Climate change mitigation and tree species change - time perspectives and potential tradeoffs

O. Janne Kjønaas[1], Sunil Mundra[2] and Håvard Kauserud[2]

[1]NIBIO, [2]Universitetet i Oslo

Source: Kjønaas et al., 2021 (in press); Bright et al., 2020; Mundra et al., Submitted

Background

1. **Increased C sequestration in forests**, including afforestation and tree planting, are proposed to be **amongst the most effective measures to mitigate climate change** (**IPCC** 2018, Eggermont et al. 2015, Bastin et al. 2019, Sippel et al. 2020).

2. **Tree species change** is proposed as a Norwegian government policy to mitigate climate change by increasing

    1. annual uptake of CO_2 in the forest

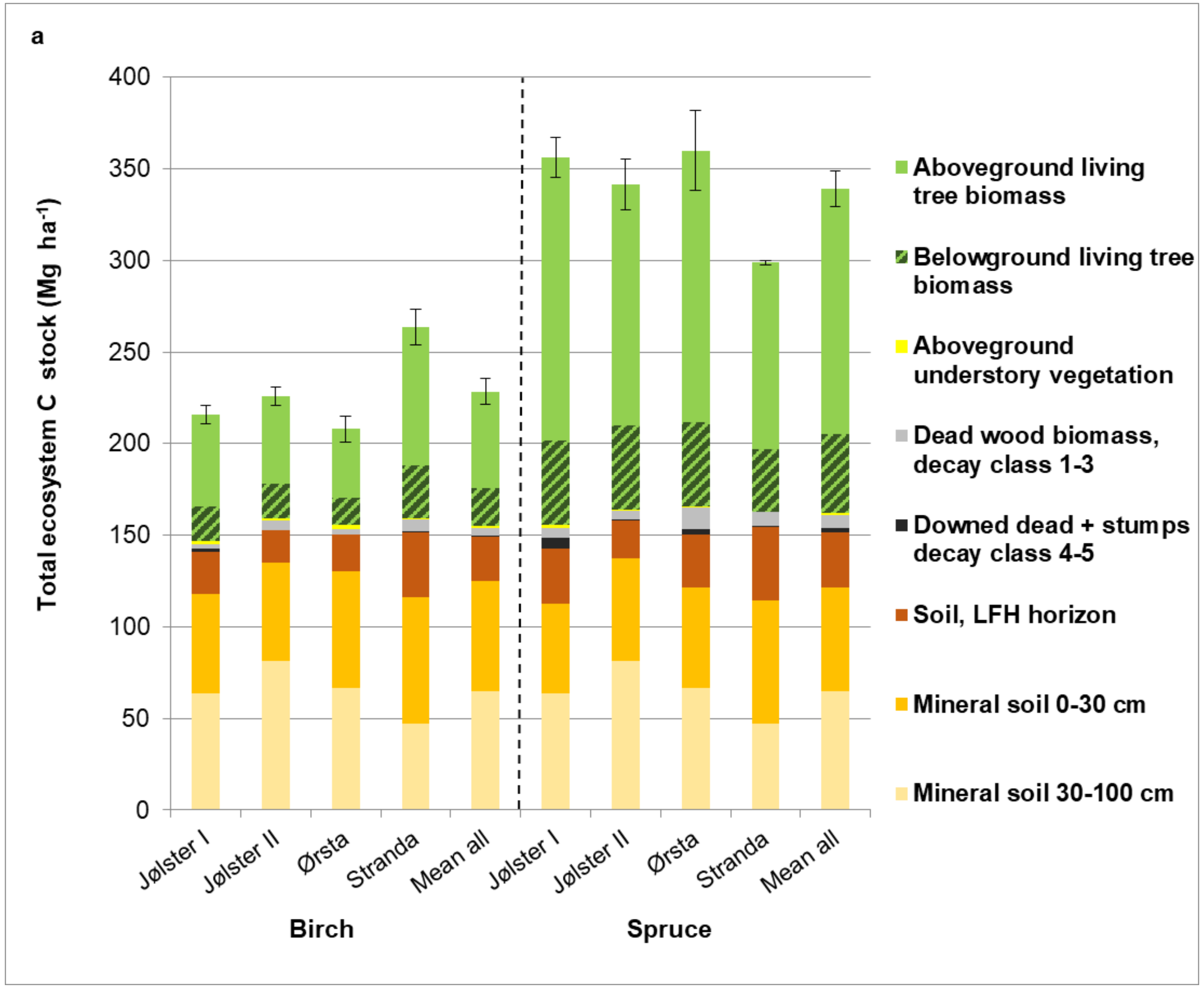
    2. long-term storage of C

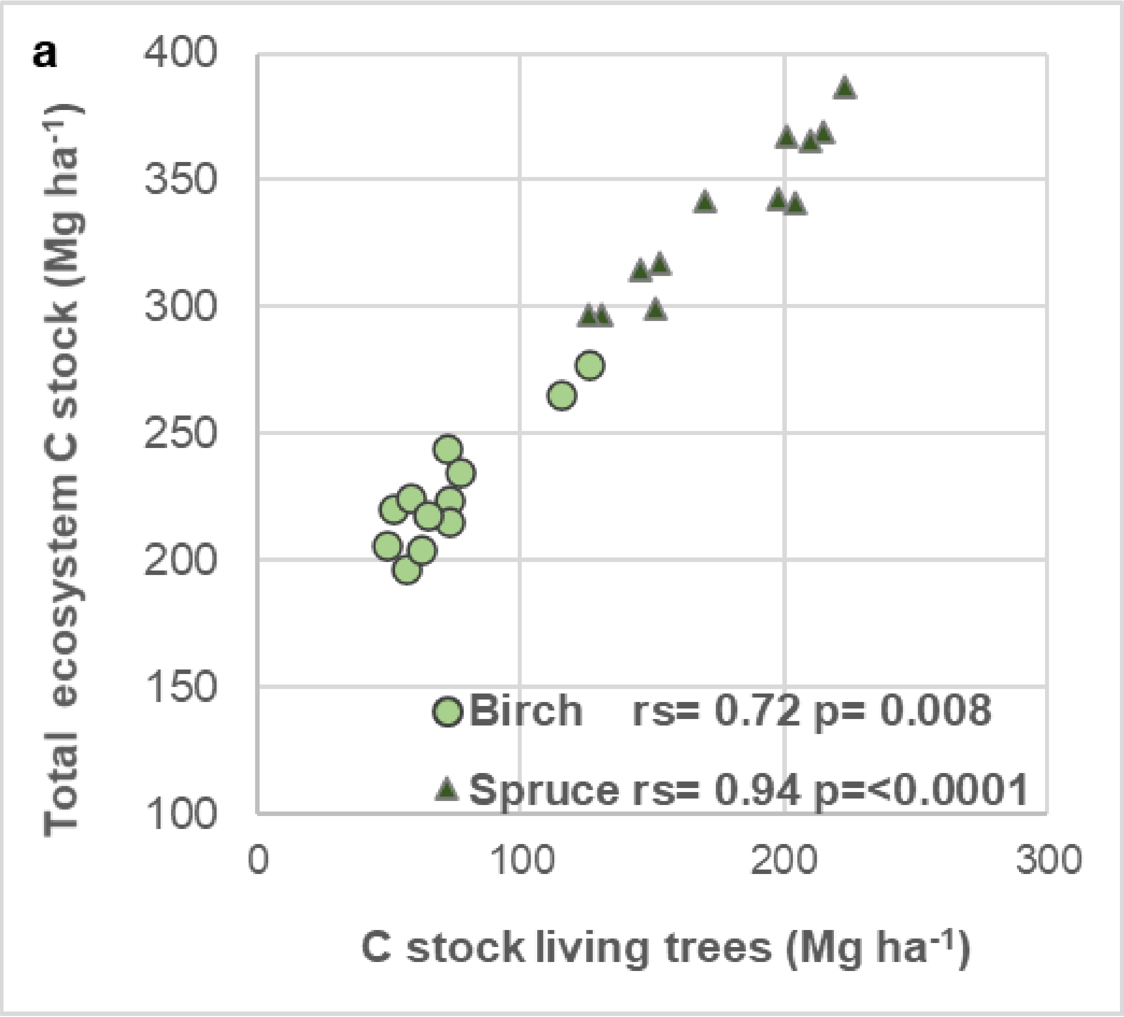
TRADEOFFS? - Effects on biodiversity and nutrient status

BalanC - The impact of increasing spruce plantation area on the carbon balance of forests in Western Norway (2016-2021)

Purpose: Quantify the effects of tree species change on C stocks and changes in paired natural birch stands in Western Norway

