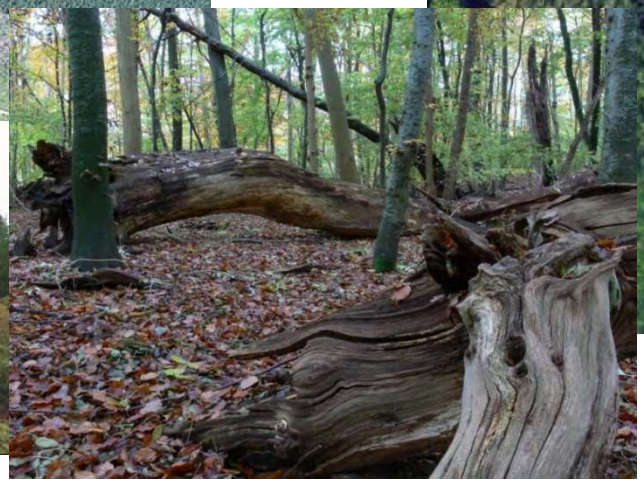
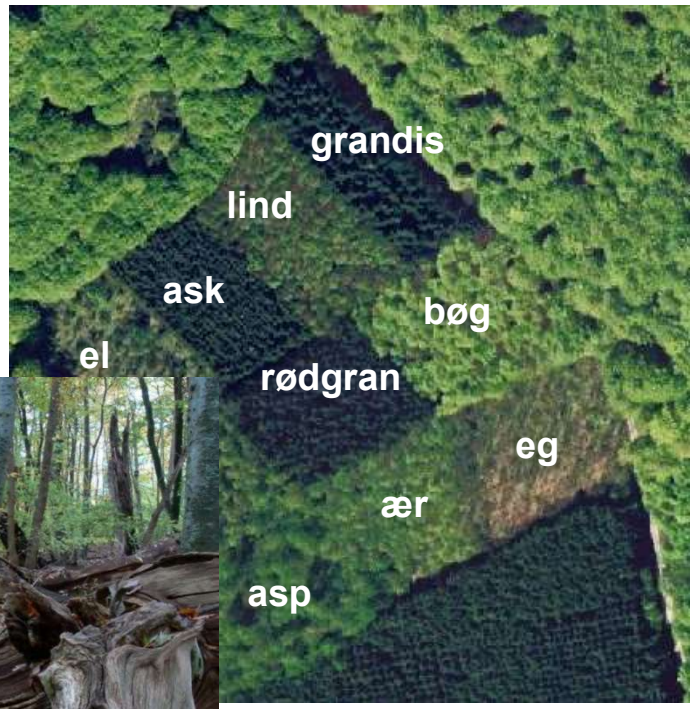
Kulstof i jordbunden i gamle og nye skove

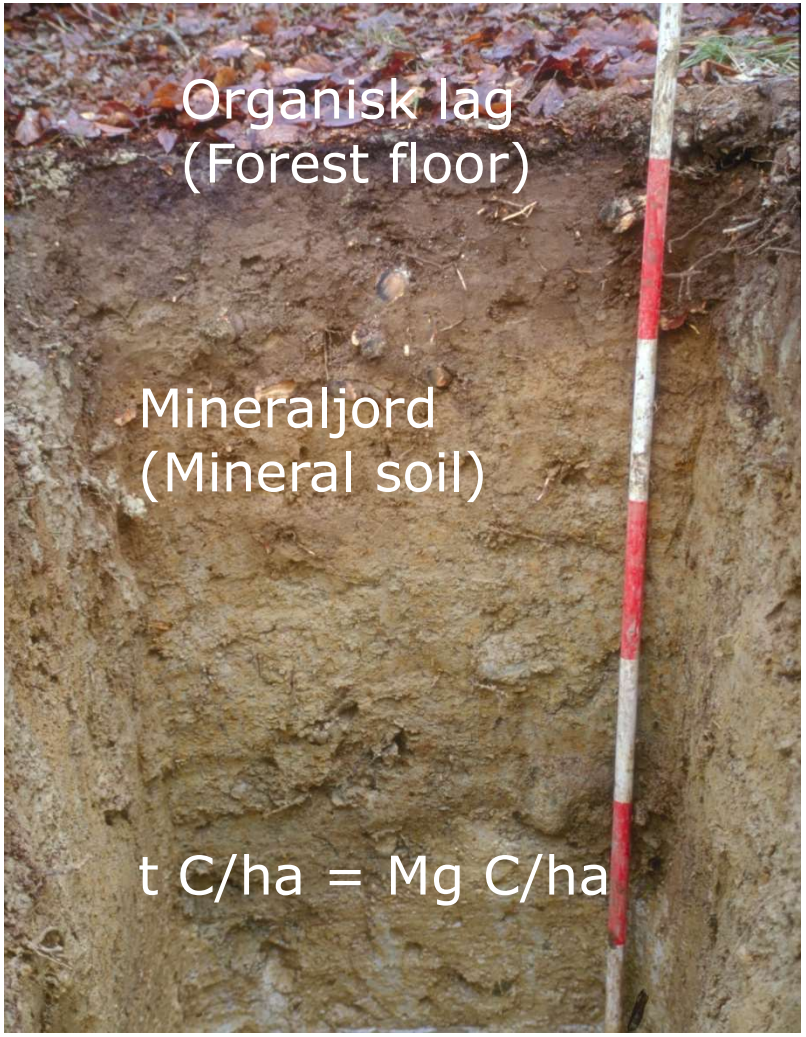
Lars Vesterdal
IGN, Københavns Universitet



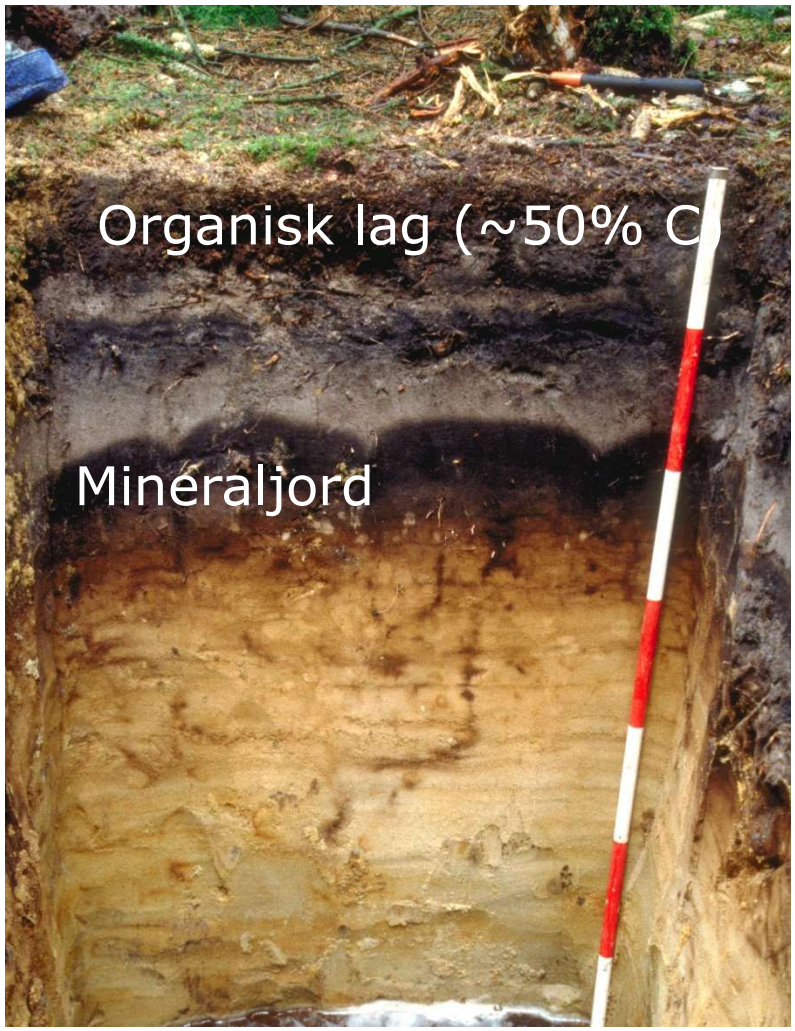


Dansk Netværk om Økosystemtjenester/IPBES, 16 juni 2020

To danske skovjorde –kulstofpuljer?



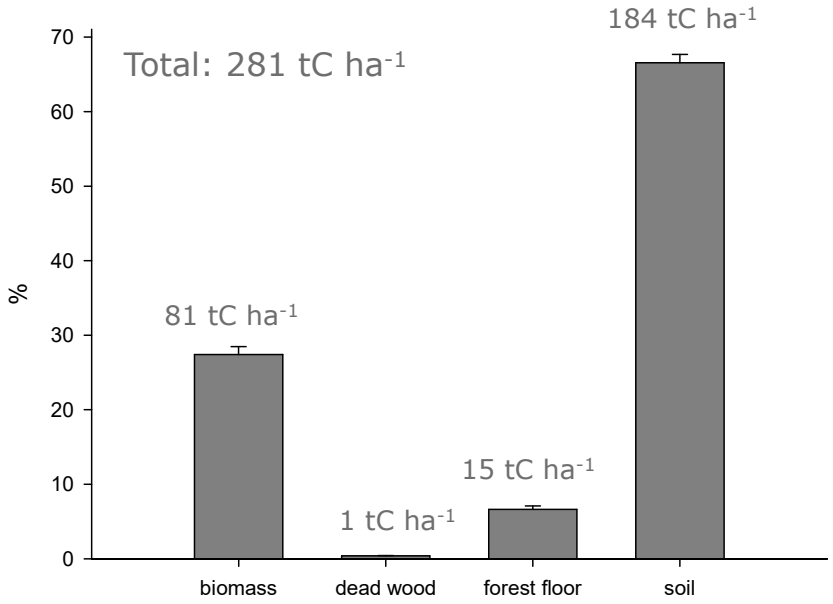
Christianssæde Skov, Lolland
Bøgeskov, leret jord (Luvisol)



Nørlund Plantage, Midtjylland
Rødgranplantage, grovsandet (Podzol)

Jordens kulstoflager udgør 60-70% af danske skoves totale kulstoflager

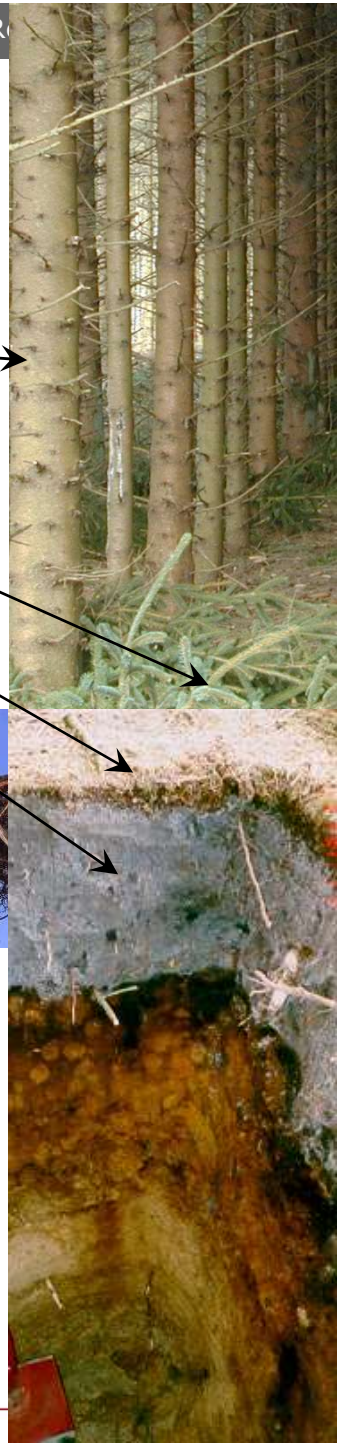
Den danske Skovstatistik (277 plots):



