The carbon balance of old-growth forests in Finland

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Introduction

- Boreal old-growth forests are large carbon storages and maintain habitats for several forest species.
- In Finland, old-growth forests have largely disappeared because of intensive forest management.
- The indicators and thresholds of old-growth forests are currently under debate.

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Indicators of old-growth forests

- National methodologies to conduct the inventory of old-growth forests are currently under discussion and development.
- The methodologies will build on the indicators proposed in the Commission guidelines for mapping and protecting EU old-growth forests

- Main indicators
  - Native tree species
  - Deadwood (amount and diversity)
  - Old or large trees (high standing volume and age)
- Complementary indicators
  - Natural stand origin
  - Structural complexity
  - Habitat trees
  - Indicator species

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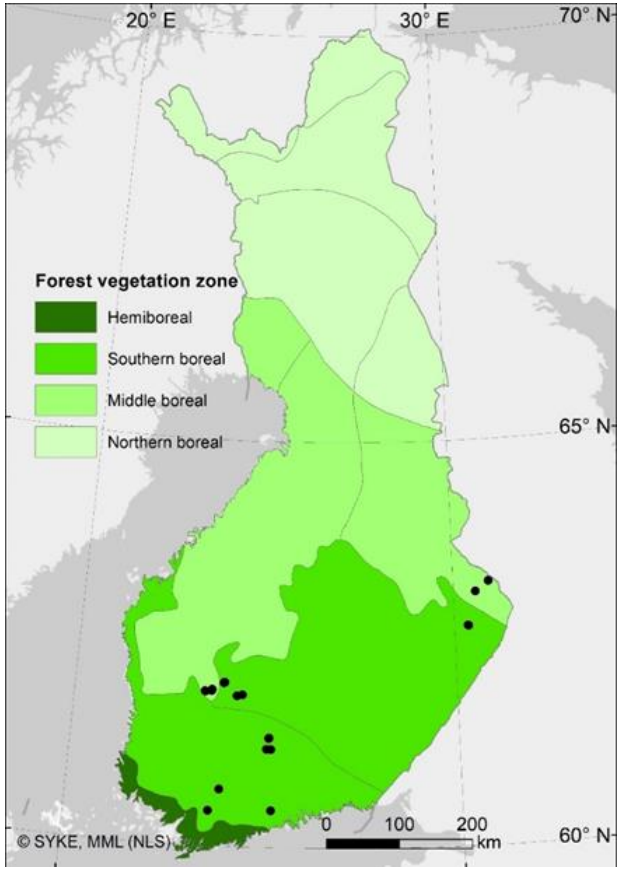
Knowledge gap

- The carbon sink capacity of old forests is currently insufficiently known due to the scarcity of repeated measurements.
- In addition, the links between the conservation of threatened species and forest carbon storage are largely unexplored.
- We postulated that the volume increment declines with stand age and that the occurrence of red-listed epiphytic lichens correlates with stand biomass.

Ryan et al. 2004. Ecological Monographs 74, 393-414.
Nascimbene et al. 2009. Biodiversity and conservation 18, 1509-1522.

Material and methods

- Three forest inventories in 1991-2019 from 27 permanent sample plots in Finland
- Norway spruce dominated mesic stands, 90-200 years old in the first measurement
- Biomass was estimated with the pipe model equations (Mäkelä & Valentine 2020)
- A lichen inventory was conducted at the same sites in 2020-2021. Epiphytic lichen diversity acts as one overall indicator of forest biodiversity.



Mäkelä, A. & Valentine, H.T. 2020. Models of Tree and Stand Dynamics. Springer.

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In an old-growth forest, the only constant is change.