C stock changes: Increased C stock in living tree biomass

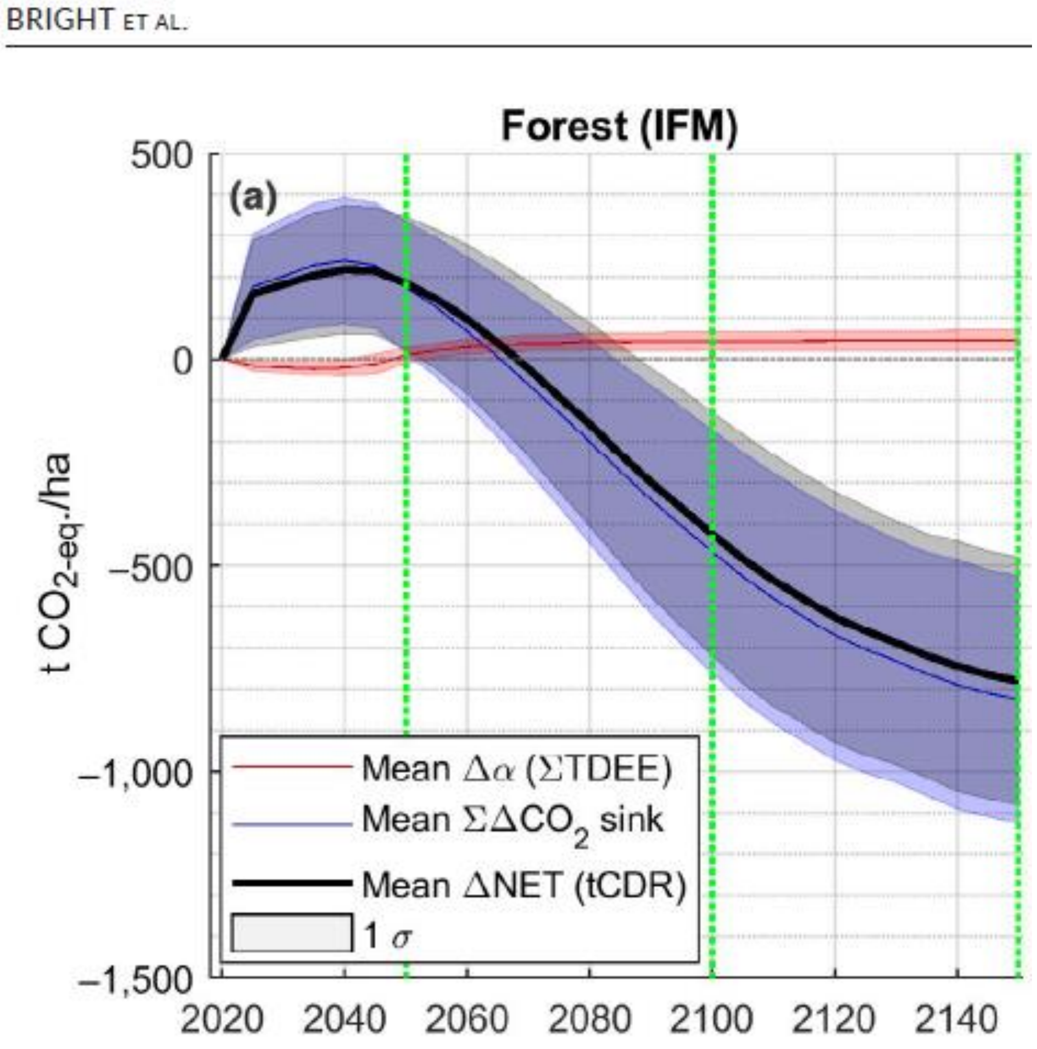




C stock ratio soil : tree biomass: Birch = 3.3 (± 0.4) Spruce = 1.4 (± 0.1)

Kjønaas et al., 2021

Modeling results: **Short term versus long term perspectives?**



C capture in forests following tree species change - based on NFI data

- **Short term**, 40 (30 – 60) years:

  Loss of C to the atmosphere

- **Long term:** 90 (70 – 120) years:

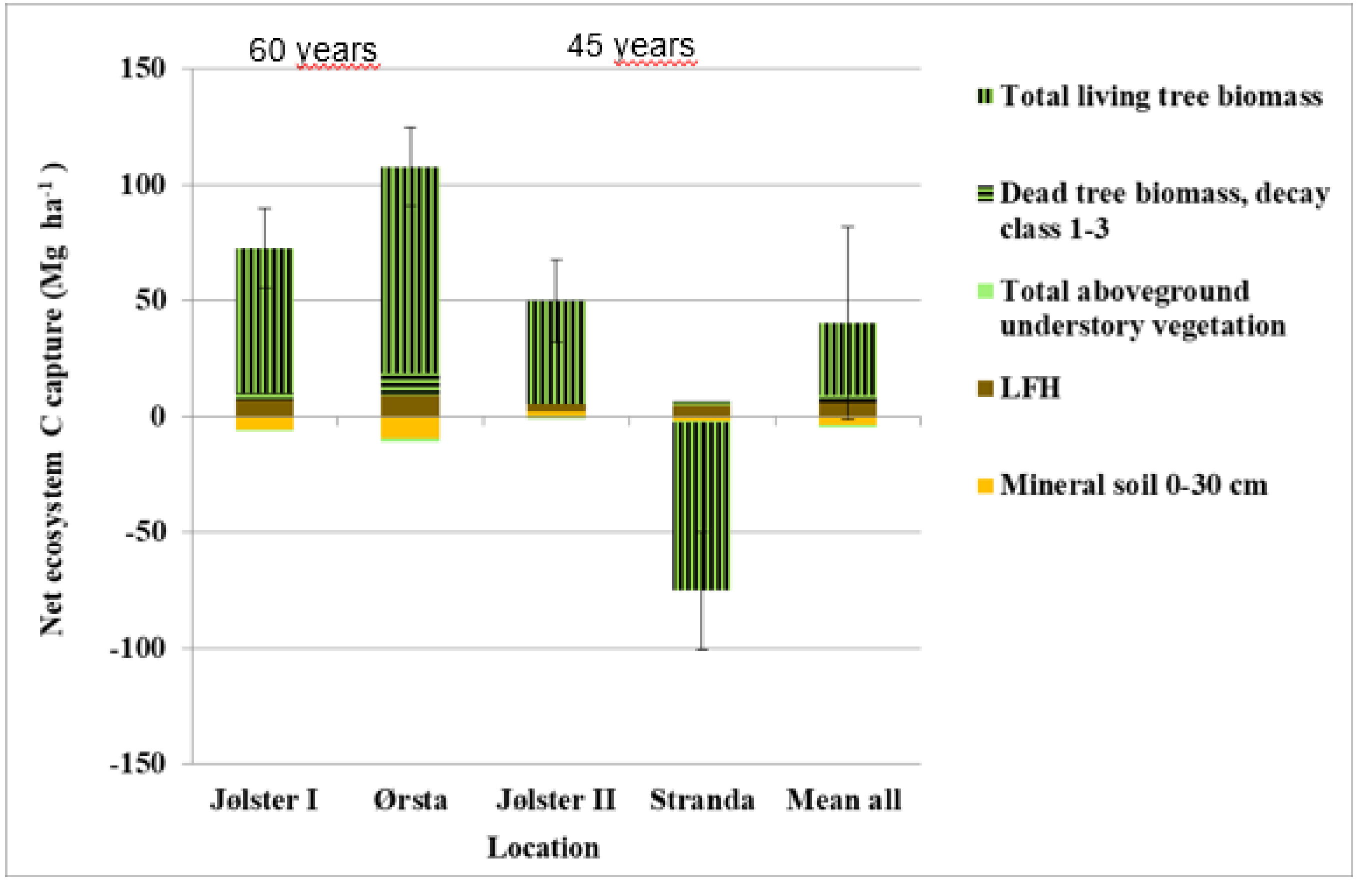
  Accumulation (Δ) of 127 (±80) Mg C ha^{-1} at 2100,

  Offset by 12 Mg C ha^{-1} (-12%) when including change in surface albedo

Bright et al 2020

Net C capture, including C debt

	C akkumulation living biomass Mg ha^{-1}	Net C capture living trees Mg ha^{-1}
Jølster I	132	63
Jølster II	111	45
Ørsta	142	89
Stranda	32	-73
Average	**104 (±30)**	**31 (±1)**