Boveland MSc thesis (2012)

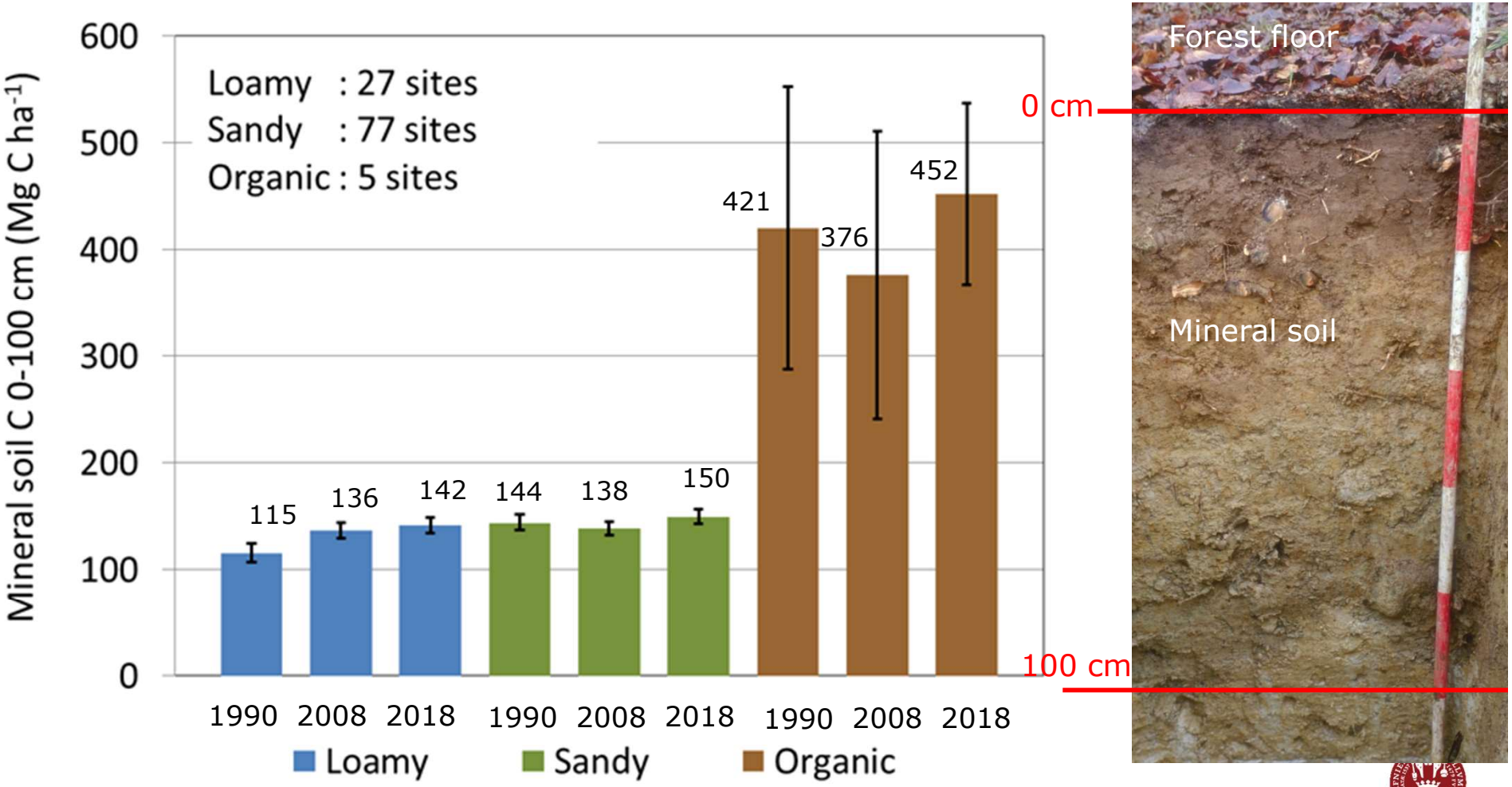
Hvilke C puljer?

- Overjordisk biomasse
- Dødt ved
- Organisk lag
- Mineraljord
- Rodbiomasse



- Europæiske skovjorde indeholder 62% of skovøkosystemets C lager (De Vos et al. 2015, Level I)
- *Kan vi ændre disse lagre (stocks) ~ binde (sequester) kulstof?*

Overvågning af ændringer i skovjordes kulstoflager - kulstoflager til 1 m på 109 skovpunkter



SINKS2, overvågning af kulstof i danske skovjorde

Hvordan påvirkes jordens kulstoflager i skov?

Hvad er effekten af udvalgte tiltag i skovdriften?

- Træartsvalg: 1) i renbestand og 2) i blandskov
- Effekt af hugst og skovdyrkningssystem
- Urørt skov
- Dræning

Hvad sker der med kulstof i jorden efter skovrejsning?

Syntese af træartseffekt

-fra træartsforsøg og parvise plots i tempereret og boreal skov

Contents lists available at SciVerse ScienceDirect

Forest Ecology and Management

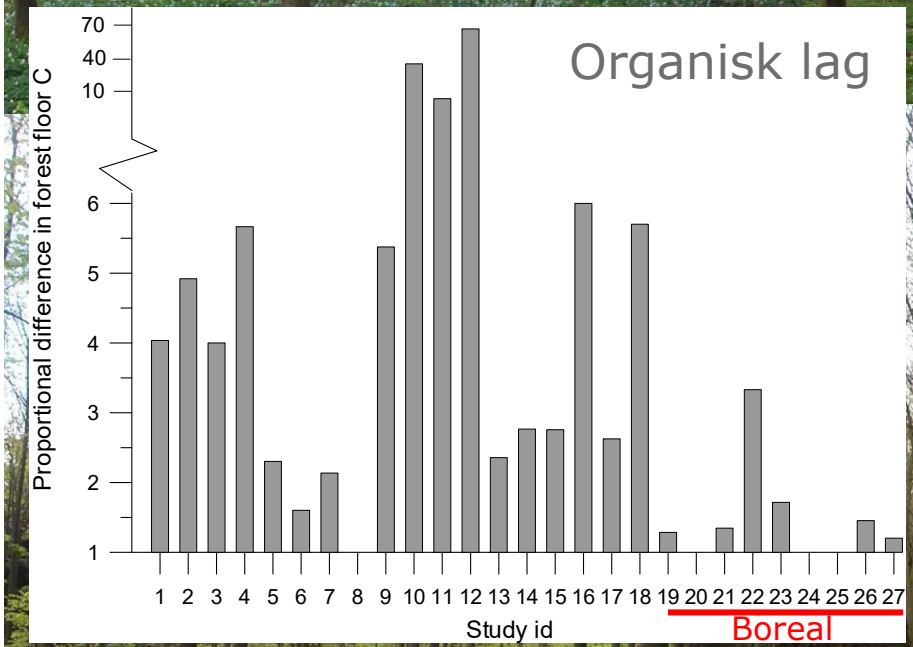
journal homepage: www.elsevier.com/locate/foreco

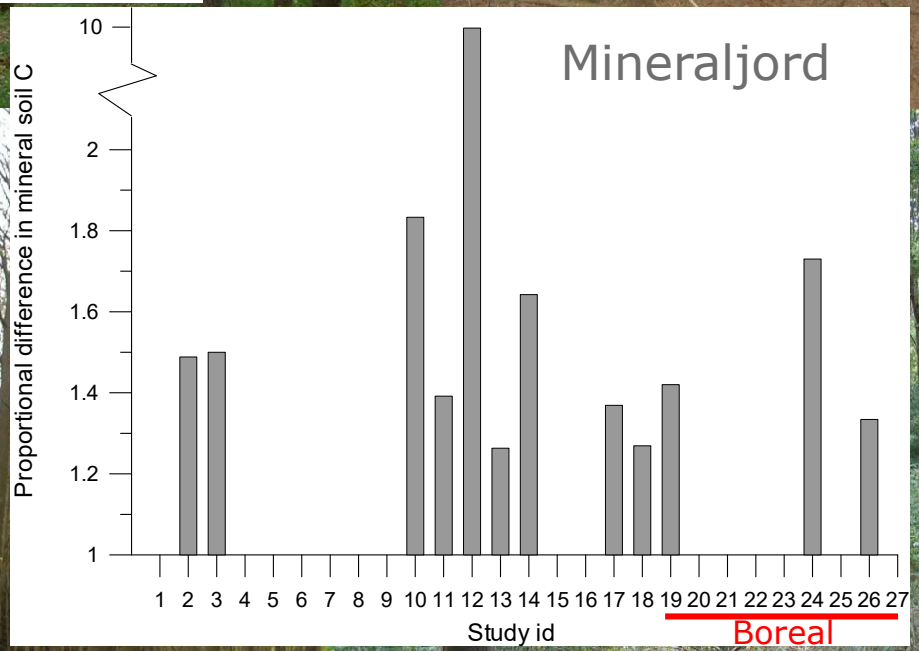
Forest Ecology and Management 309 (2013) 4–18

Do tree species influence soil carbon stocks in temperate and boreal forests?

Lars Vesterdal [a,*], Nicholas Clarke [b], Bjarni D. Sigurdsson [c], Per Gundersen [a]

[a] Department of Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, DK-1958 Frederiksberg C, Denmark
[b] Norwegian Forest and Landscape Institute, P.O. Box 115, N-1431 Ås, Norway
[c] Agricultural University of Iceland, Hvanneyri, IS-311 Borgarnes, Iceland