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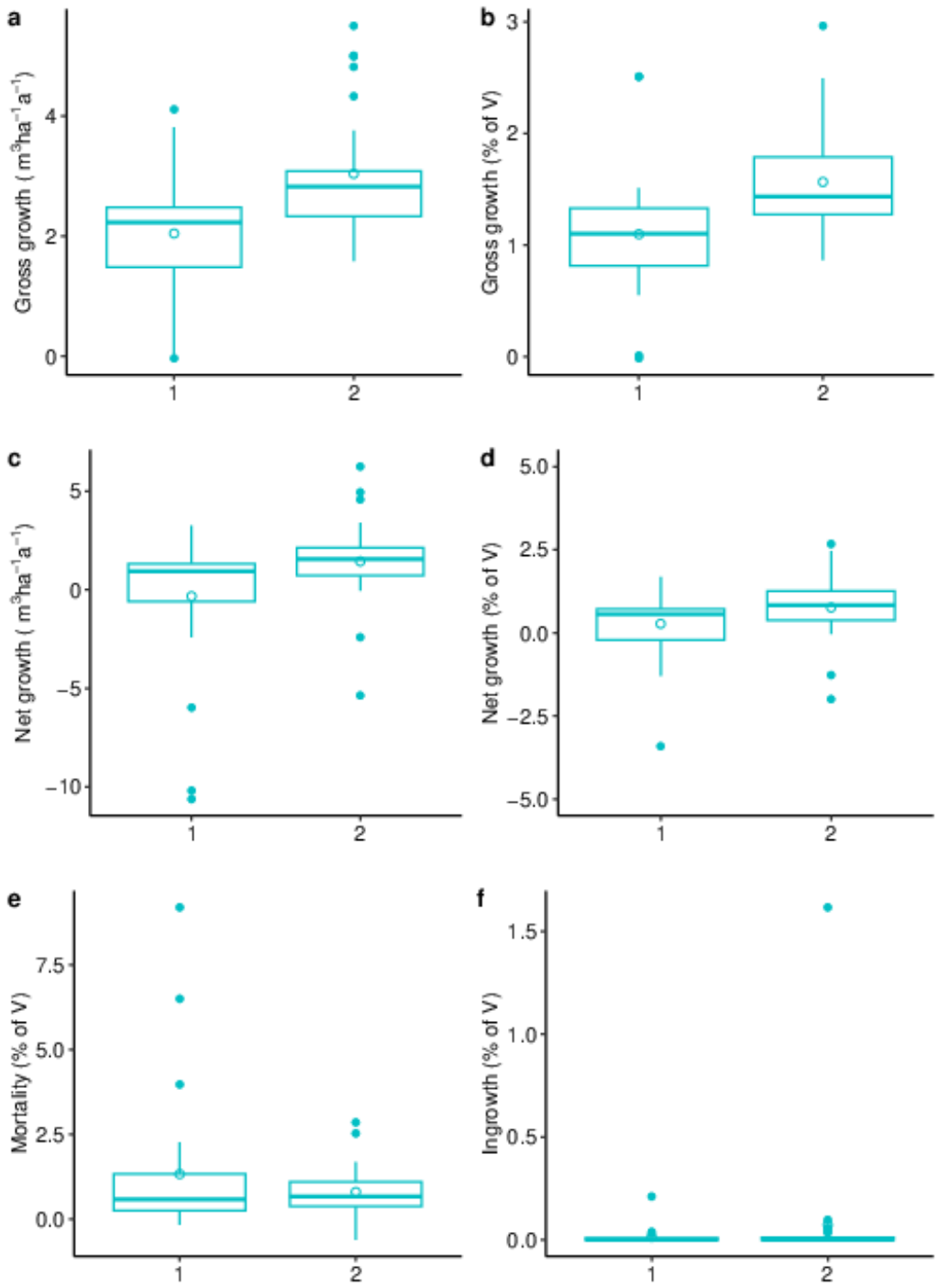

Volume increment

- The mean gross volume increment increased, both absolutely and relative to the standing volume.
- Growth was smaller or equal than natural mortality resulting in zero net volume increment in most sites.
- The growth increase was driven by the lower canopy layers (DBH ≤ 30 cm in the first measurement).

