# Skovdrift og kulstofudledninger

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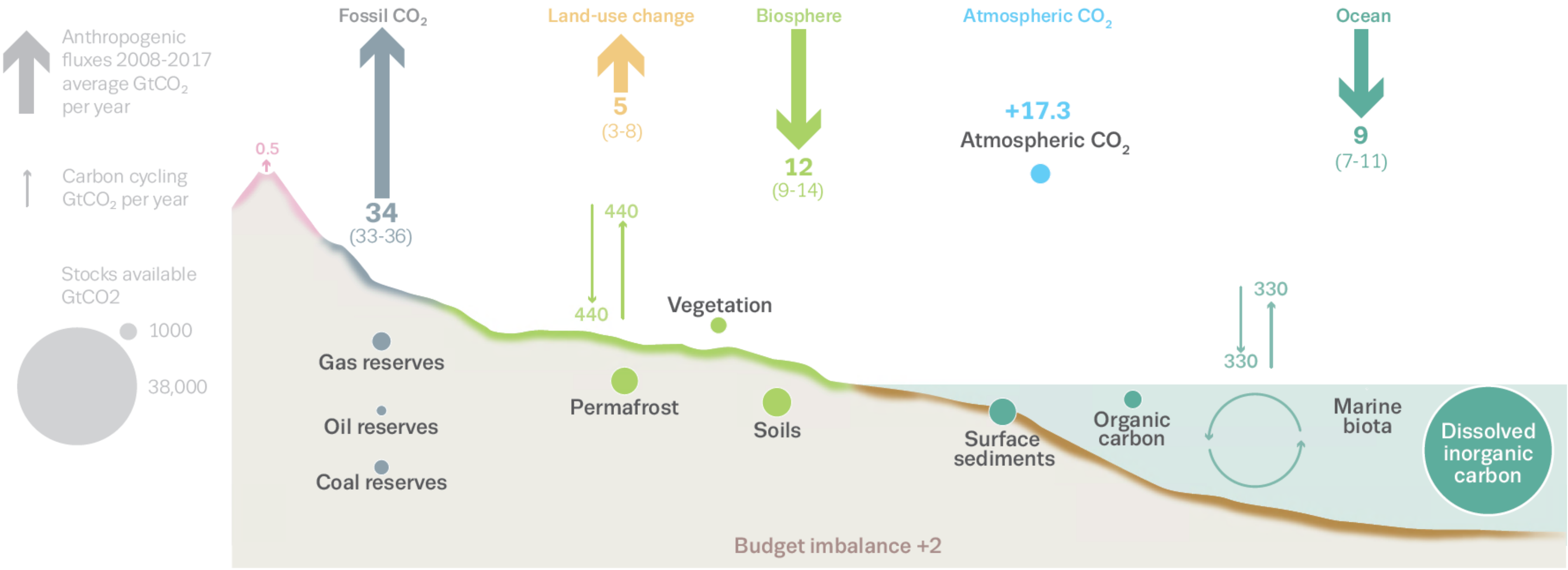
# Kulstofcyklen

## Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2008–2017 (GtCO$_2$/yr)



Source: CDIAC; NOAA-ESRL; Le Quéré et al 2018; Ciais et al. 2013; Global Carbon Budget 2018

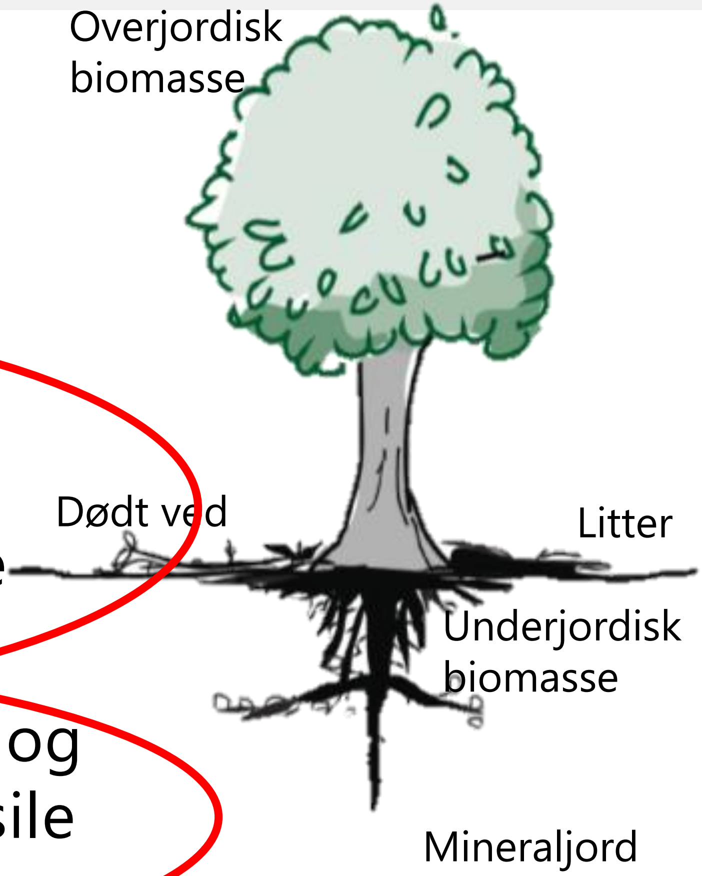
# Klimaforandringer kan modvirkes gennem 4 overordnede skovbrugsrelaterede aktiviteter:

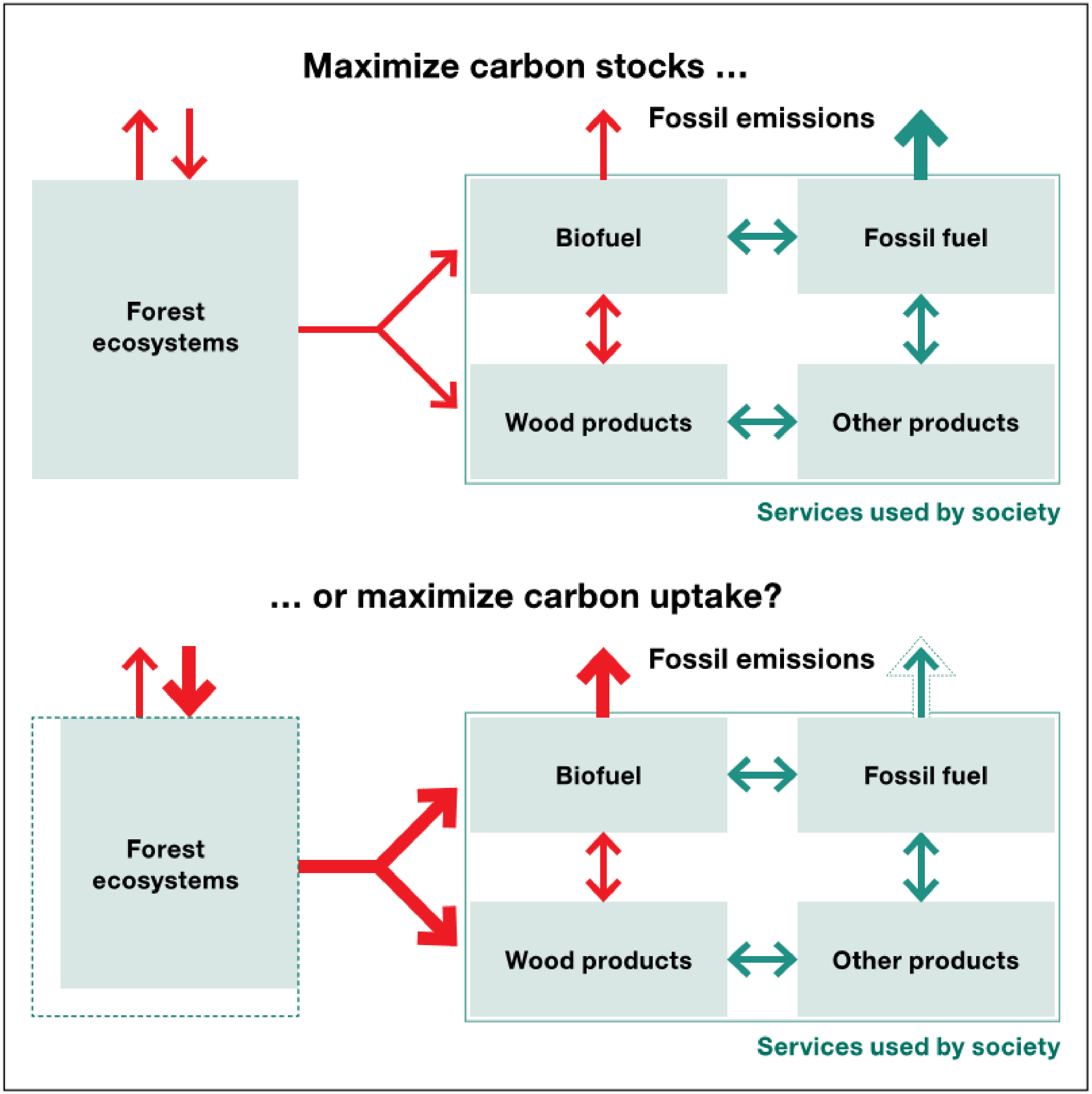
(i) øge kulstofpuljen i skov gennem skovrejsning og gentilplantning,

(ii) øge kulstofpuljerne i eksisterende skove,

(iii) øge anvendelsen af træ til energi og materialer som erstatning for fossile kilder og $CO_2$-dyre materialer, og

(iv) reducere afskovning og skovødelæggelse.

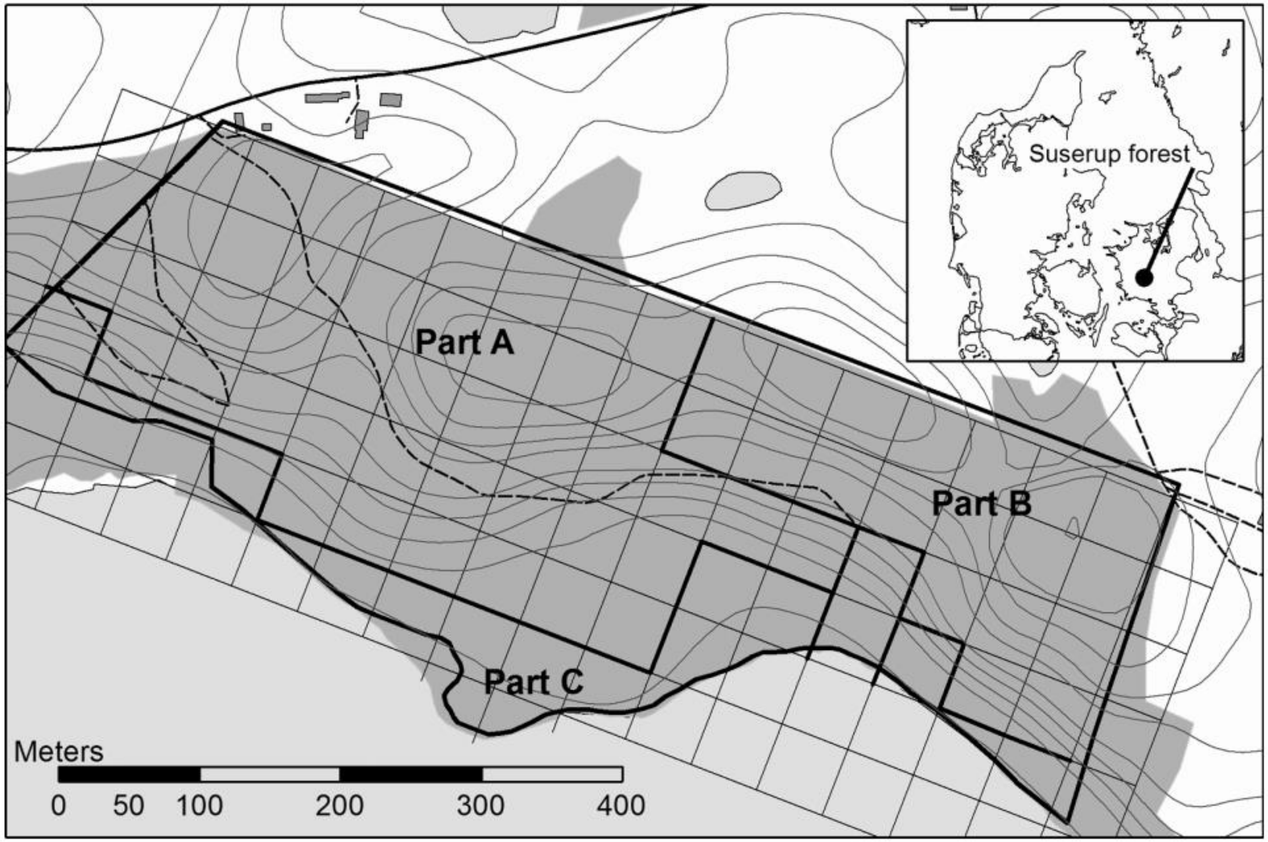




Kurz et al. (2016). Climate change mitigation through forest sector activities: principles, potential and priorities. Unasylva 246, 61-67.