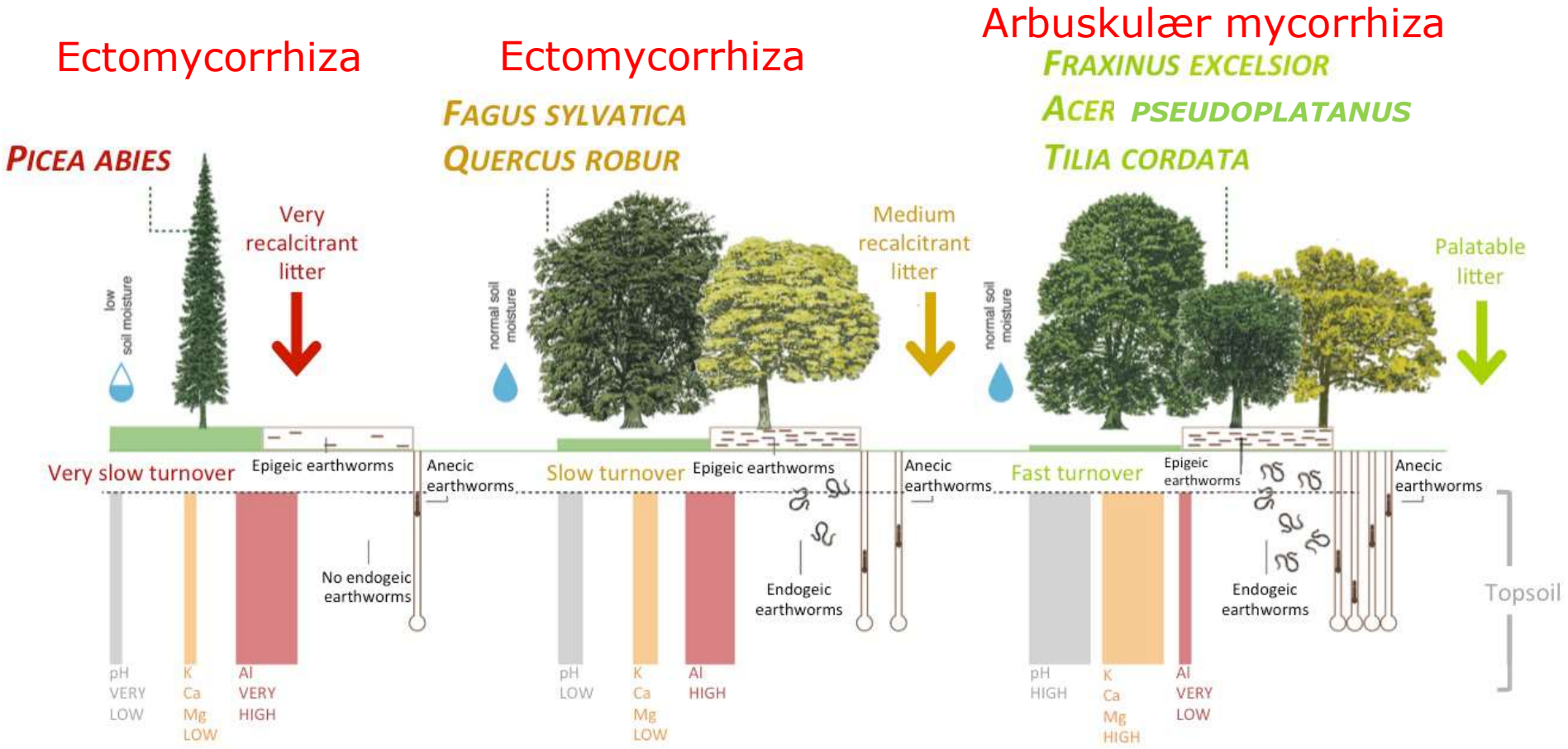




C lager varierer 2-5x:
Ask, ær<bøg<nåletræer

C lager varierer med 40-50%
Nåletræer, bøg<ask

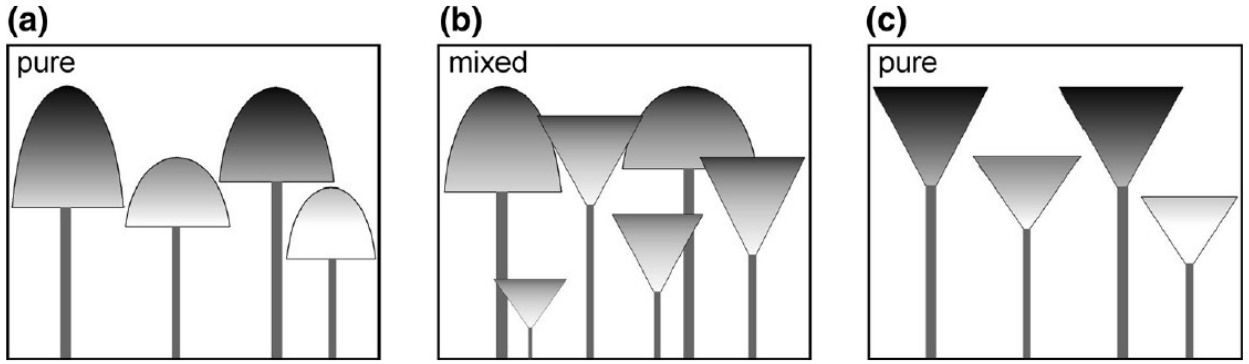
Markante træartsgrupper i relation til jordens kulstoflager

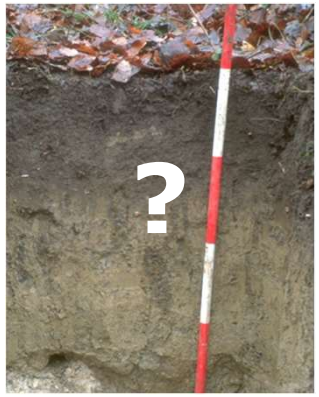


Høj (15 tC/ha)	*Kulstof i organisk lag*	*Lav (1-2 t C/ha)*
Lav (60 tC/ha)	*Kulstof i mineraljord*	*Høj (70 t C/ha)*
Lav	*regnorme*	*Høj*
Lav	*bakteriel aktivitet*	*Høj*
Høj	*svampeaktivitet*	*Lav*
Lav	*rodbiomasse og -input*	*Høj*

Træartsdiversitet i blandingsskov?

- for målrettet brug af blandingsskov mhp. Kulstofbinding i jord



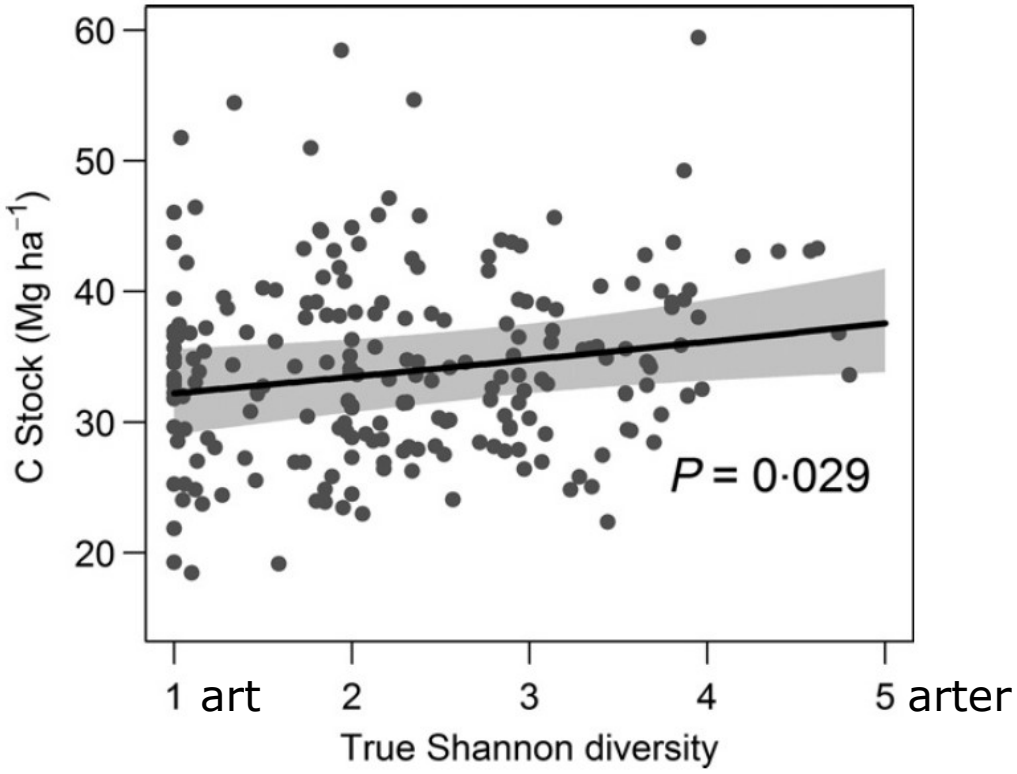


Pretzsch et al. (2015): beech and Scots pine across Europe

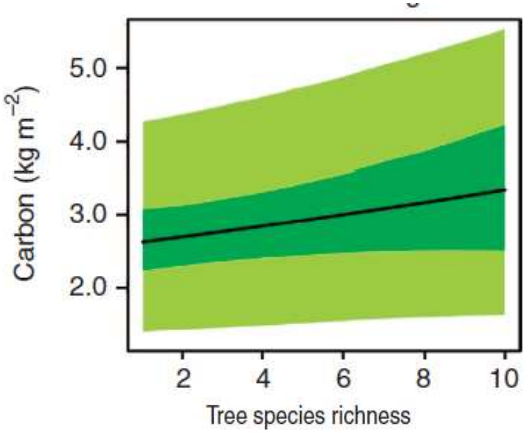
- Træarter kan udnytte økosystemets nicher bedre i blandinger – giver højere produktivitet, e.g. Jucker et al. (2014), Pretzsch et al. (2015)

- Jord: Højere input af døde blade til organisk lag og døde rødder til mineraljord pga. niche differentiering?

Konsistent men svag positiv effekt på C lager af træartsdiversitet på tværs af Europa



Dawud et al. (2017), Functional Ecology 31, 1153–1162



Gamfeldt et al. (2013, Swedish NFI)
Nature Comm. 4:1340

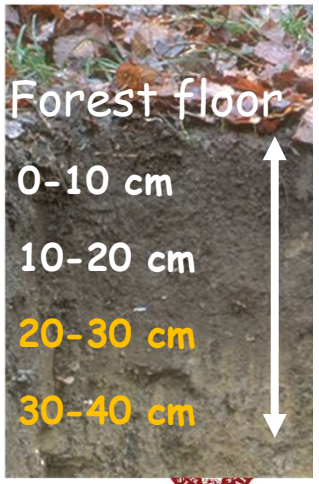
Ecosystems (2016) 19: 645–660
DOI: 10.1007/s10021-016-9958-1

ECOSYSTEMS

Træartsdiversitet i Bialowieza, Polen - hvad sker der med C i jordprofilet?

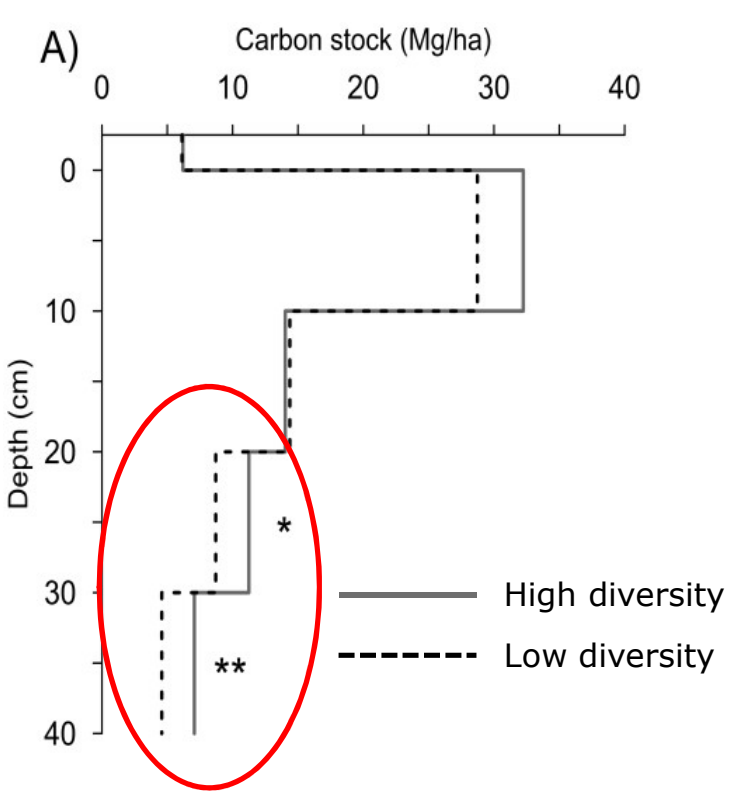
Is Tree Species Diversity or Species Identity the More Important Driver of Soil Carbon Stocks, C/N Ratio, and pH?

