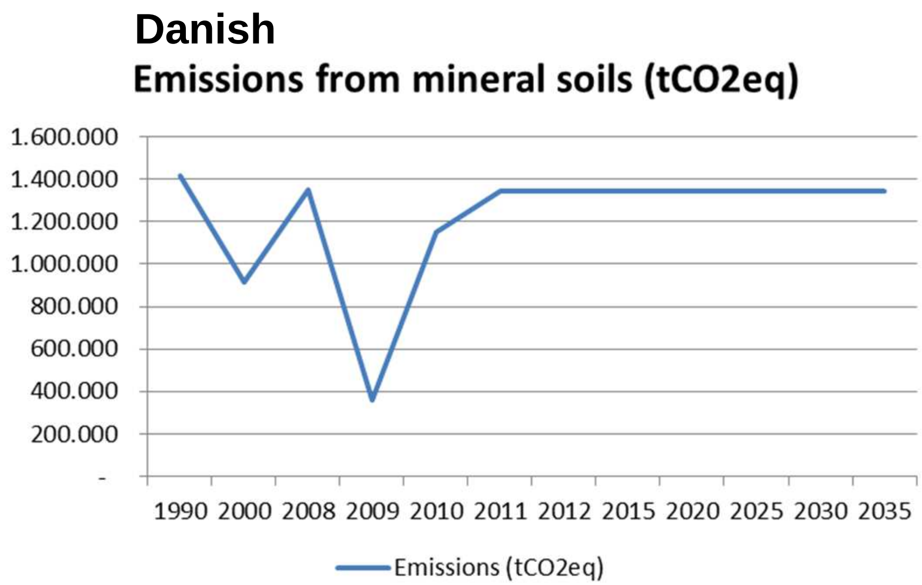


› The resulting ecosystem services are estimated by a valuation study for Odense – fjord, river and lakes.

Participants: Berit Hasler, Flemming Møller, Louise Martinsen, Janus Larsen, Brian Kronvang, Hans Estrup Andersen

Sub-project: Climate regulating service from enhancing soil organic carbon

- Carbon in soil and biomass plays a crucial role in regulating the global carbon cycle
- Soil carbon stocks are declining in many regions
- Denmark has lost on average ca. 1.2MtCO_{2eq}/yr since 1990 from mineral cropland



Source: DCE, 2013

Aims of project

- Assess carbon sequestration effects of no-tillage on mineral cropland
- Estimate costs of setting up a voluntary Payment for Ecosystem Services (PES)
- Marginal abatement costs of no-tillage & comparison with other mitigation option costs

Tillage practices

- *Conventional tillage* – mouldboard ploughing in autumn and spring to a normal depth of 18-30cm, followed by seed bed preparation and sowing
- *Reduced (shallow) tillage* – Soil tillage to a maximum depth of 10cm by means of a cultivator, disc harrow, or rotovator
- *Direct drilling (or non-tillage)* - Direct drilling in un-tilled soil where straw has been removed or burned and weeds have been killed by use of chemicals.
- *Conservation tillage* - Plant residues have been left on the soil surface. Plant establishment is made by use of direct drilling or reduced soil tillage methods.

Enhanced ecosystem services through reduced or no-tillage

› Improvements in soil structure (soil aggregate stability) by letting air and water enter the soil:

– regulates risks of dry conditions (reduced surface crusting -> improves germination and seedling establishment)

– regulates inundations as water infiltration rate increases (hydrological regulation)

› Accumulation of organic carbon (carbon sequestration)

› Enhanced soil fauna (biodiversity – earth worms and fungal communities)

› Increases in soil nutrients (available potassium & phosphorous)

› Protection against soil erosion

› Enhanced soil aggregate stability

› Decreased leaching of nitrogen

Source: Rasmussen, 1999; Andersen, 1987

IPCC Guidelines on Carbon Stock Effects of Tillage Practices

	Default reference	Stock change factors					
	($tCHA^{-1}$ 0-30cm)	High input w. manure	Medium input	Land use (over 20 years)	Full tillage	Reduced tillage	No tillage
HAC soils	95	1.44 (+/-13%)	1	0.69 (+/-12%)	1	1.08	1.15
LAC soils	85						
Sandy soils	71						