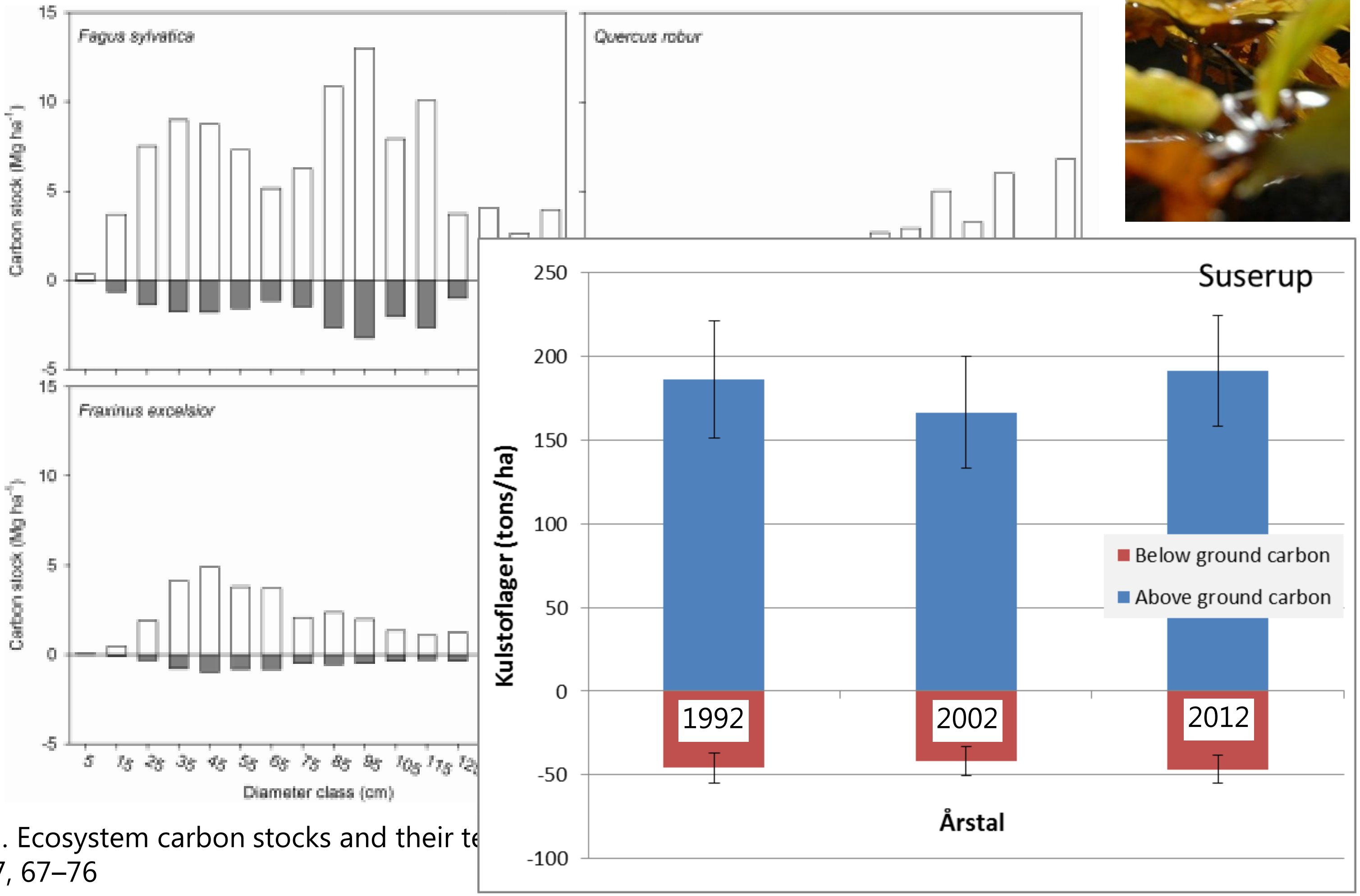
# Den urørte skovs rolle i kampen mod klimaforandringer