Seid Muhie Dawud,[1]* Karsten Raulund-Rasmussen,[1] Timo Domisch,[2] Leena Finér,[2] Bogdan Jaroszewicz,[3] and Lars Vesterdal[1]

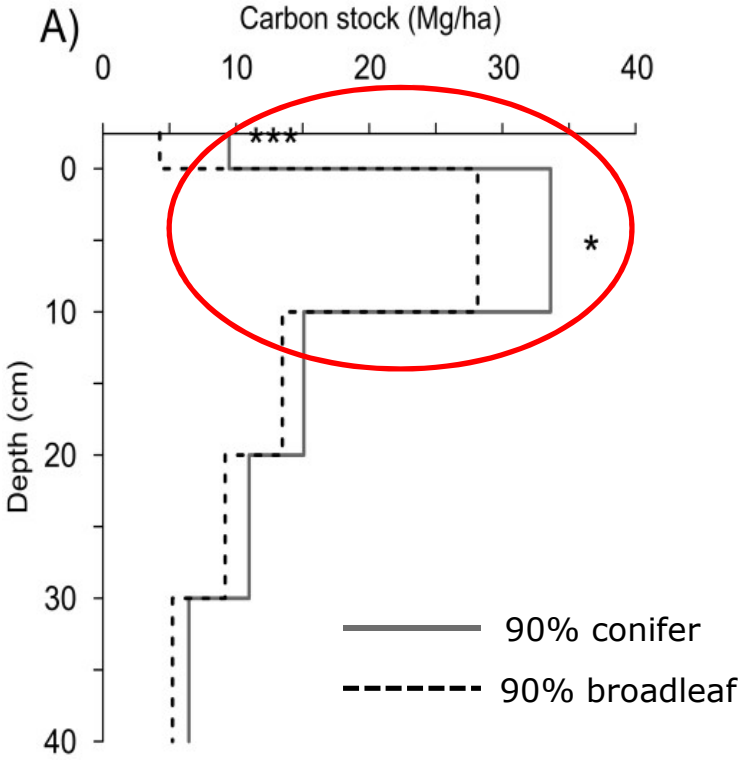


Jordens kulstof påvirkes i dybere jordlag af træartsdiversitet og i øverste jordlag af træartstypen

Træartsdiversitet

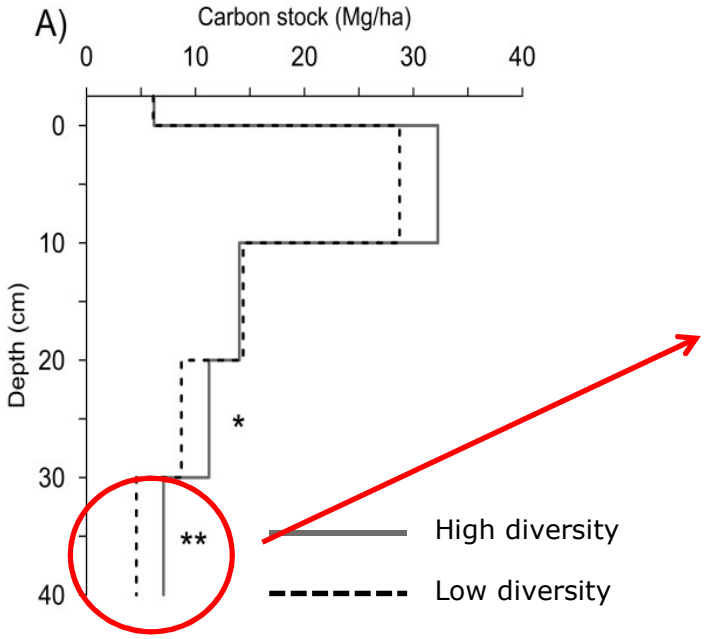


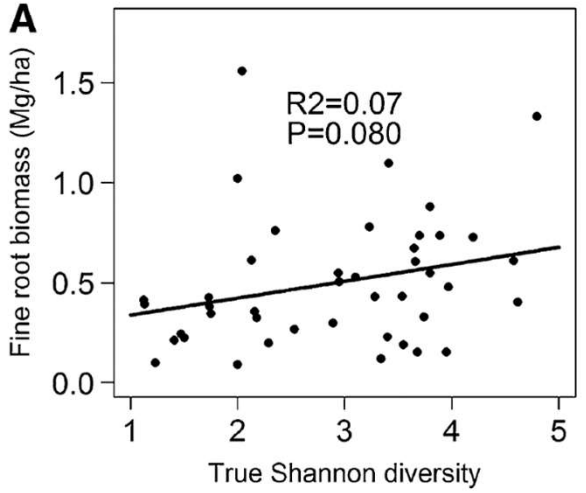
Træartstype (løvtræ/nåletræ)

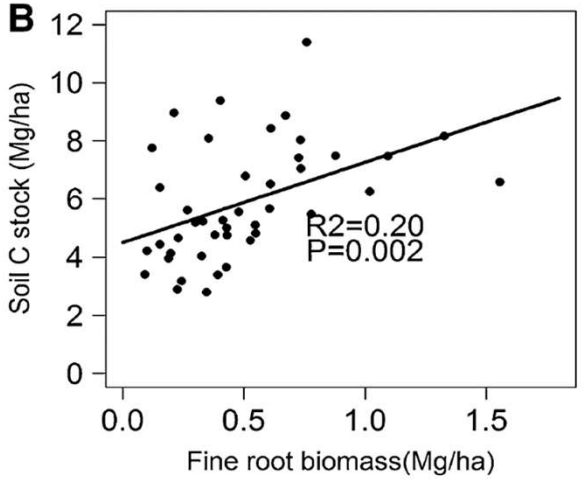


Dawud et al. (2016), Ecosystems

Which mechanism drives more subsoil C in diverse forests?



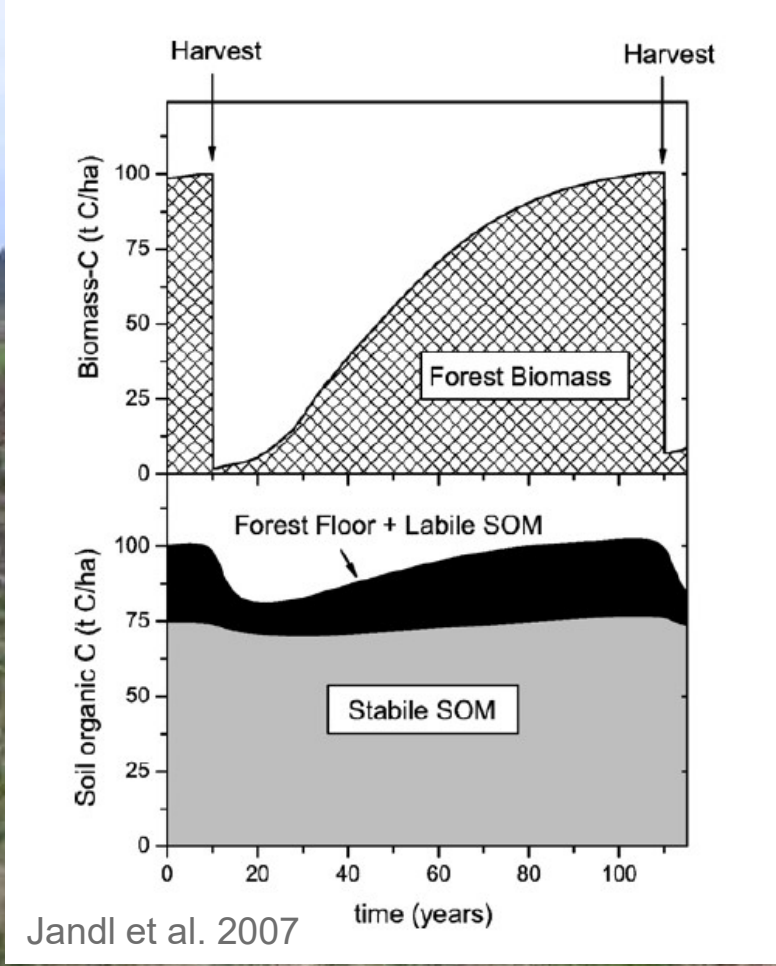




- Roots are important drivers of species diversity effect on soil C?

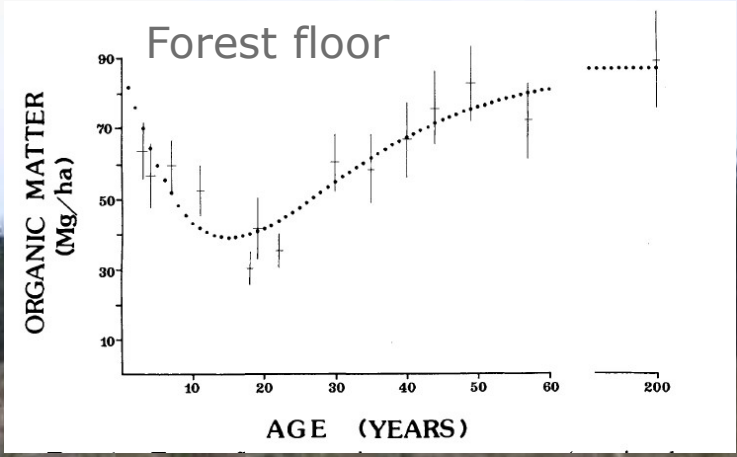
Dawud et al. (2016), Ecosystems 19: 645–660; Finér et al. (2017), For Ecol. Manage. 406: 330-350