HAC – high activity clay; LAC – low activity clay

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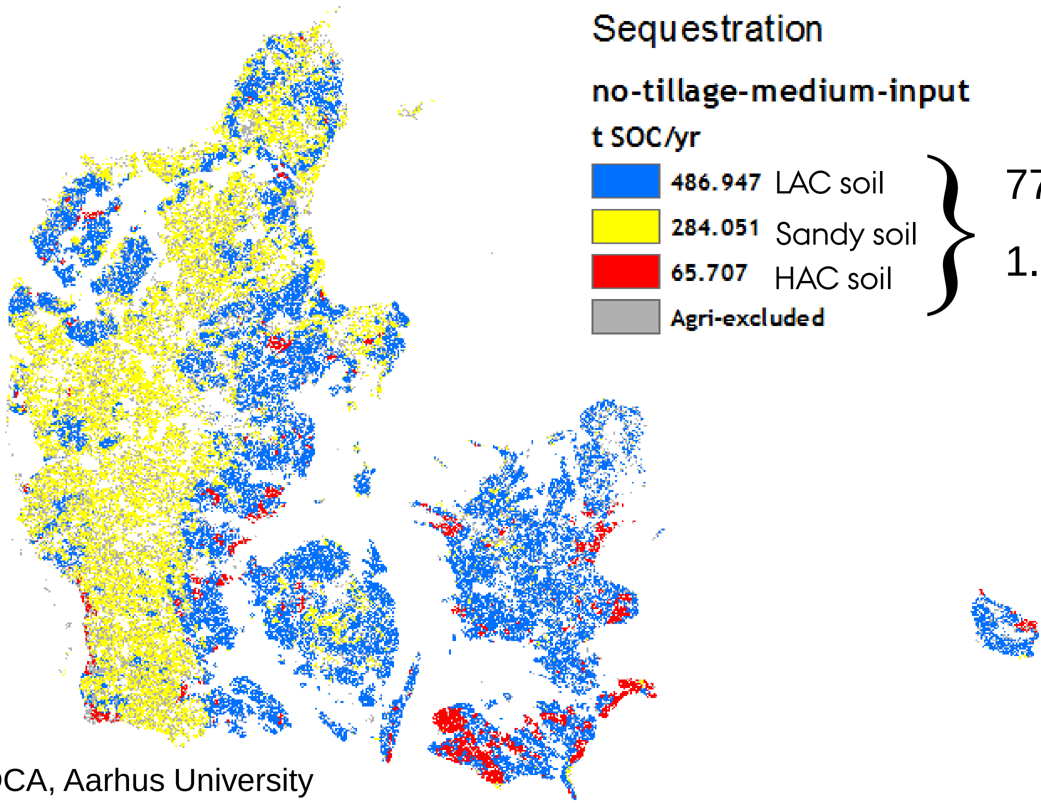
Carbon sequestration on no-tillage cropland – medium input