Suserup skov: kulstofpuljer undersøgt i 1992, 2002 og 2012



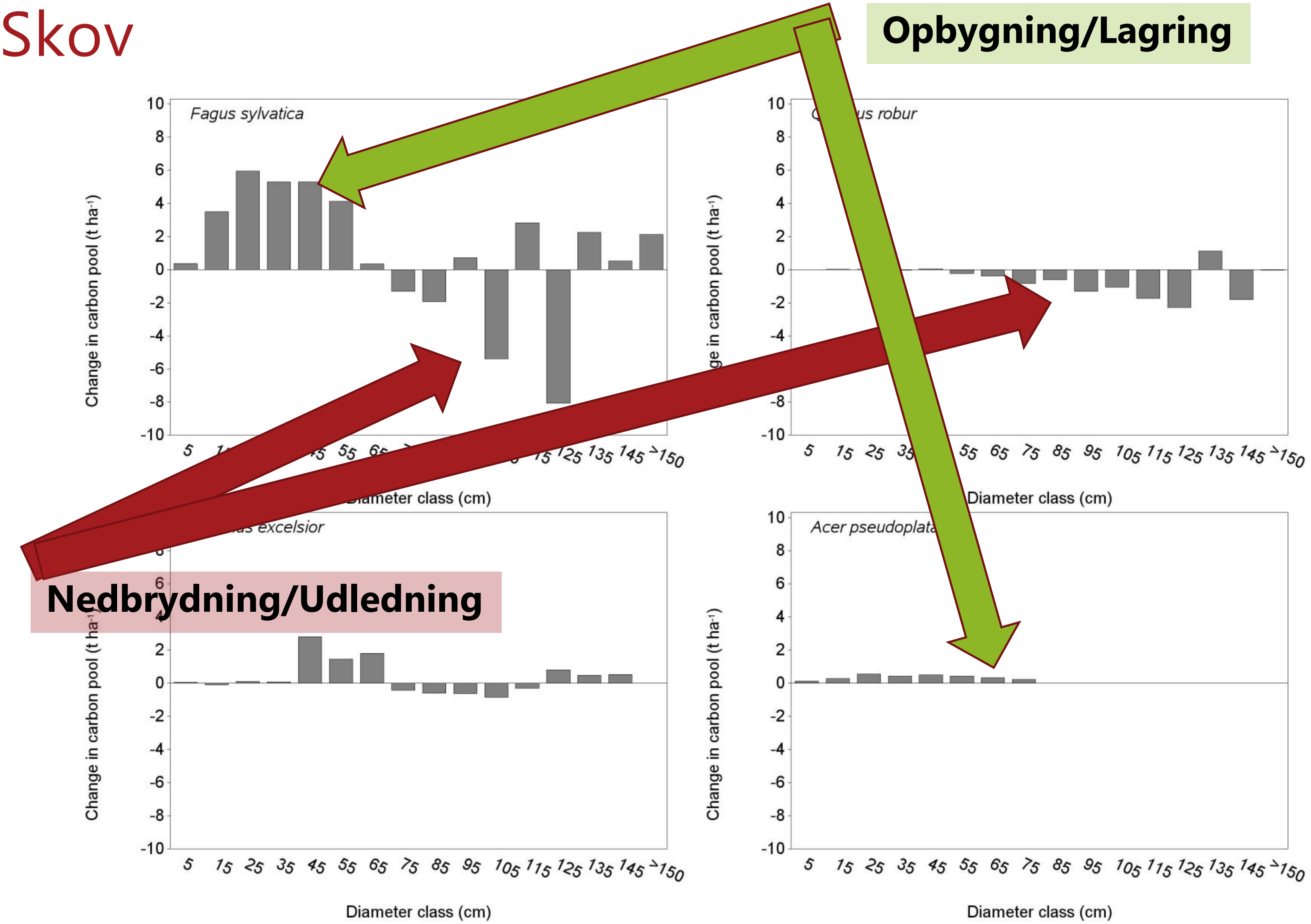
# Levende biomasse

- Kulstofpuljerne i levende biomasse i Suserup Skov er 230 tons C/ha
- Kulstofpul
100 tons (
gennemsr
- Kulstofpul
biomasse
seneste 2(



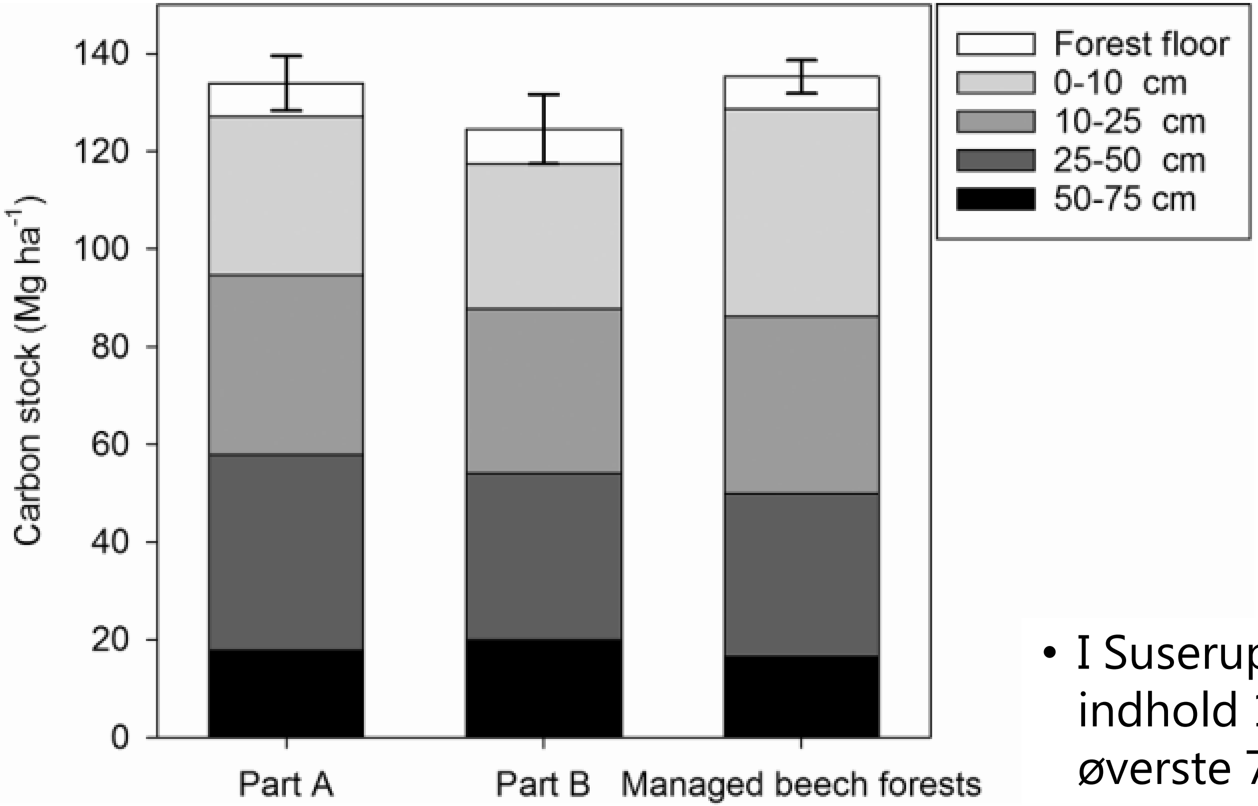
Nord-Larsen et al. (2019). Ecosystem carbon stocks and their te
forest. For. Ecol. Man 447, 67–76

# Ændringer i den levende biomasse i Suserup Skov


**Opbygning/Lagring**

**Nedbrydning/Udledning**

# Jordbundens kulstofpuljer



- I Suserup Skov var jordbundens C-indhold 120-130 tons C/ha i de øverste 75 cm
- Sammenlignet ved samme dybde er der ikke forskel mellem urørte og drevne skove