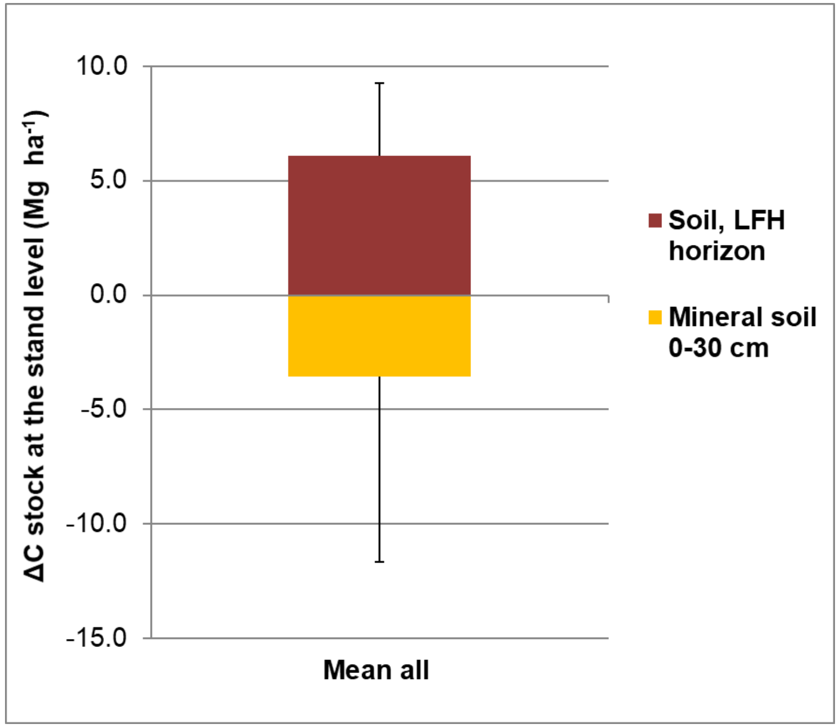


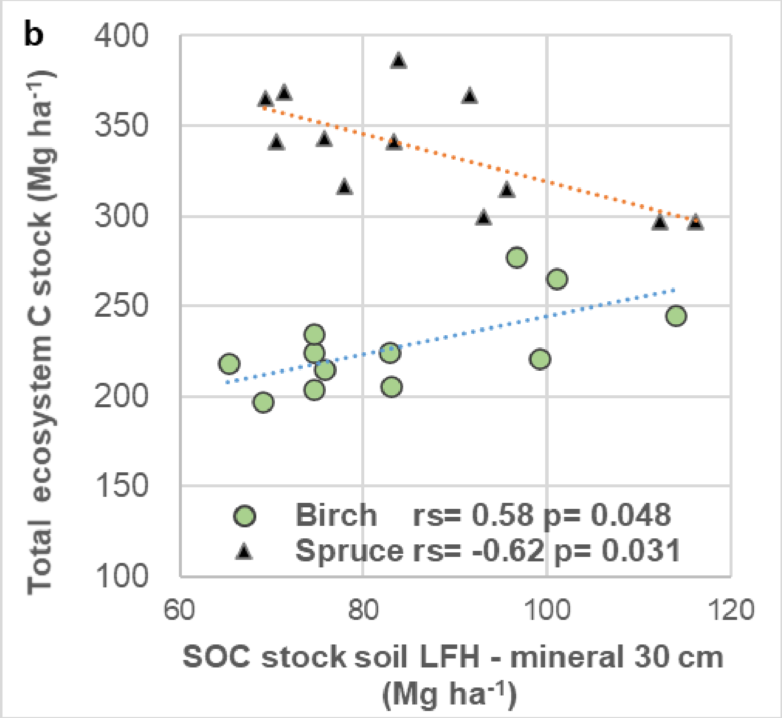
Optimalization:

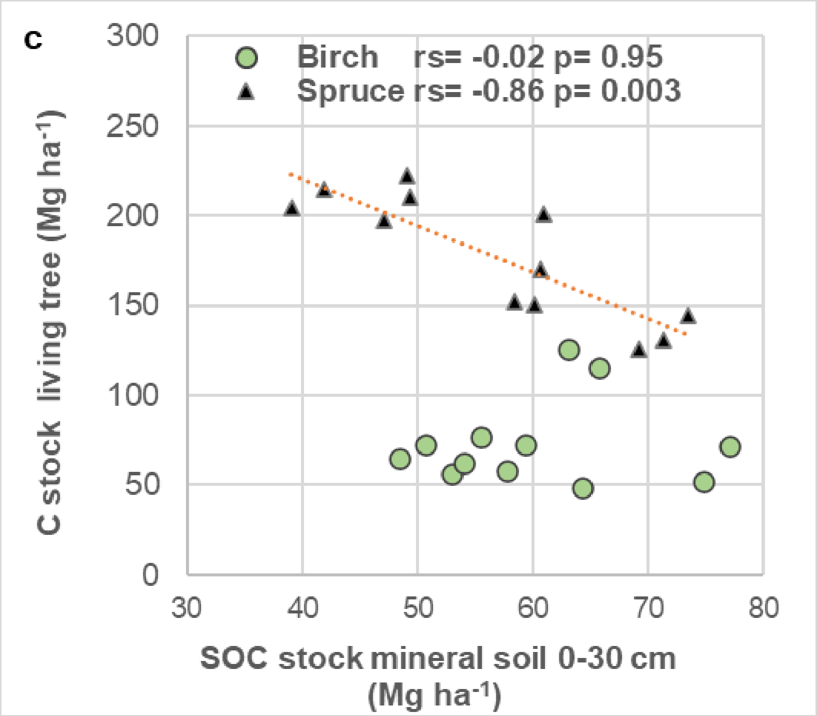
- A need to increase rotation length (>45 – 60 years)
- Biomass in original birch stand is a key – young stands at stand initiation stage

Kjønaas et al., 2021

Long term storage and stability of SOC?