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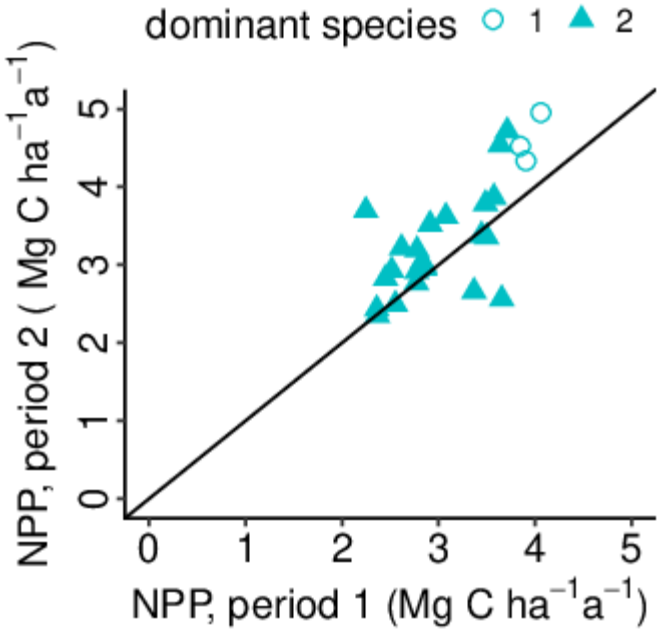
Net primary production

- NPP consisted of the annual increment of biomass and litter production.
- NPP was 2.2-5.0 Mg C $ha^{-1}a^{-1}$ depending on the site, comparable with the estimates by Gundersen et al. 2021.
- Unexpectedly, NPP accelerated in most sites between period 1 (1991-2006) and 2 (2006-2019). Site disturbance history and climate change could explain the trends.



Akujärvi et al. Manuscript.

Gundersen et al. 2021. Nature.
https://doi.org/10.1038/s41586-021-03266-z

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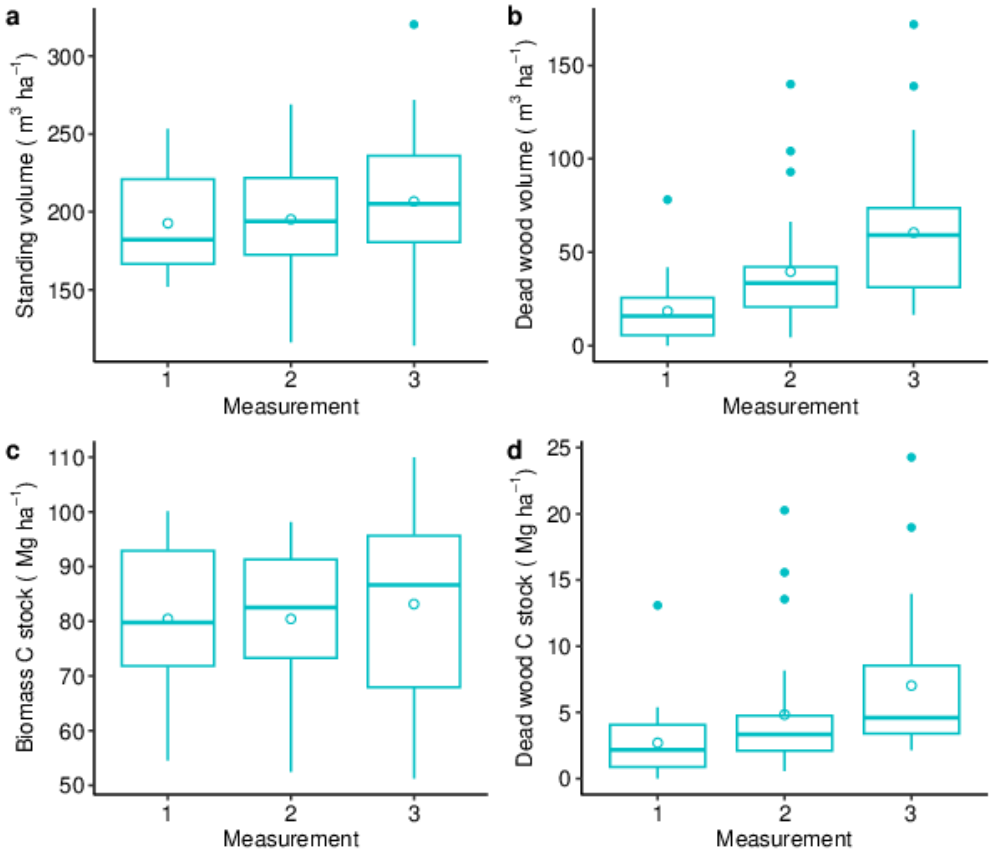
Carbon stocks