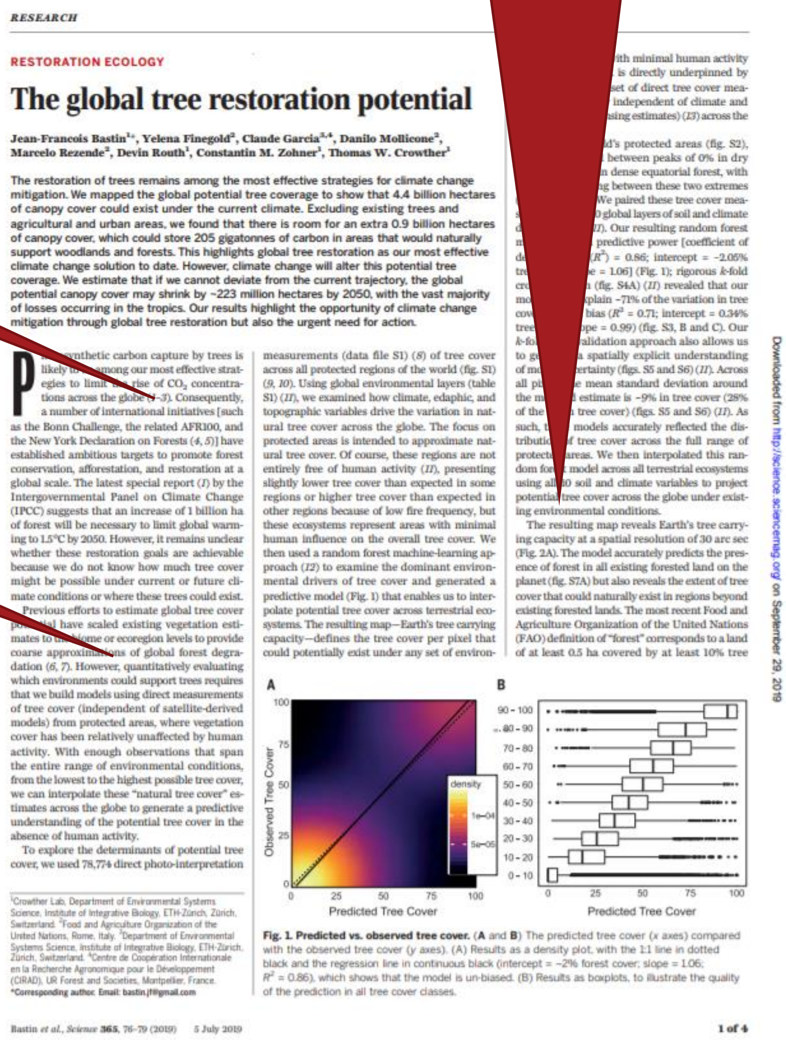
Nord-Larsen et al. (2019). Ecosystem carbon stocks and their temporal resilience in a semi-natural beech-dominated forest. For. Ecol. Man 447, 67–76

# Den gode nyhed …. ?

Opsparing af 205 mia. tons kulstof

1.7-1.8 mia ha skov

0.9 mia. ha kronedække



*RESEARCH*

RESTORATION ECOLOGY

## The global tree restoration potential

Jean-Francois Bastin[1*], Yelena Finegold[2], Claude Garcia[3,4], Danilo Mollicone[2], Marcelo Rezende[2], Devin Routh[1], Constantin M. Zohner[1], Thomas W. Crowther[1]

The restoration of trees remains among the most effective strategies for climate change mitigation. We mapped the global potential tree coverage to show that 4.4 billion hectares of canopy cover could exist under the current climate. Excluding existing trees and agricultural and urban areas, we found that there is room for an extra 0.9 billion hectares of canopy cover, which could store 205 gigatonnes of carbon in areas that would naturally support woodlands and forests. This highlights global tree restoration as our most effective climate change solution to date. However, climate change will alter this potential tree coverage. We estimate that if we cannot deviate from the current trajectory, the global potential canopy cover may shrink by ~223 million hectares by 2050, with the vast majority of losses occurring in the tropics. Our results highlight the opportunity of climate change mitigation through global tree restoration but also the urgent need for action.

P ynthetic carbon capture by trees is likely to among our most effective strategies to limit rise of $CO_2$ concentrations across the globe (1–3). Consequently, a number of international initiatives [such as the Bonn Challenge, the related AFR100, and the New York Declaration on Forests (4, 5)] have established ambitious targets to promote forest conservation, afforestation, and restoration at a global scale. The latest special report (1) by the Intergovernmental Panel on Climate Change (IPCC) suggests that an increase of 1 billion ha of forest will be necessary to limit global warming to 1.5°C by 2050. However, it remains unclear whether these restoration goals are achievable because we do not know how much tree cover might be possible under current or future climate conditions or where these trees could exist.

Previous efforts to estimate global tree cover po tial have scaled existing vegetation estimates to biome or ecoregion levels to provide coarse approxima ons of global forest degradation (6, 7). However, quantitatively evaluating which environments could support trees requires that we build models using direct measurements of tree cover (independent of satellite-derived models) from protected areas, where vegetation cover has been relatively unaffected by human activity. With enough observations that span the entire range of environmental conditions, from the lowest to the highest possible tree cover, we can interpolate these "natural tree cover" estimates across the globe to generate a predictive understanding of the potential tree cover in the absence of human activity.

To explore the determinants of potential tree cover, we used 78,774 direct photo-interpretation measurements (data file S1) (8) of tree cover across all protected regions of the world (fig. S1) (9, 10). Using global environmental layers (table S1) (11), we examined how climate, edaphic, and topographic variables drive the variation in natural tree cover across the globe. The focus on protected areas is intended to approximate natural tree cover. Of course, these regions are not entirely free of human activity (11), presenting slightly lower tree cover than expected in some regions or higher tree cover than expected in other regions because of low fire frequency, but these ecosystems represent areas with minimal human influence on the overall tree cover. We then used a random forest machine-learning approach (12) to examine the dominant environmental drivers of tree cover and generated a predictive model (Fig. 1) that enables us to interpolate potential tree cover across terrestrial ecosystems. The resulting map—Earth's tree carrying capacity—defines the tree cover per pixel that could potentially exist under any set of environ-

ith minimal human activity
is directly underpinned by
set of direct tree cover mea-
independent of climate and
sing estimates) (13) across the

d's protected areas (fig. S2),
between peaks of 0% in dry
n dense equatorial forest, with
g between these two extremes
We paired these tree cover mea-
s 0 global layers of soil and climate
d 11). Our resulting random forest
m predictive power [coefficient of
de ($R^2$) = 0.86; intercept = −2.05%
tre e = 1.06] (Fig. 1); rigorous k-fold
cro n (fig. S4A) (11) revealed that our
mo xplain ~71% of the variation in tree
cov bias ($R^2$ = 0.71; intercept = 0.34%
tree ope = 0.99) (fig. S3, B and C). Our
k-fo validation approach also allows us
to ge a spatially explicit understanding
of mo ertainty (figs. S5 and S6) (11). Across
all pi e mean standard deviation around
the m l estimate is ~9% in tree cover (28%
of the tree cover) (figs. S5 and S6) (11). As
such, t models accurately reflected the dis-
tributio f tree cover across the full range of
protecte areas. We then interpolated this ran-
dom for model across all terrestrial ecosystems
using all 0 soil and climate variables to project
potential tree cover across the globe under exist-
ing environmental conditions.