Effects of harvesting and reforestation

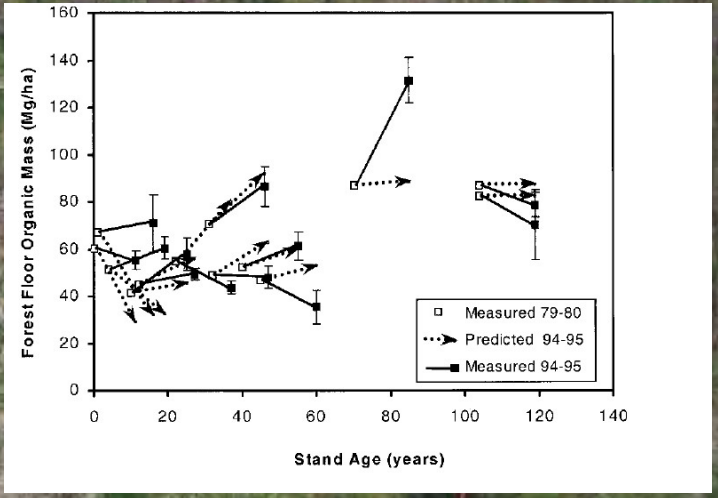


Jandl et al. 2007

Soil C stocks are usually restored within a new rotation

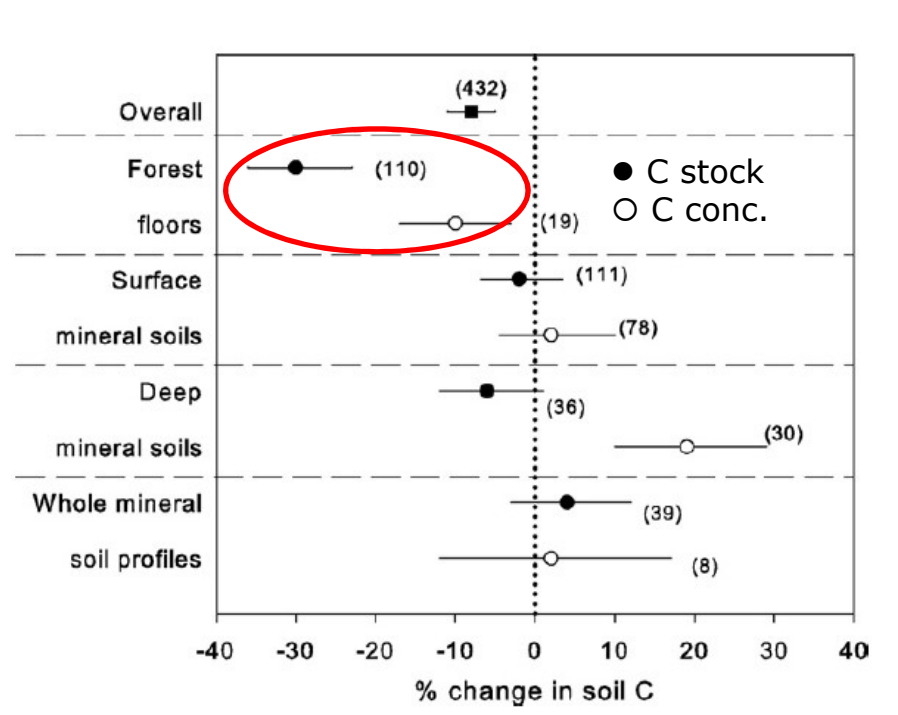


Covington, 1981



Resampling by Yanai et al. 2003

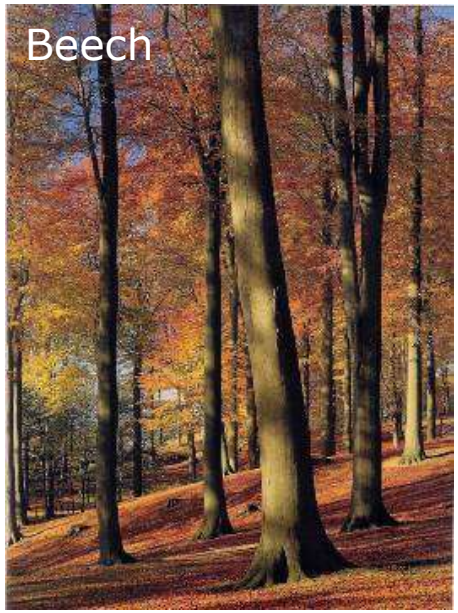
Harvesting effects – meta-analysis

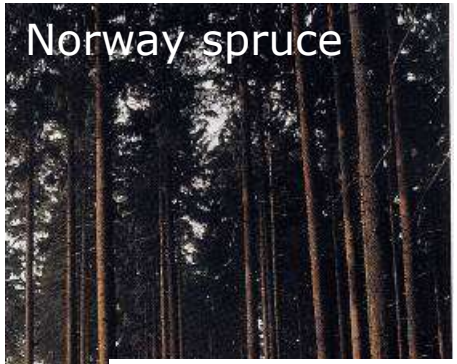


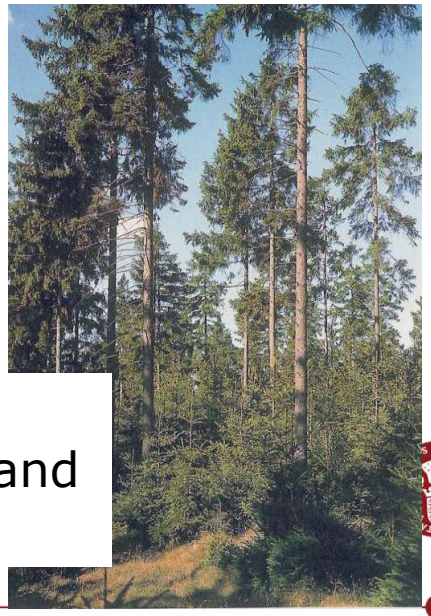
- Overall loss of C: 8%
- Forest floors more likely to lose C than mineral soils (ns)
- Losses not permanent

Nave et al. (2010), For. Ecol. Manage. 259: 857–866

Konvertering fra renafdriftssystem til naturnært skovbrug ("continuous cover forestry")





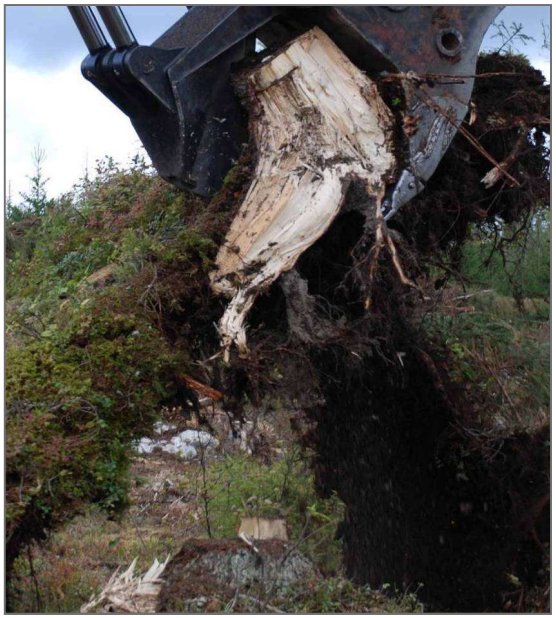


- Positiv effekt i modelsimulering
- Manglende empirisk evidens i Sverige og Tyskland
- Manglende viden i Danmark

Trend 1:
More biomass for energy – cause for concern?

Whole-tree harvesting

Conventional stem-only



Stump harvesting
Photo: J.P. Skovsgaard

Preface

Environmental consequences of tree-stump harvesting

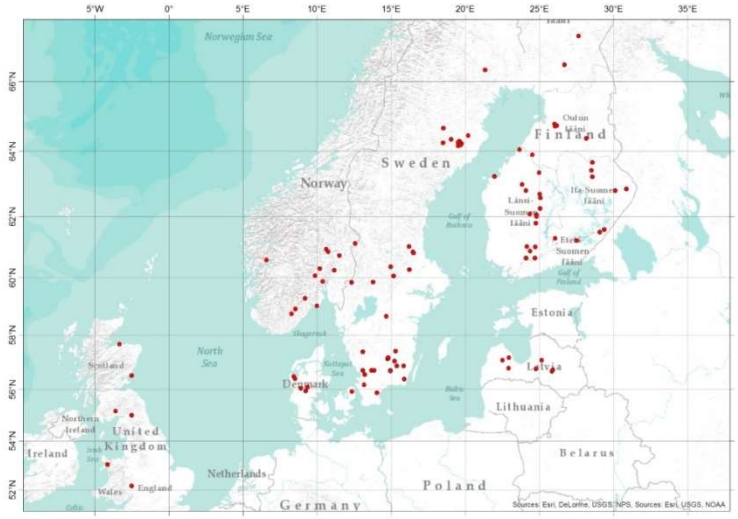
Editorial

Stump harvesting – impact on climate and environment ☆

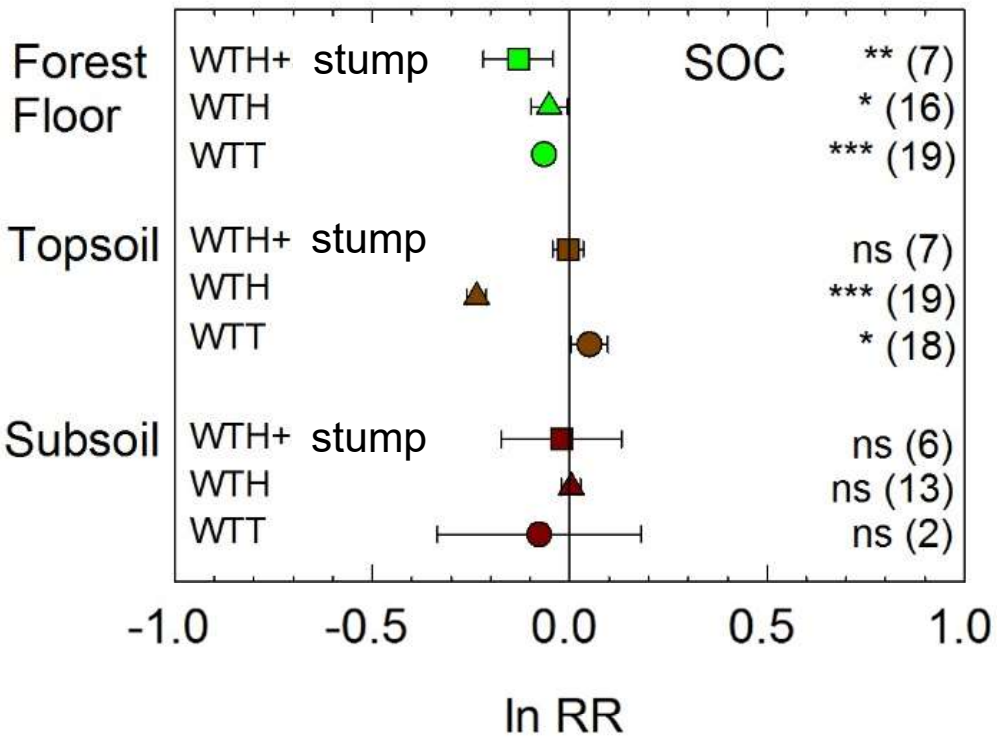
- Loss of C in forest floor (12%), not in mineral soil
- Whole-tree harvesting has a more negative effect than stump removal alone
- The soil C stock regenerates within a rotation

Persson (2013), Persson (2016), Strömgren et al. (2013), Eliasson et al. (2013)

Nordic meta-analysis of whole-tree harvesting effects



Study sites. Map: Sigmundur H. Brink, AUI

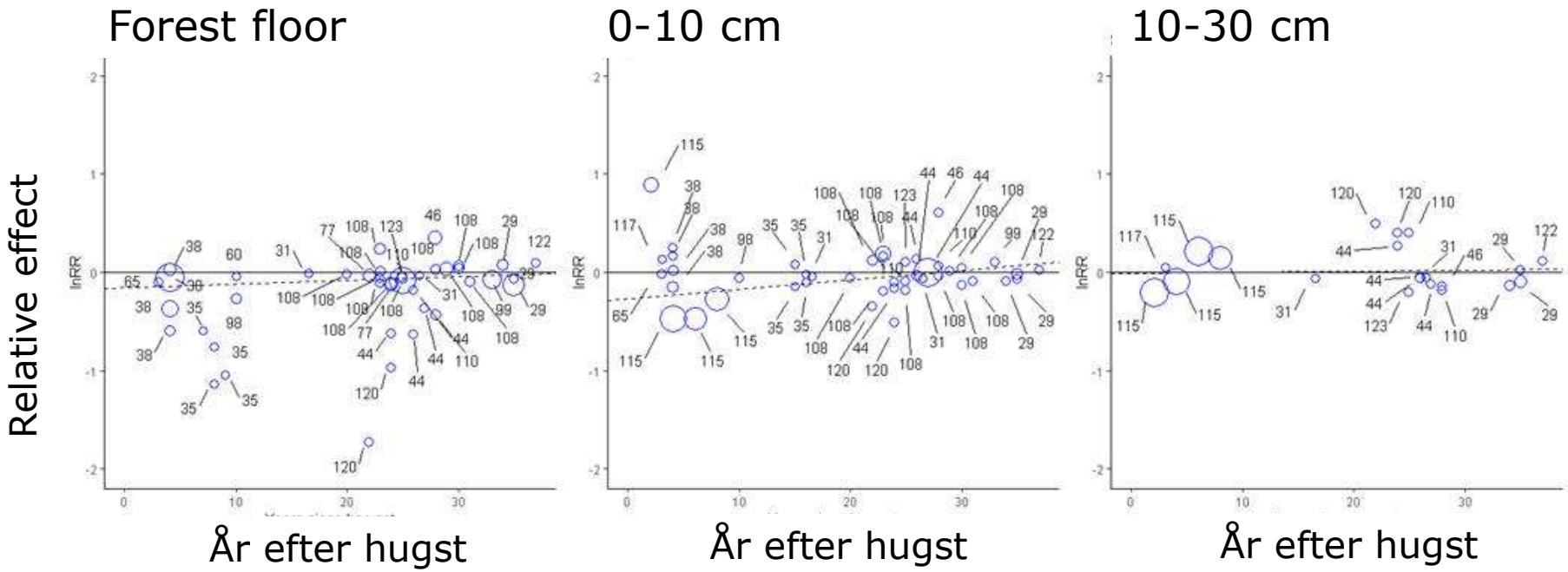


- Intensified harvesting reduces carbon stocks, also in mineral soil
- WTH with stump harvesting results in largest FF C loss
- WTH alone: largest mineral soil C loss

CAR-ES (Clarke et al. in prep.)

norden
Nordic Forest Research (SNS)

Nordisk meta-analyse af effekt af heltræhugst på kulstof i jord - negative effekter forsvinder efter 30+ år



CAR-ES (Clarke et al. in prep.)