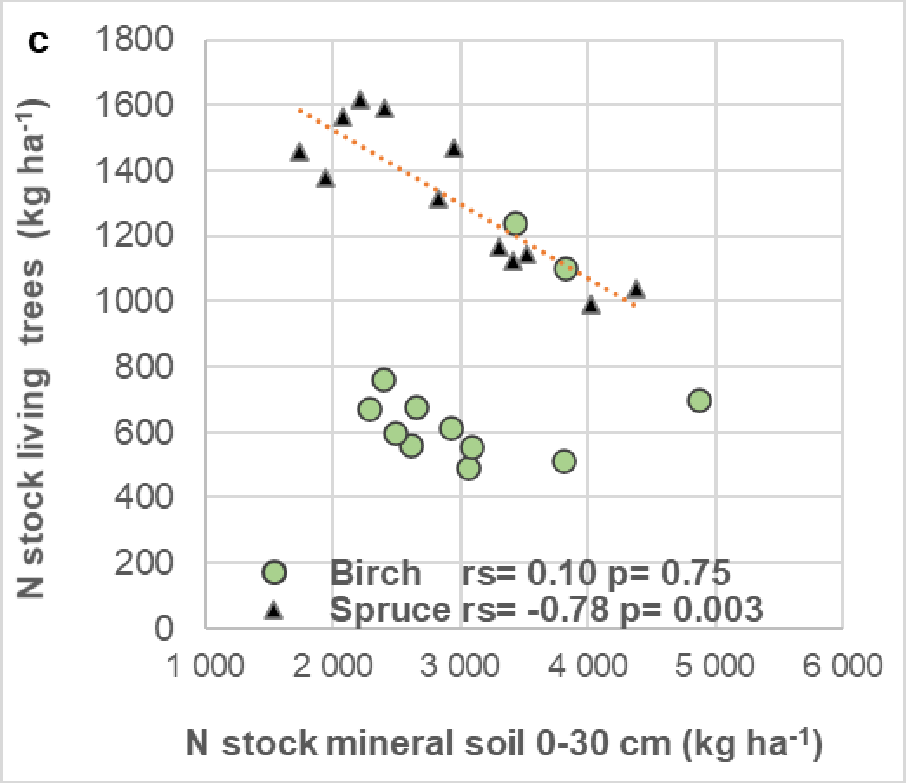


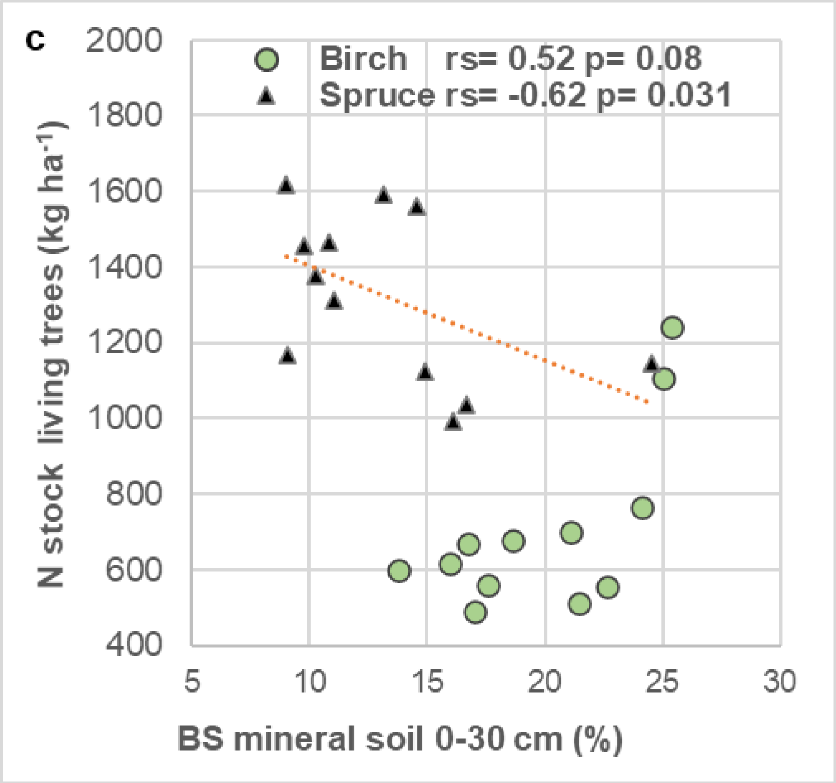


Coniferous species accumulate more SOC in the forest floor (LFH), broadleaves more in the mineral soil (Vesterdal et al 2013; Mayer et al 2020)

Kjønaas et al., 2021

Long term nutrient (im)balance?



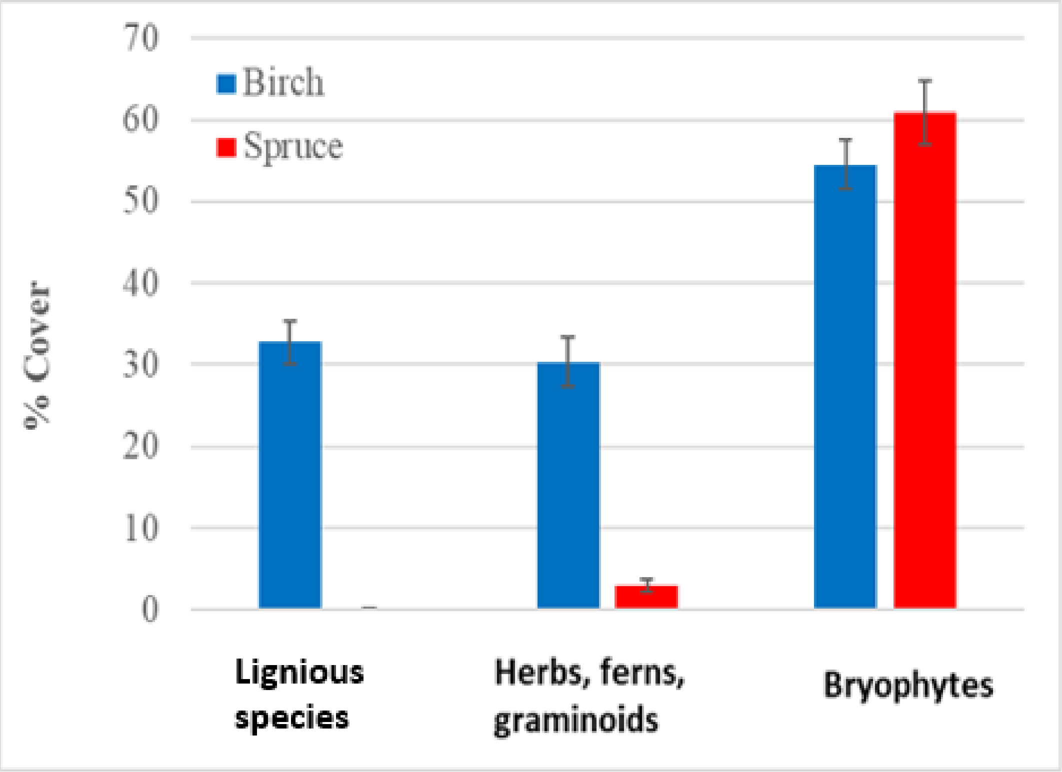


Increased biomass growth may increase decomposition of SOC, as availability of N generally constrains biomass production
(e.g. Högberg et al 2017; Tamm, 1991).

Significantly lower BS and exchangeable Ca and Mg in the upper mineral soil in spruce stands

Adverse impacts to biodiversity?

Understory vegetation (%Cover)