The resulting map reveals Earth's tree carrying capacity at a spatial resolution of 30 arc sec (Fig. 2A). The model accurately predicts the presence of forest in all existing forested land on the planet (fig. S7A) but also reveals the extent of tree cover that could naturally exist in regions beyond existing forested lands. The most recent Food and Agriculture Organization of the United Nations (FAO) definition of "forest" corresponds to a land of at least 0.5 ha covered by at least 10% tree

**Fig. 1. Predicted vs. observed tree cover.** (**A** and **B**) The predicted tree cover (x axes) compared with the observed tree cover (y axes). (A) Results as a density plot, with the 1:1 line in dotted black and the regression line in continuous black (intercept = −2% forest cover; slope = 1.06; $R^2$ = 0.86), which shows that the model is un-biased. (B) Results as boxplots, to illustrate the quality of the prediction in all tree cover classes.

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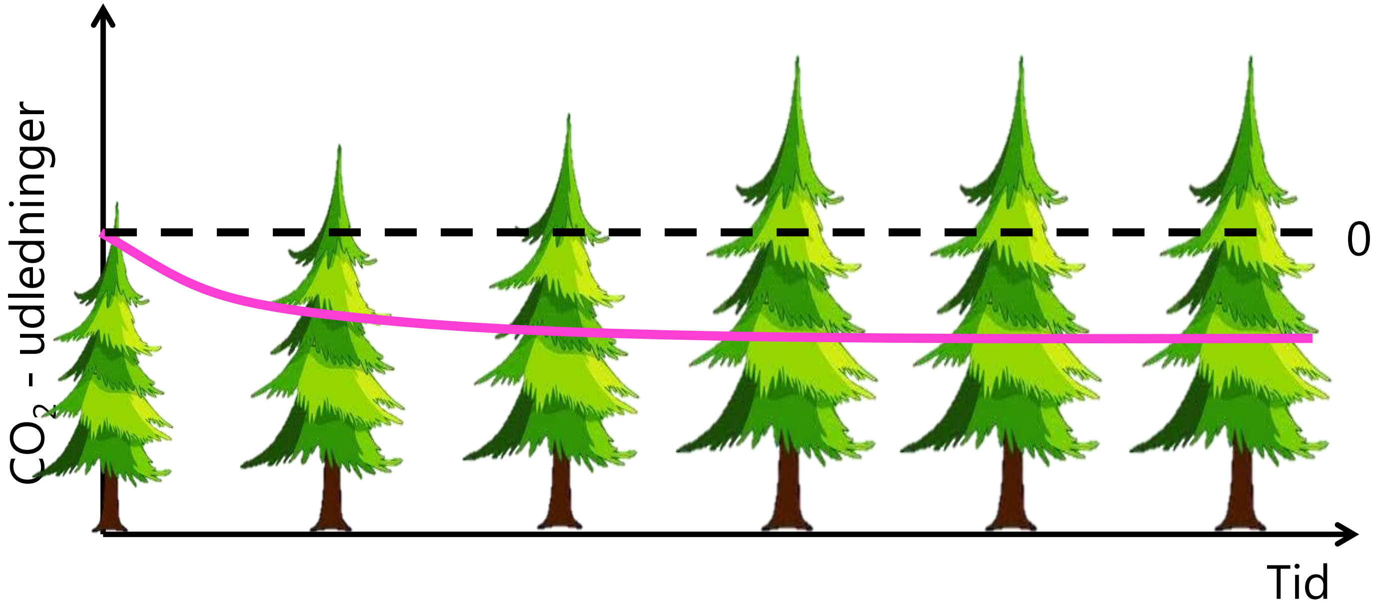
Bastin *et al.*, *Science* **365**, 76–79 (2019) 5 July 2019 1 of 4

Bastin et al. (2019). The global tree restoration potential. Science 365, 76-79.

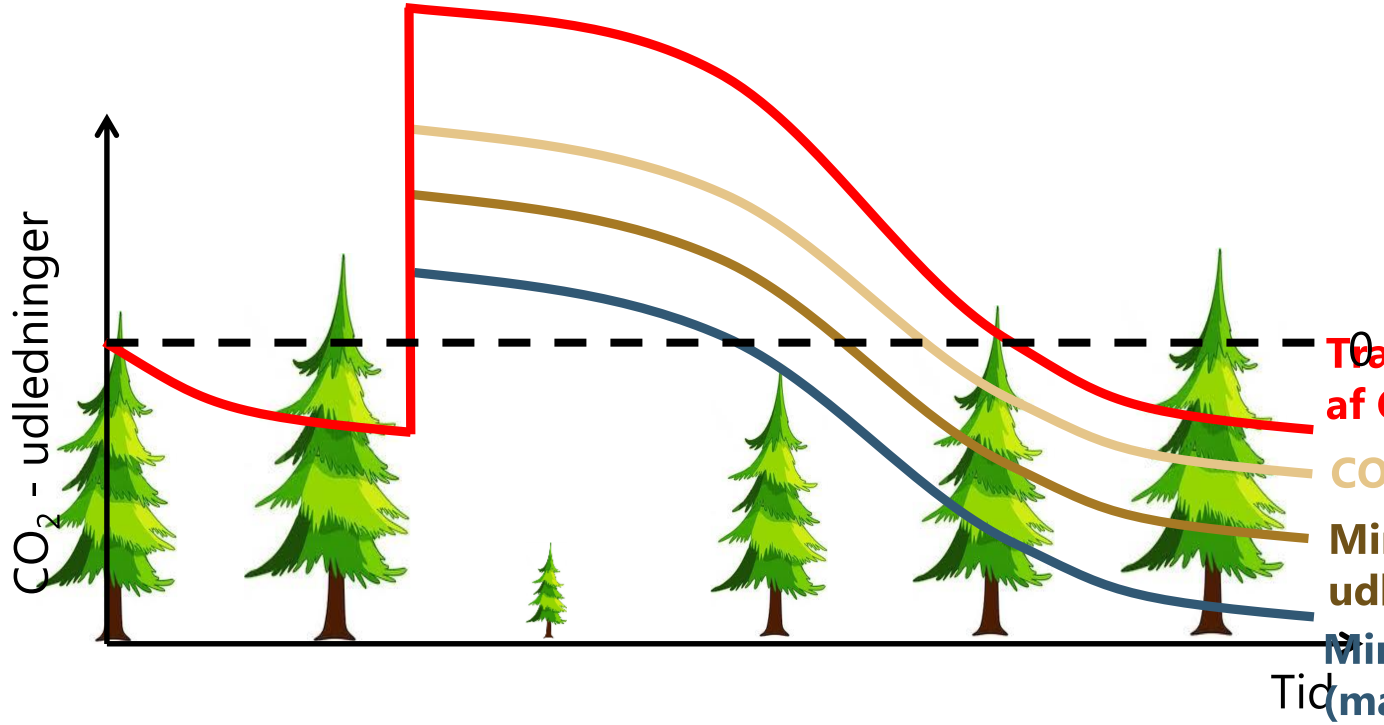
# At bruge skoven eller lade være?