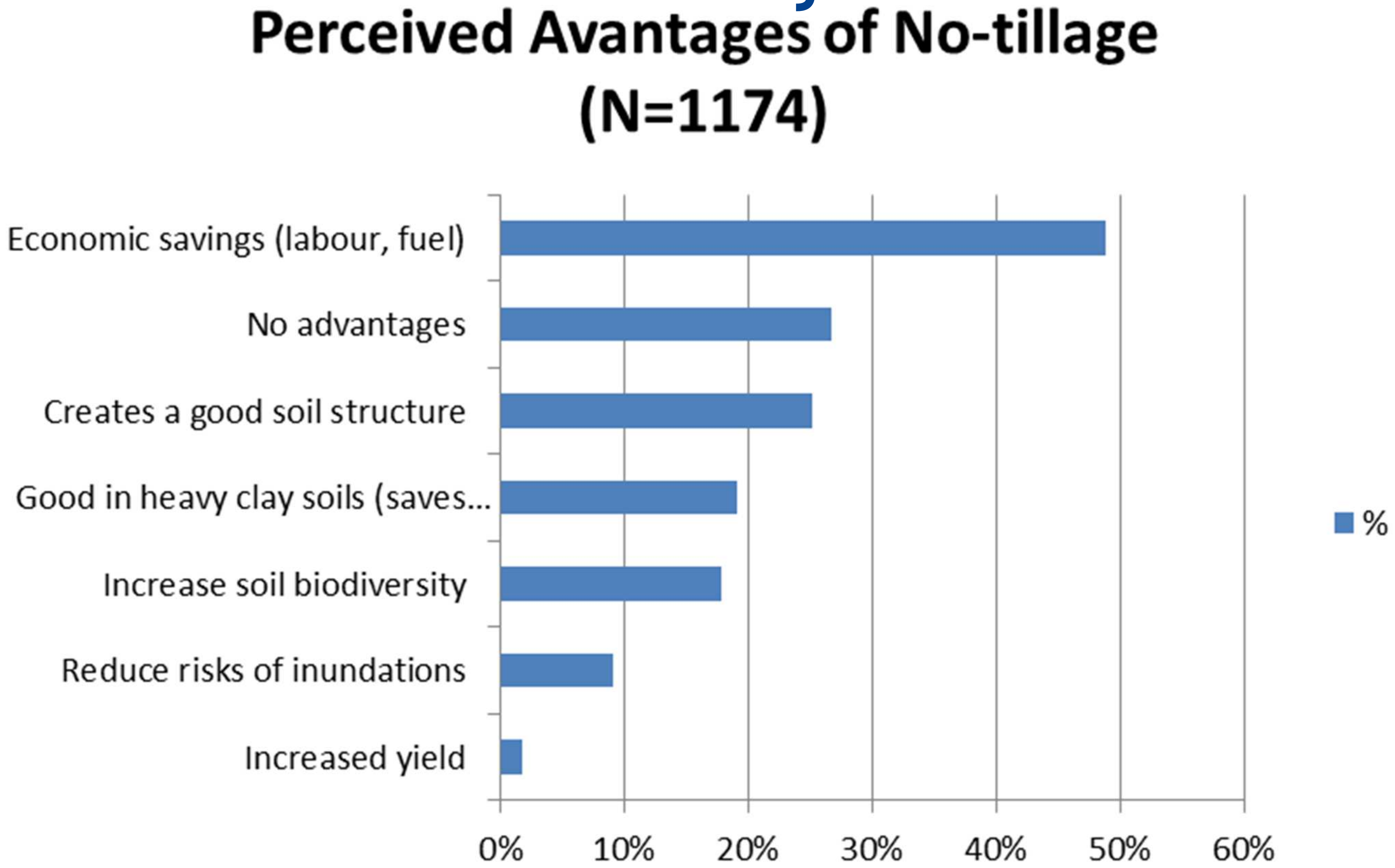
771.000tC/yr = 2.8MtCO2eq/yr

1.5tCO2eq/ha/yr

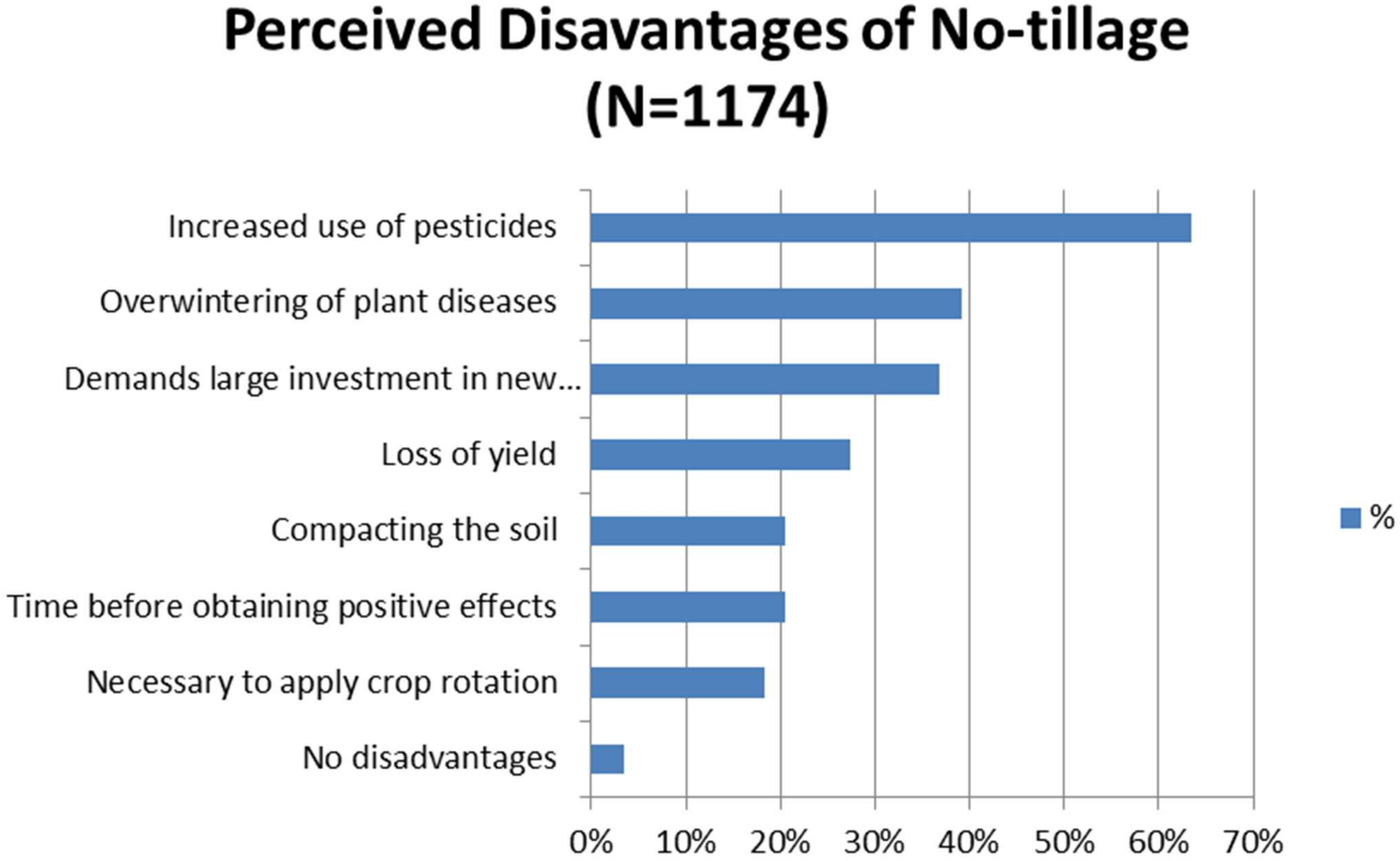
Agri excluded" = grassland in rotation; permanent grassland and organic soils

LAC= Soil types 4-6; HAC= Soil types 7-10; Sandy soil= Soil types 1-3

Farmers' views on no-tillage



Farmers' views



How is no-tillage applied?

Farmers with experience in no-tillage (NT)

- Ca. 5% of respondents practice NT on their whole land
- Almost 20% of respondents practice NT to some extent.

Farmers without experience in NT

- 6% consider starting with NT
- Vast majority of those interested would need more information before starting (70%)
- 17% would need compensation and ca. 7% a guarantee on yield-loss compensation

Farmers' preferences for potential NT schemes (N=483)

MNL Regression

Variable	Coefficient
No Tillage 25%	0,23**
No Tillage 50%	-0,28**
No Tillage 75%	-0,70***
Sludge (1=yes)	-0,05
Contract length (1=10 yrs)	-0,11**
Contract cancellation (1=yes)	0,13**
Compensation (dkr)	0,0033***
ASC_SQ	2,54***
LL2	-2466,86

Public Costs of implementing no-tillage as a performance contract

- Welfare estimate based on contracts of 10yrs with possibility of cancelling the contract at any time with no additional costs; no sludge involved.