Kjønaas et al., 2021

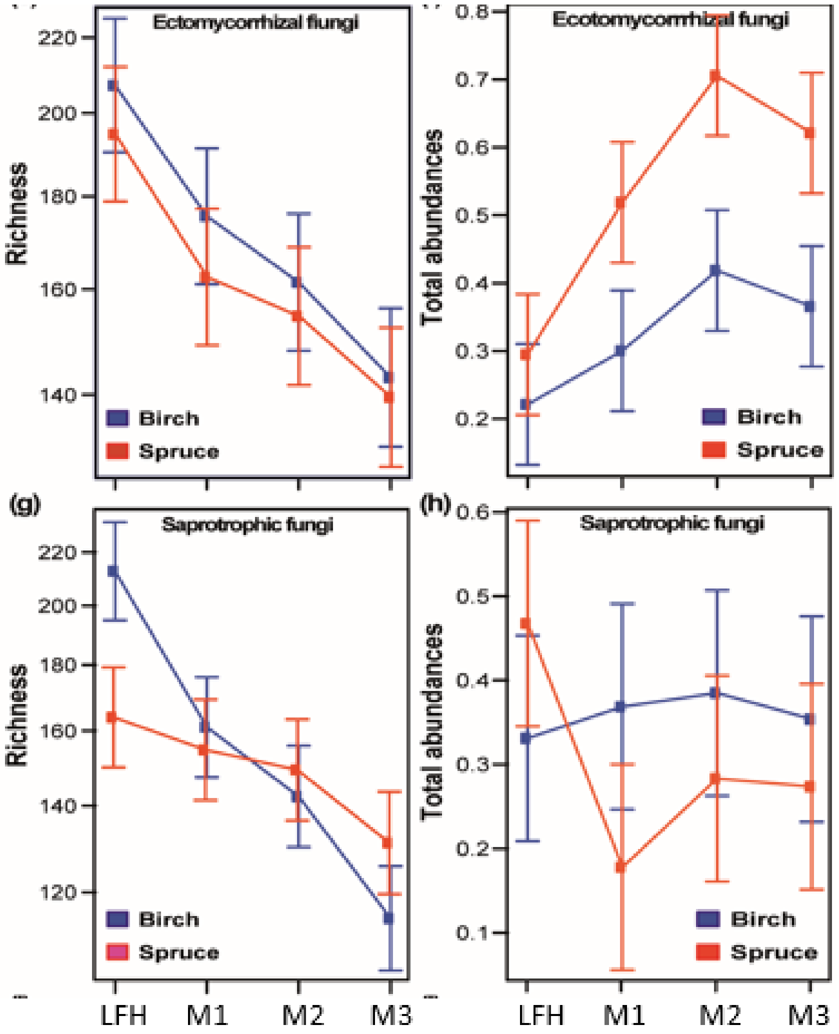
FUNGI - functional groups

Species richness - diversity

abundance

Ectomycorrhiza

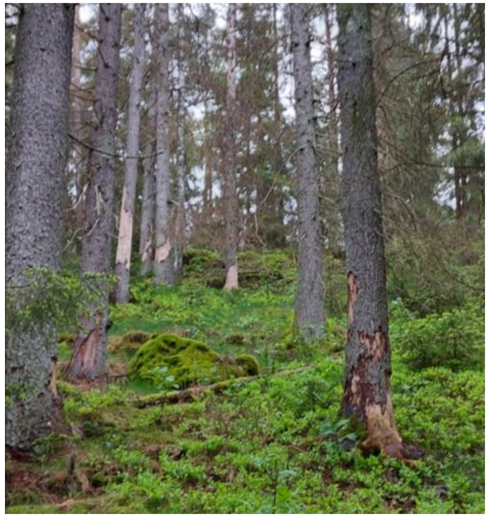
Saprotrofer



Mundra et al, submitted.

Tree species change in a climate change perspective?

Forecast, regional climate change: increasing temperature and precipitation; increasing periodic drought stress during dry summer spells; generally: increasing storm frequency /intensity



- **Increased decomposition of SOC in surface soil**
- **Storm damage/wind throws** S>B
  - Sheding of leaves, rooting depths
    2003; Hansson et al., 2011; Dawud et al., 2016)
- **Wildfires:** S>B
  - Thickness of humus layer >4-6 cm (Rogers et al 2015)
  - Shallow-rooted species rarely survive ground fires (Rogers et al. 2015)
- **Drought stress:** S>B
  - Rooting depth (Puhe, 2003; Rosner et al. 2018).
- **Biotic damages: ?**
  - Bark beeetle outbreaks (Jonsson and Lagergren 2018, Kosunen et al. 2019, Timmermann et al. 2018)
  - Others?

BIG QUESTIONS – ANSWERES?

1. TREE SPECIES CHANGE: TO WHAT, WHERE – and HOW MUCH?

2. HOW DO WE BALANCE LONGER TERM CLIMATE MITIGATION and
   - short term increase in atmospheric CO_2 – tipping point?
   - potential long term loss in nutrient status
   - loss in biodiversity

3. HOW TO OPTIMIZE - CREATING WIN-WIN SOLUTIONS?

4. WHAT RECOMENDATIONS CAN WE GIVE NOW?

THANK YOU