## Urørt skov



# At bruge skoven eller lade være?

## Dyrket skov



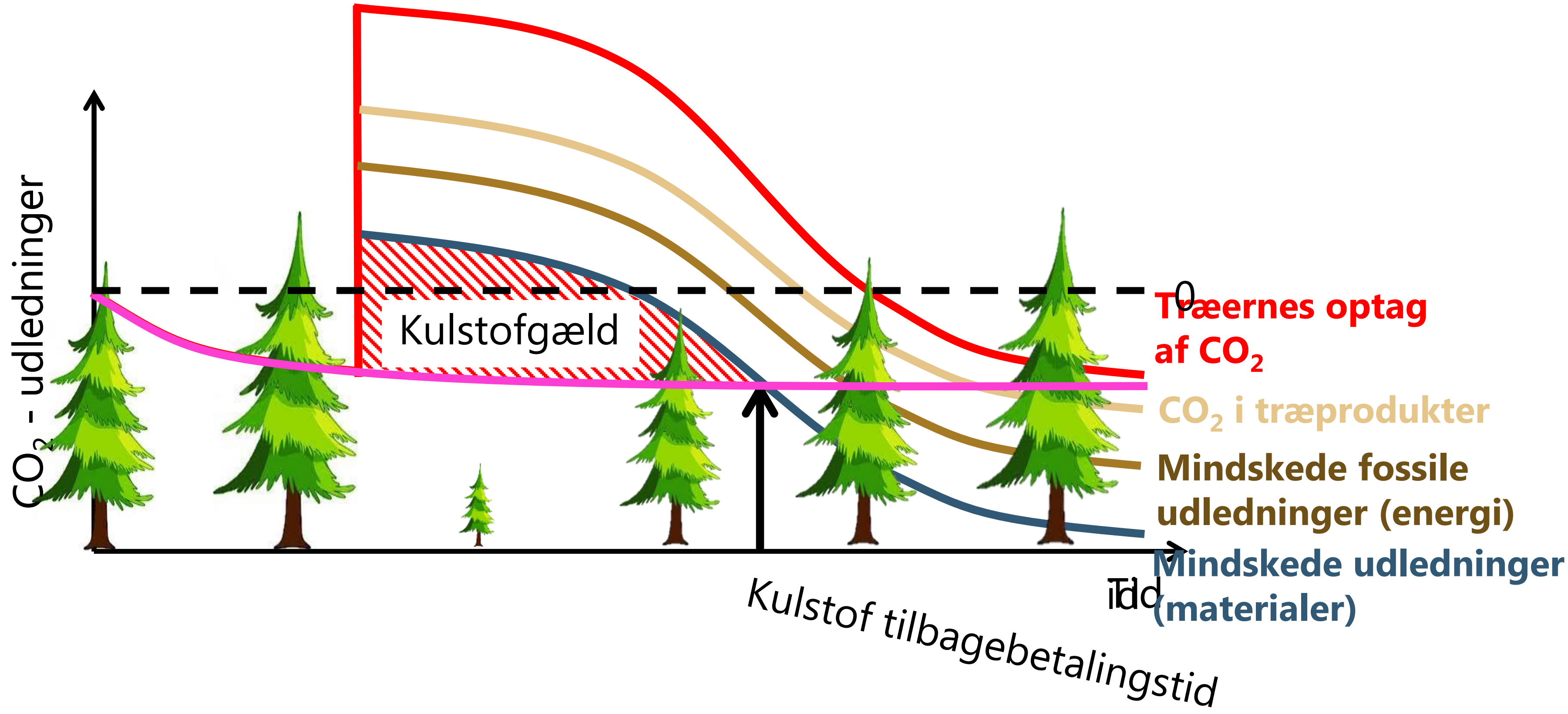
**Træernes optag af $CO_2$**

**$CO_2$ i træprodukter**

**Mindskede fossile udledninger (energi)**

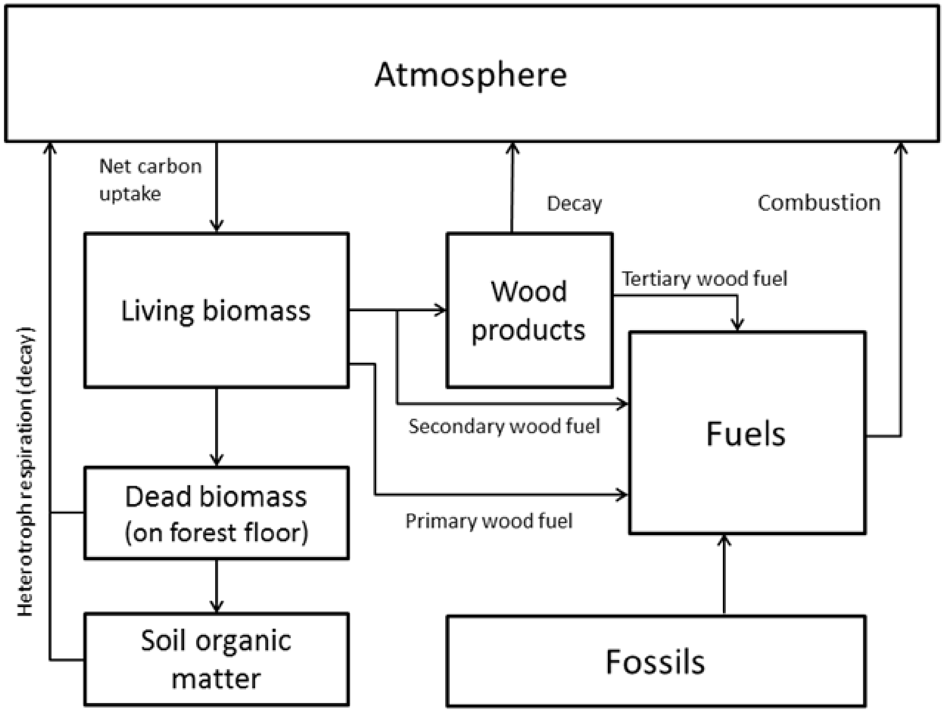
**Mindskede udledninger (materialer)**

# At bruge skoven eller lade være?



# Tre scenarier med en 100 årig bøgebevoksning som udgangspunkt

- Urørt skov (STORE)
- 'Business as usual' (BAU)
- Intensiv dyrkning af popler til energiformål (SUBST)