Nordic Forest Research (SNS)

Trend 2: Udlægning af urørt skov - kan vi kombinere biodiversitet og kulstof i jord?

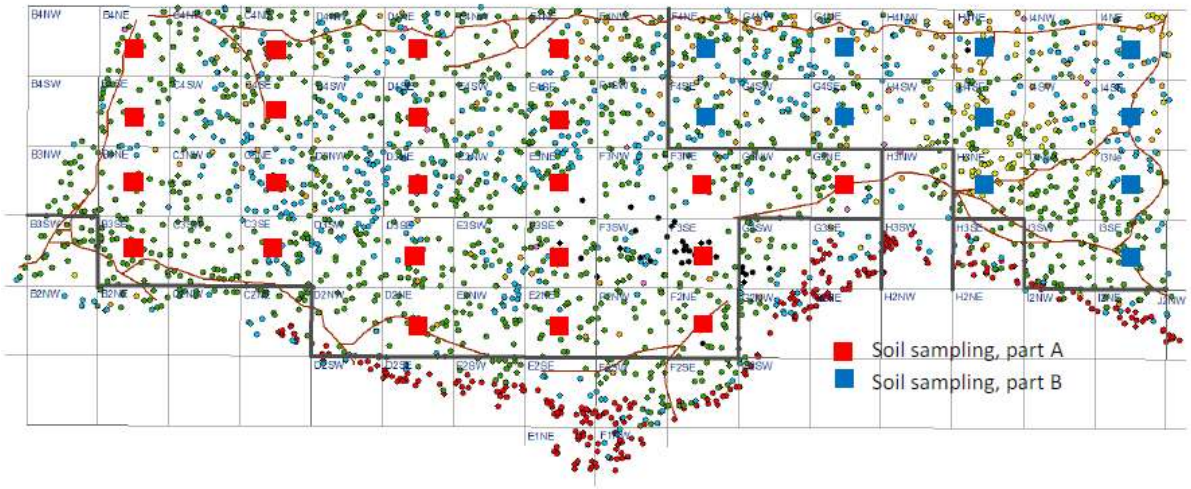

Suserup Skov, Denmark

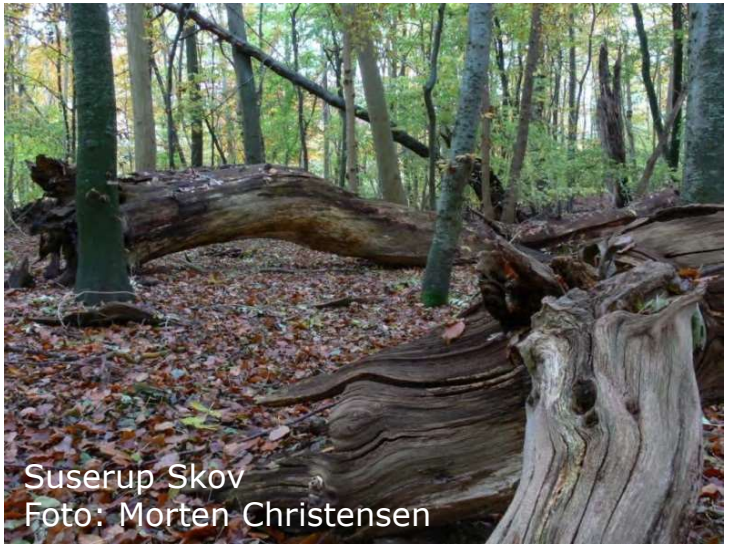

Hainich Forest Reserve, Germany
Photo: Ian Seiferling

Veldrænet jord/højbund:

- I USA mere kulstof i urørt skov, men ingen forskel i mineraljord (Hoover et al. 2012)
- Mere kulstof i organisk lag i tyske urørte skove (Grüneberg et al. 2013)
- To tyske genmålinger i *Hainich:* meget store ændriger på 0.65-1.64 t C/ha/år over 4-5 år (Tefs & Gleixner, 2012; Schrumpf et al., 2014).
- Ikke nok N til at understøtte den høje C binding?
- Ændringer større end efter forstyrrelser

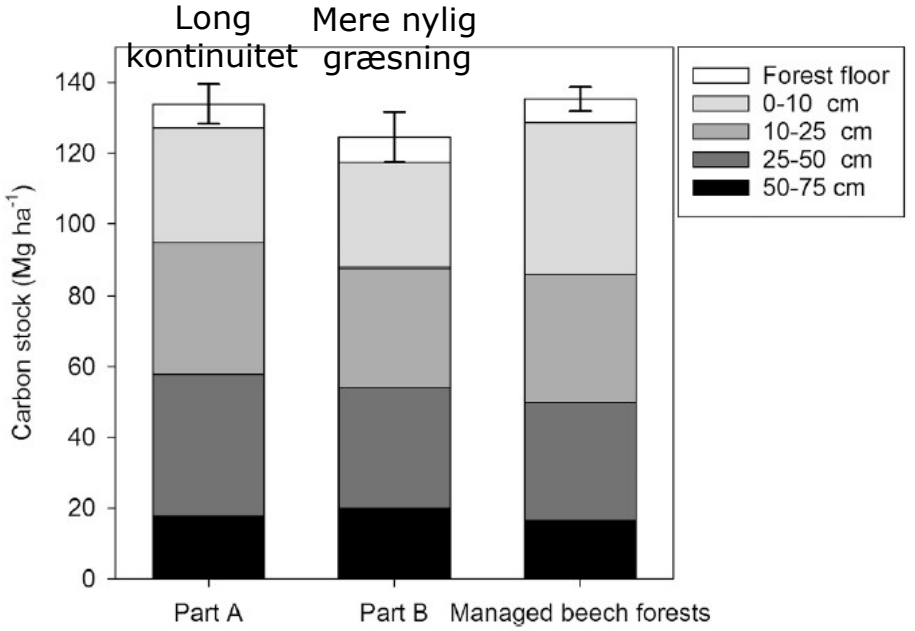
Kulstof i jord i Suserup Skov





- I *Suserup Skov* er kulstoflageret 125±7 and 134±6 t C/ha til 75 cm
- Samme lager som i 19 bøgeskove på veldrænet jord i Midt- og Sydsjælland (135±3 t C/ha)

Nord-Larsen et al. (2019), For. Ecol. Manage. 447: 67-76



Hvad sker der med kulstoflager og drivhusgasser på grøftede lavbundsjorde, når dræning stoppes passivt eller aktivt?

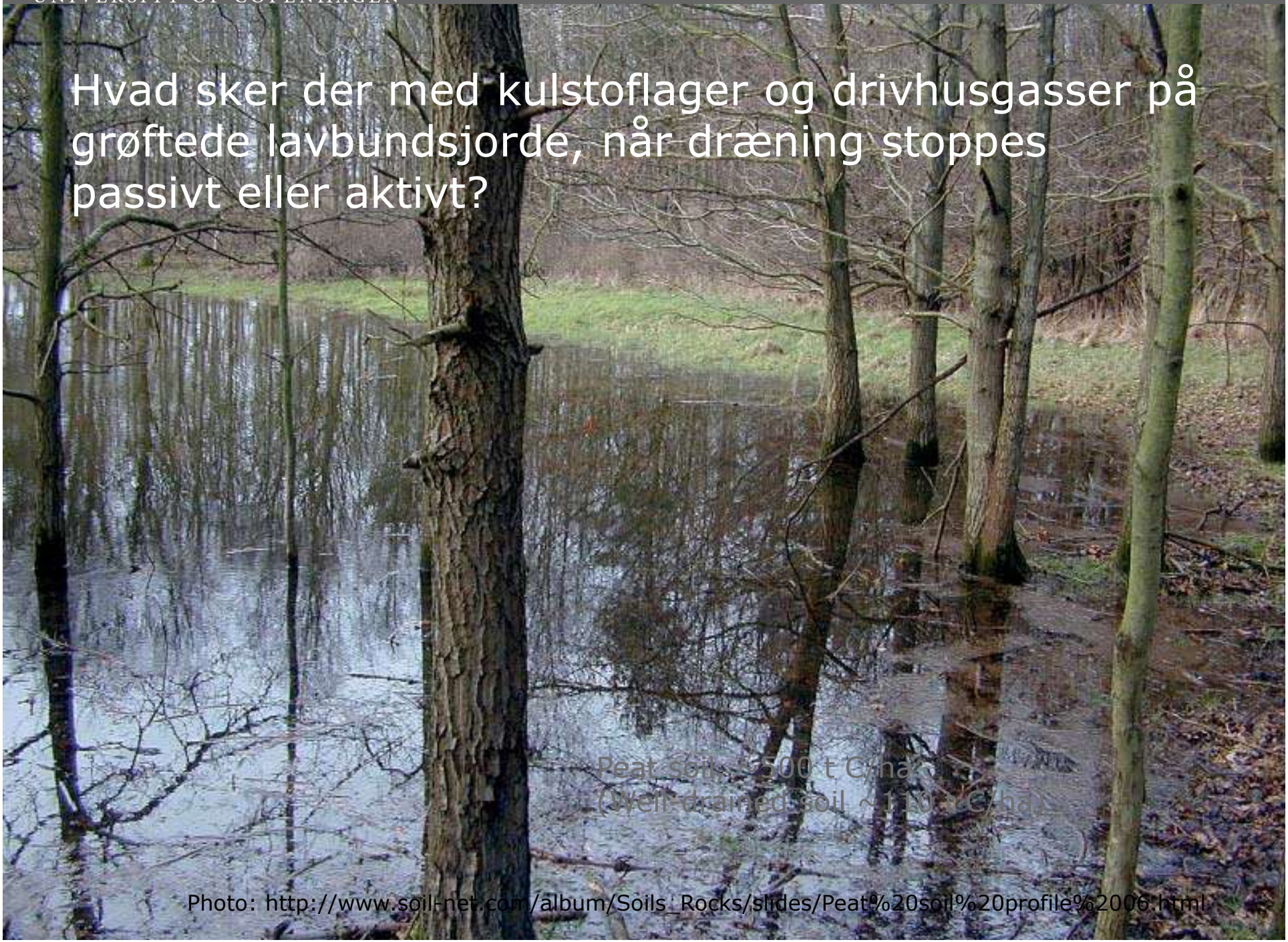
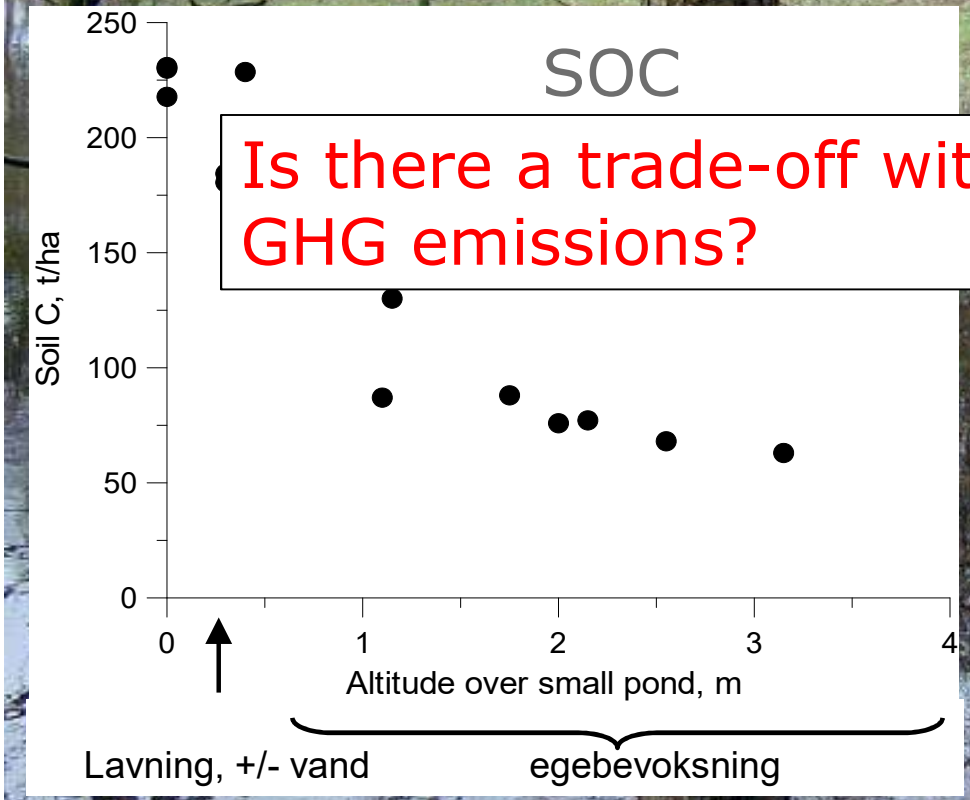
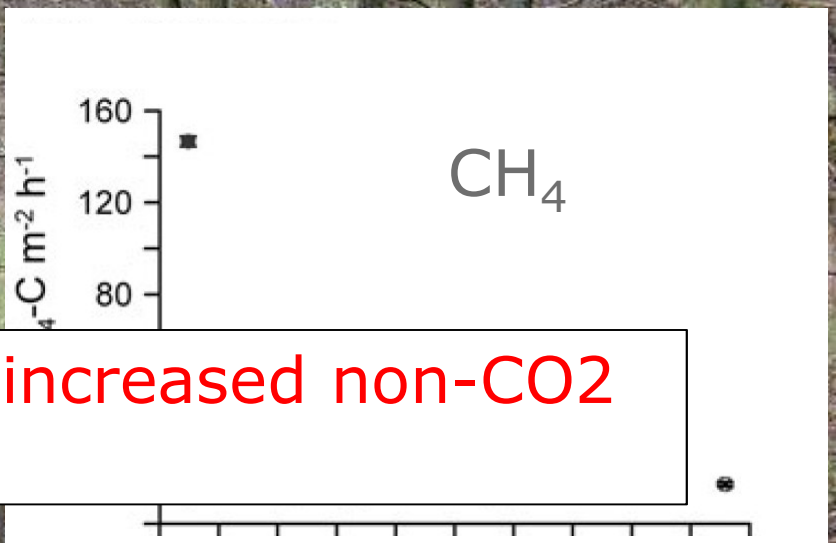