- Despite the increased growth, the carbon stock of biomass remained quite stable.
- A large proportion of the gross growth ended up to the deadwood carbon pool, which showed a drastic increase.
- However, some of the logs might have remained undetected in the first measurement, adding uncertainty to the estimates.



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The studied forests hosted several lichen species.

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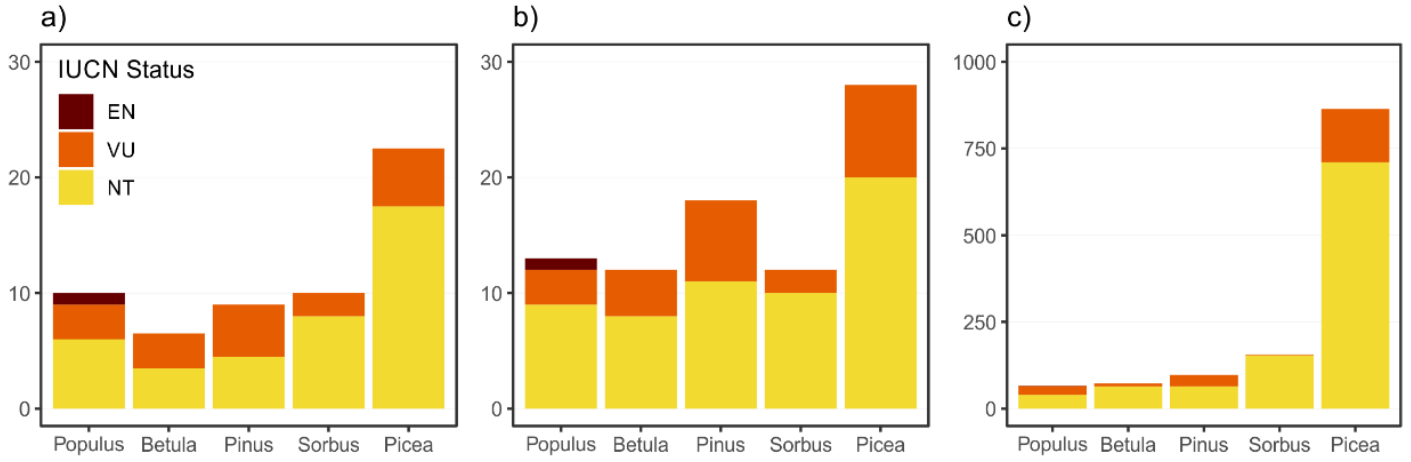
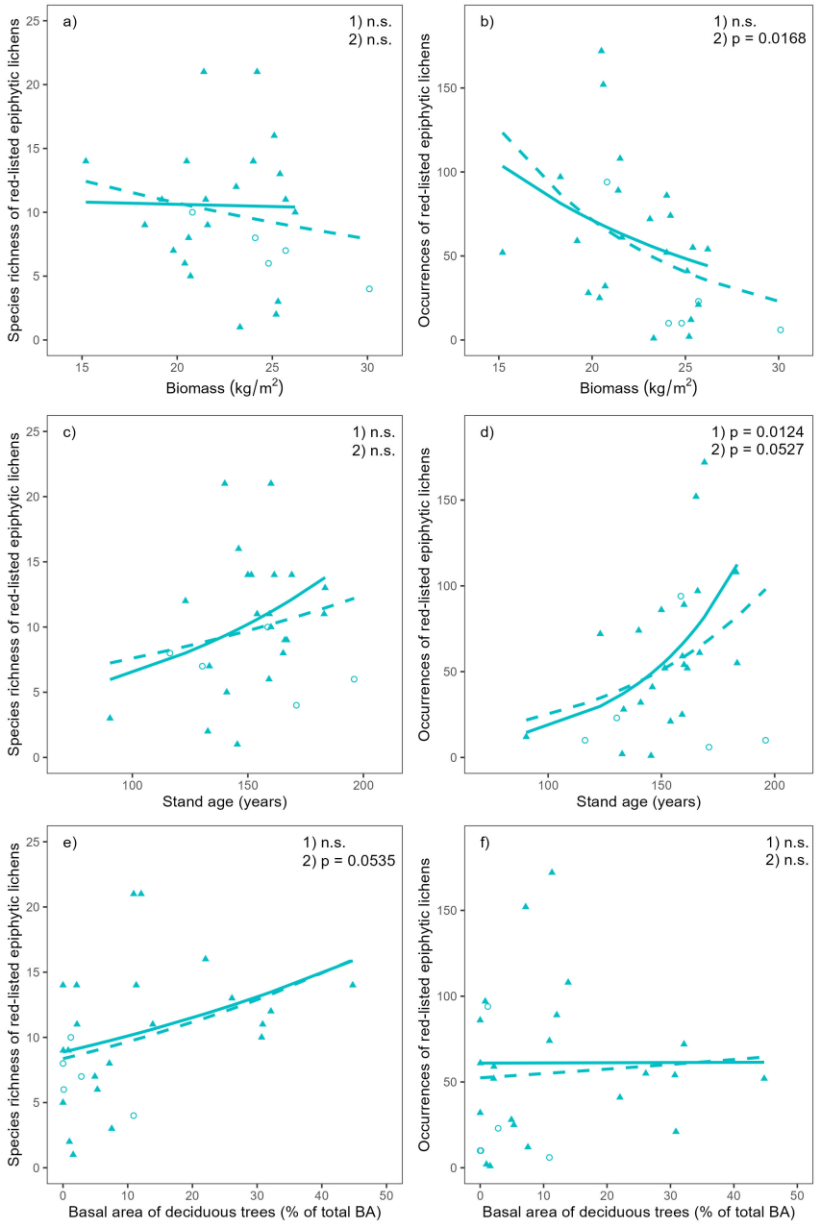
Epiphytic lichen occurrences

- In total, 58 species of red-listed epiphytic lichens and allied fungi were recorded from the 27 study sites.
- Norway spruce (*Picea abies*) was the most important host of red-listed lichens. Rowan (*Sorbus aucuparia*) proved to be important in the understory.



a) The number of red-listed lichen species that occurred primarily on the given tree species
b) The total number of red-listed lichen species per tree species
c) The total number of occurrences of red-listed lichen species per tree species



Species diversity vs. forest structure

- The number of red-listed lichen occurrences was negatively correlated with *stand biomass* (p=0.0168).
- The species richness and the number of occurrences of red-listed lichens increased with *stand age*.
- The species richness of red-listed lichens had a marginally significant positive relationship with *the relative BA of deciduous trees*.

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Conclusions

- The studied forests demonstrated constant growth of the lower canopy layers and a high accumulation rate of deadwood during the last decades.
- The diversity of epiphytic lichens was associated with low stand biomass, high stand age and a mixture of coniferous and deciduous tree species.
- The results suggest that preserving the characteristics of old-growth forests supports both climate change mitigation and biodiversity conservation.

Research team

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Thank you!

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