Atmosphere

Net carbon uptake

Decay

Combustion

Living biomass

Wood products

Tertiary wood fuel

Secondary wood fuel

Fuels

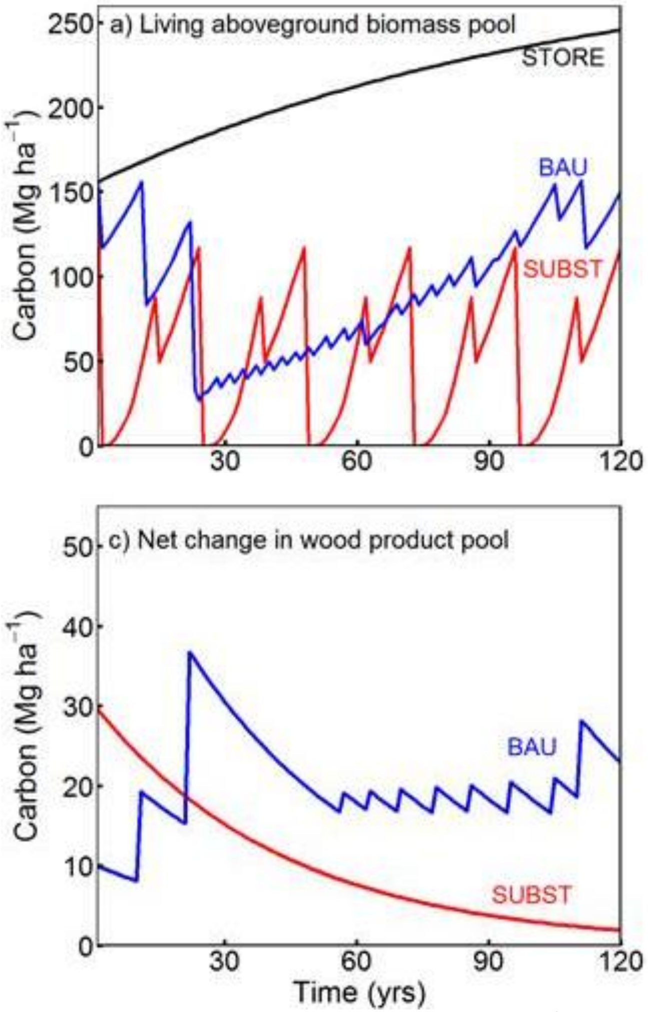
Primary wood fuel

Dead biomass (on forest floor)

Soil organic matter

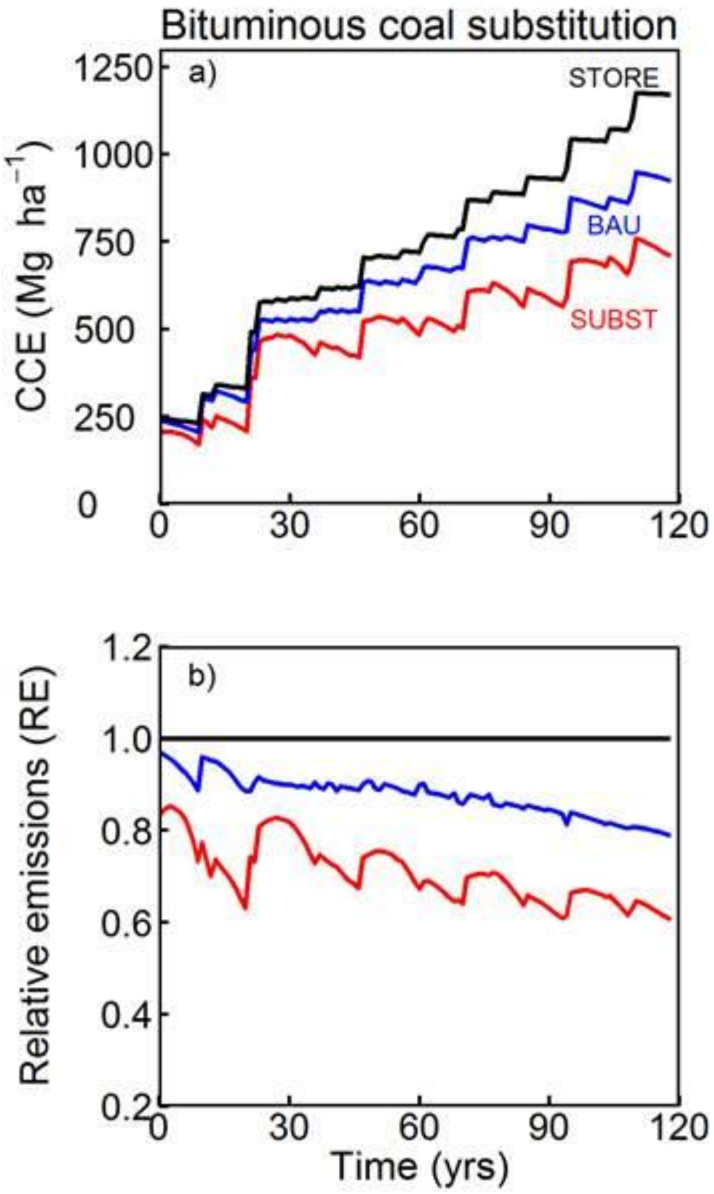
Fossils

Heterotroph respiration (decay)



Taeroe et al. (2017) Do forests best mitigate CO2 emissions to the atmosphere by setting them aside for maximization of carbon storage or by management for fossil fuel substitution? J Env Man 197, 117-129.

- Urørte skove fører samlet set til større $CO_2$-emissioner end skove med skovdrift
- Årsagen er fortsat udledning af fossilt $CO_2$ og mindsket $CO_2$ optag
- Substitutionseffekten afhænger af den alternative fossile energikilde
- Substitution af CO2-dyre materialer kan øge klimaeffekten af skovdyrkning betydeligt



Taeroe et al. (2017) Do forests best mitigate CO2 emissions to the atmosphere by setting them aside for maximization of carbon storage or by management for fossil fuel substitution? J Env Man 197, 117-129.

# Hvor skå vi hen du?

# Konklusioner

- Studier viser at urørt skov leder til større samlede CO2-emissioner end fortsat aktiv brug af skoven
- Klima-effekten af skovdyrkningen afhænger af hvilke fossile energikilder træet erstatter (Kul>Olie>Naturgas)
- Klima-effekten af skovdyrkningen afhænger af om produkterne erstatter fossil-dyre materialer
- I et klima-perspektiv er det centralt at skovbruget sigter efter at producere gavntræprodukter til en biobaseret økonomi.