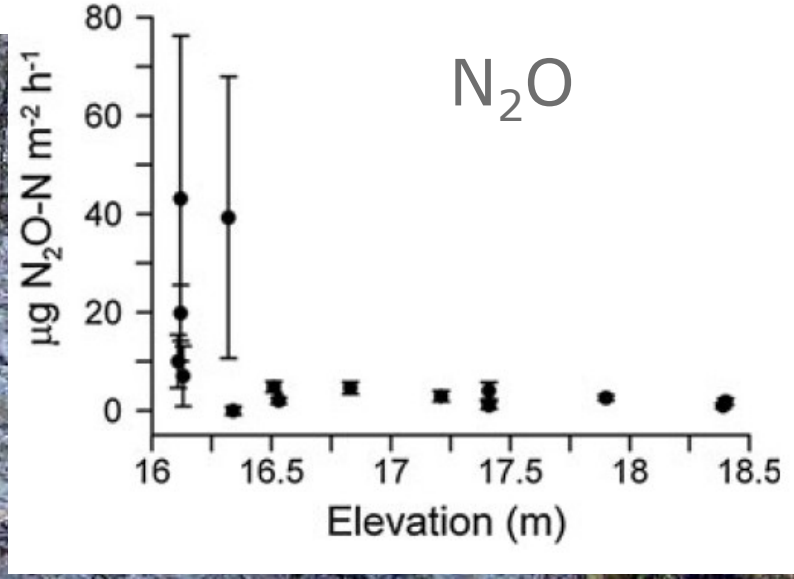
Photo: http://www.soil-net.com/album/Soils_Rocks/slides/Peat%20soil%20profile%2006.html

Dræning og kulstof i jord langs topografisk transekt



Is there a trade-off with increased non-CO2 GHG emissions?





Christiansen et al. Biogeochemistry (2012) 107:437–454
Vestskoven, Denmark

Nye skove – hvad sker der med kulstof i jorden?

Landbrugsjord springer i skov i Litauen

Aktiv skovrejsning 1954-2012 v. Billund

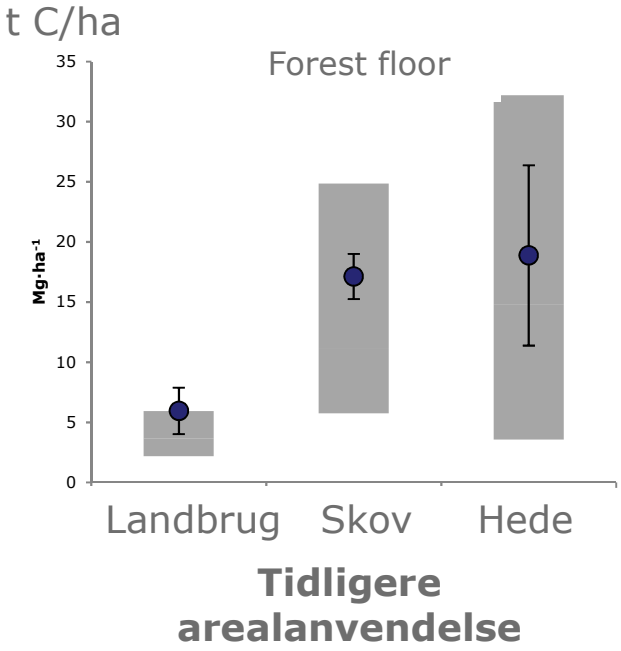
Soil carbon in adjacent cropland and forest

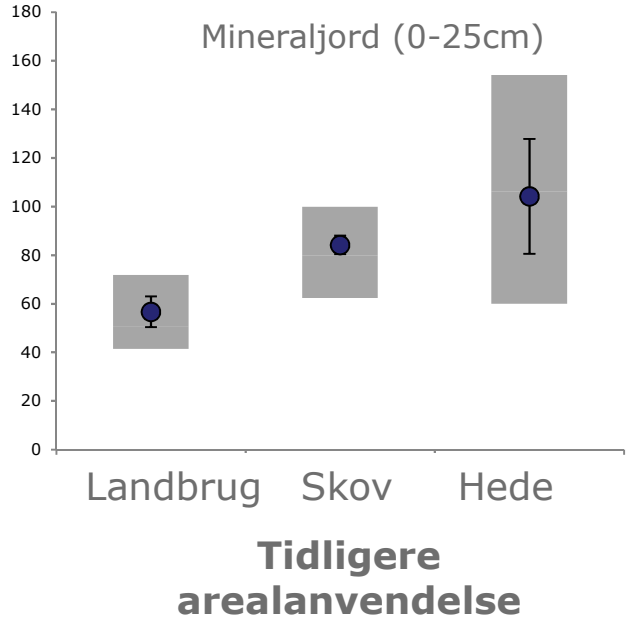
Which soil has most carbon?

Forest

Cropland

Kulstoflager i nye (<20 år) og gamle skove (>70 år)

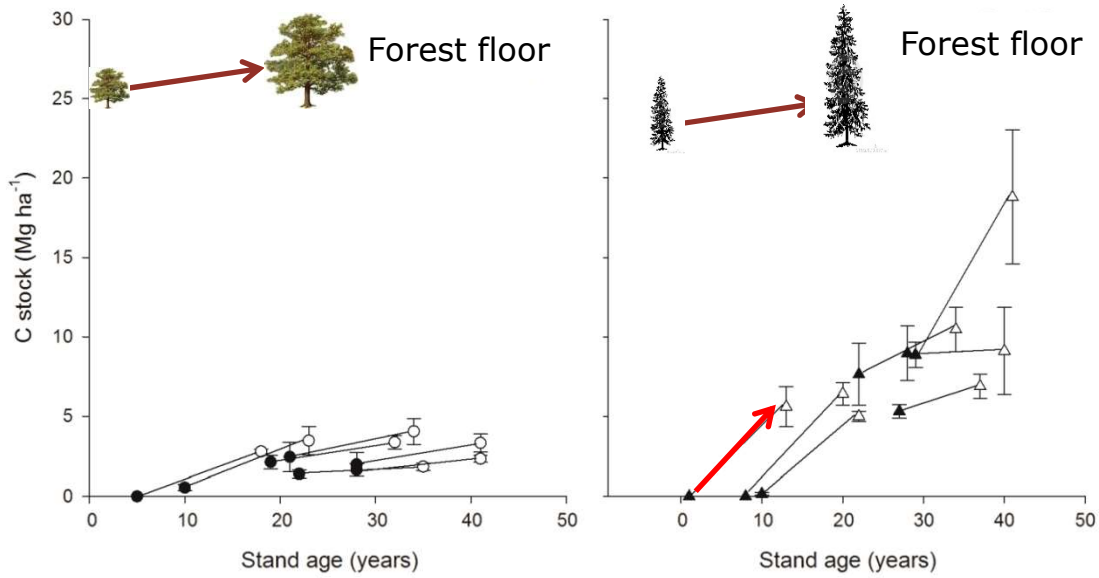


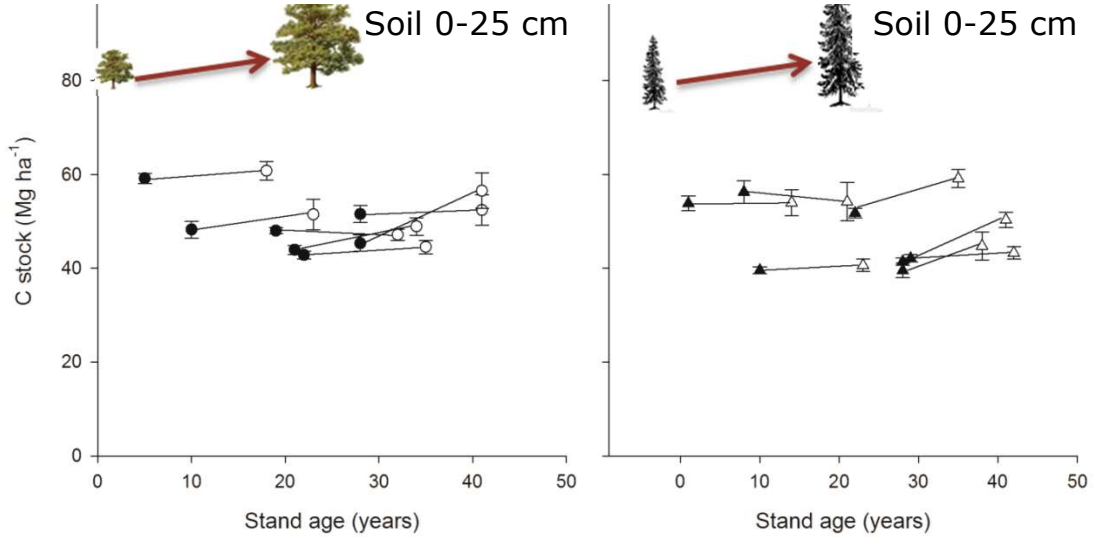


Vesterdal et al., overvågning af kulstof i danske skovjorde

Resampling approach: Vestskoven revisited after 13 years

Soil C stock change at stand level 1998-2011





ELSEVIER
Forest Ecology and Management 169 (2002) 137–147
Forest Ecology and Management
www.elsevier.com/locate/foreco