Reduced tillage (% of land area)	Compensation (dkr/ha/yr)
50%	995
75%	1103

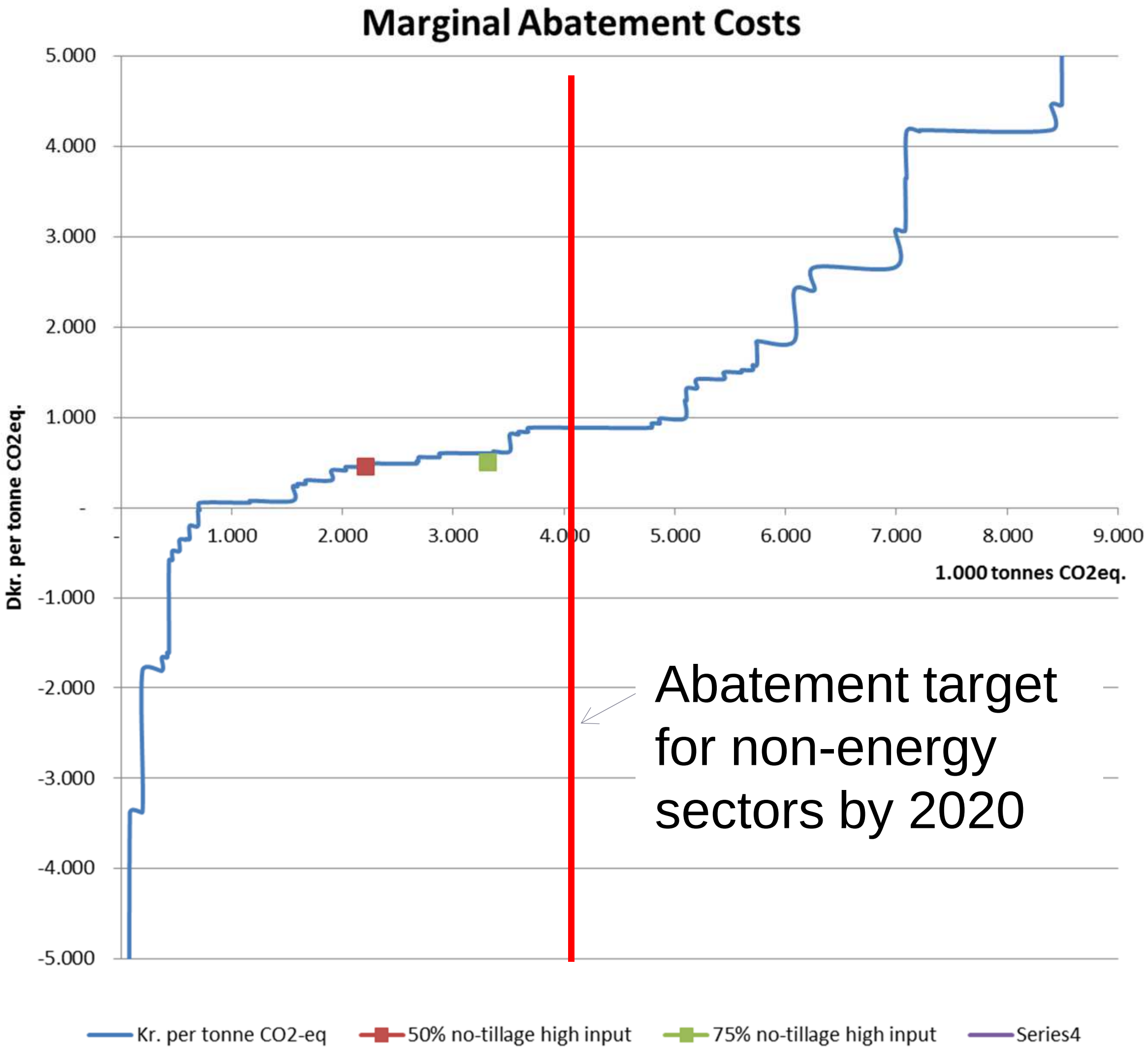
Public total costs & marginal costs of implementing No-tillage

Reduced tillage (% of land area)	Total costs (bn dkr)	Marginal costs (dkr/tCO2e)
50%	1.0	454[a]-653[b]
75%	1.65	503[a]-724[b]

[a] High input

[b] Medium input

Marginal Abatement Costs - Denmark



Source: Kebmin, 2013

Conclusions/Perspectives

› No-tillage is potentially a significant contributor to reducing carbon emissions:

– No-tillage could potentially sequester 2.8-4MtCO2eq/yr calculated over a 20 year period if all mineral soils were under no-tillage

– Contracting with farmers for 50%-75% of their land could potentially sequester up to 2.2-3.3MtCO2eq/yr (over a 20yr period)

› Contracts are expensive due to high shares of farmers resisting.

– This is not only the cost of implementing the measure but includes the costs of getting farmers on board

– If a regulation is made in stead, the public would not incur these costs

› Abatement costs appear to be well within reasonable ranges

– Marginal costs of NT are below the missing 4.03MtCO2eq in terms of marginal costs and cumulative emissions

Continuing work…

- Latent class analysis of farmers' preferences – are there significant groupings among farmers?
- Danish field data on no-tillage effects – by how much will this differ from IPCC guidelines?

Thank you for your attention

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