Change in soil organic carbon following afforestation of former arable land

Lars Vesterdal*, Eva Ritter, Per Gundersen
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Global Change Biology
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Afforestation effects on SOC in former cropland: oak and spruce chronosequences resampled after 13 years

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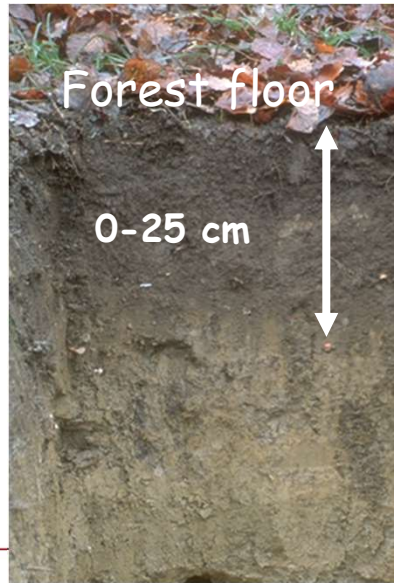
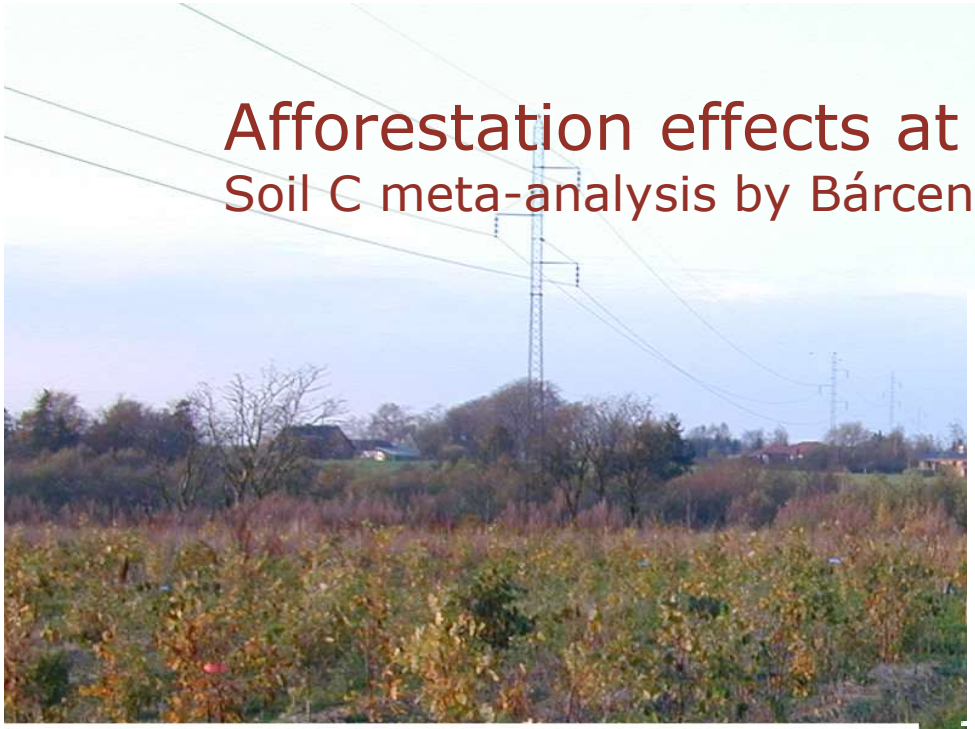
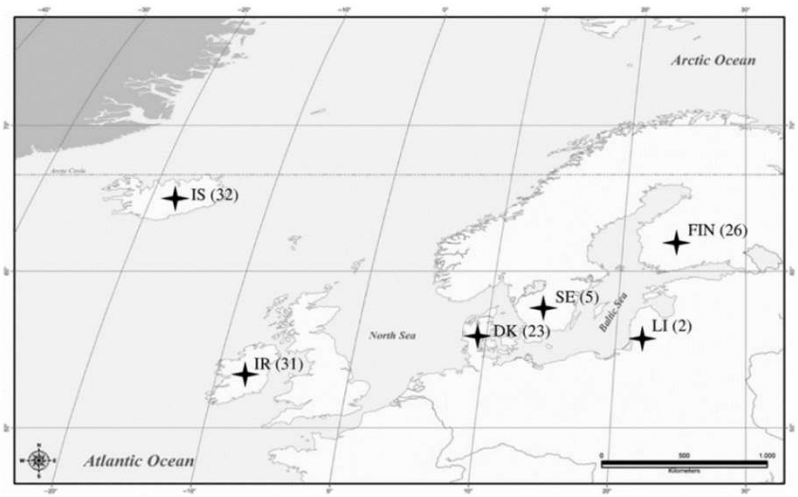
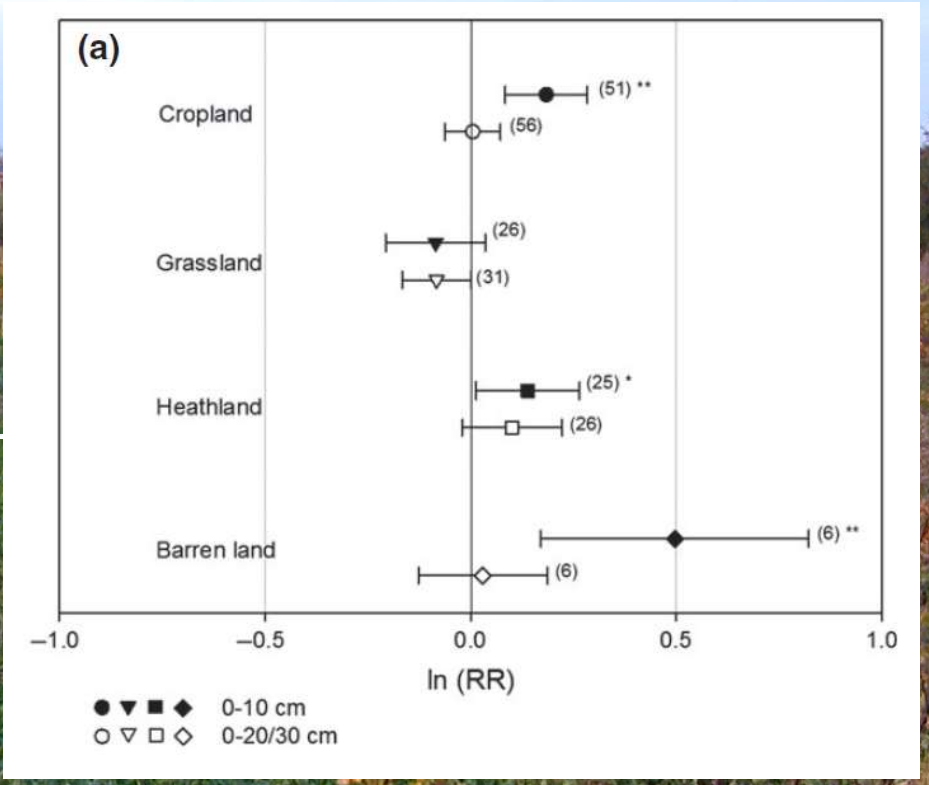


Afforestation effects at regional scale

Soil C meta-analysis by Bárcena et al. 2014







Global Change Biology

Global Change Biology (2014) 20, 2393–2405, doi: 10.1111/gcb.12576

REVIEW

Soil carbon stock change following afforestation in Northern Europe: a meta-analysis

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Hvad ved vi?

"Skovdrift" har oftest en mindre negativ effekt på jordens kulstofindhold (primært organisk lag), men kan modificeres ved:

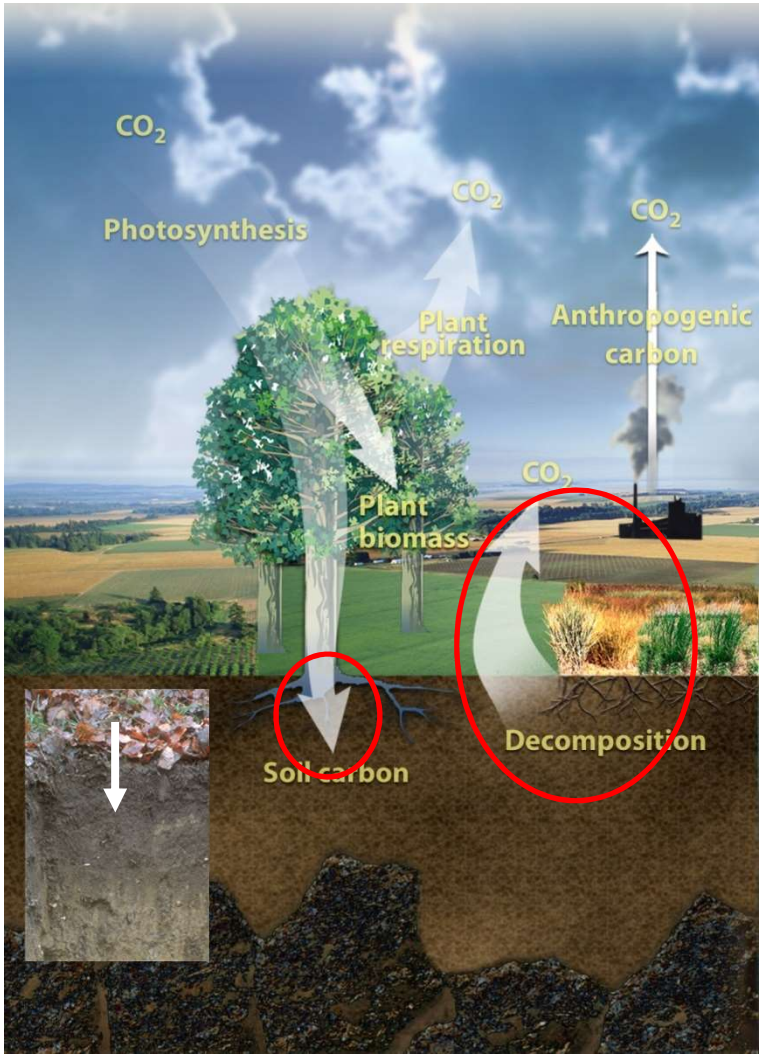
- Målrettet *træartsvalg* (O-horisont 2-5x, mineraljord 40-50%) og *træartsblanding* (mindre respons end af træart alene)
- Intensiteten, hvormed vi fjerner biomasse ved *hugst* (men mest i organisk lag, og regenererer over omdrift) - udlægning af urørt skov vil have beskeden positiv effekt
- Regulering af hydrologien ved *dræning* har størst effekt (men udledning af metan og lattergas kan være en joker). Størst effekt af urørt skov på lavbund?

Ny skov binder kulstof i jord – men primært på tidligere omdriftsjord

Effekter er *kontekstafhængige*:

- Jordbundstype, klima, dræningsforhold…

Hvor er hullerne i vores viden?



- *Manglende empirisk evidens* vedr. ændringer (kg/ha/år), svære at måle
- *Manglende data og forsøg* til at validere modeller
- Hvilke *former* for kulstof og hvor *stabilt* er det?
- Hvad sker dybere i jorden (>30-50 cm)? Er det relevant at gå dybere, og hvor?
- N_2O and CH_4 bør inkluderes for at vurdere *samlet drivhusgaseffekt*
- Kulstofbinding skal evalueres sammen med andre services: *synergies and trade-offs*?

http://genomicscience.energy.gov/carboncycle/

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Influence of forest management activities on soil organic carbon stocks: A knowledge synthesis

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