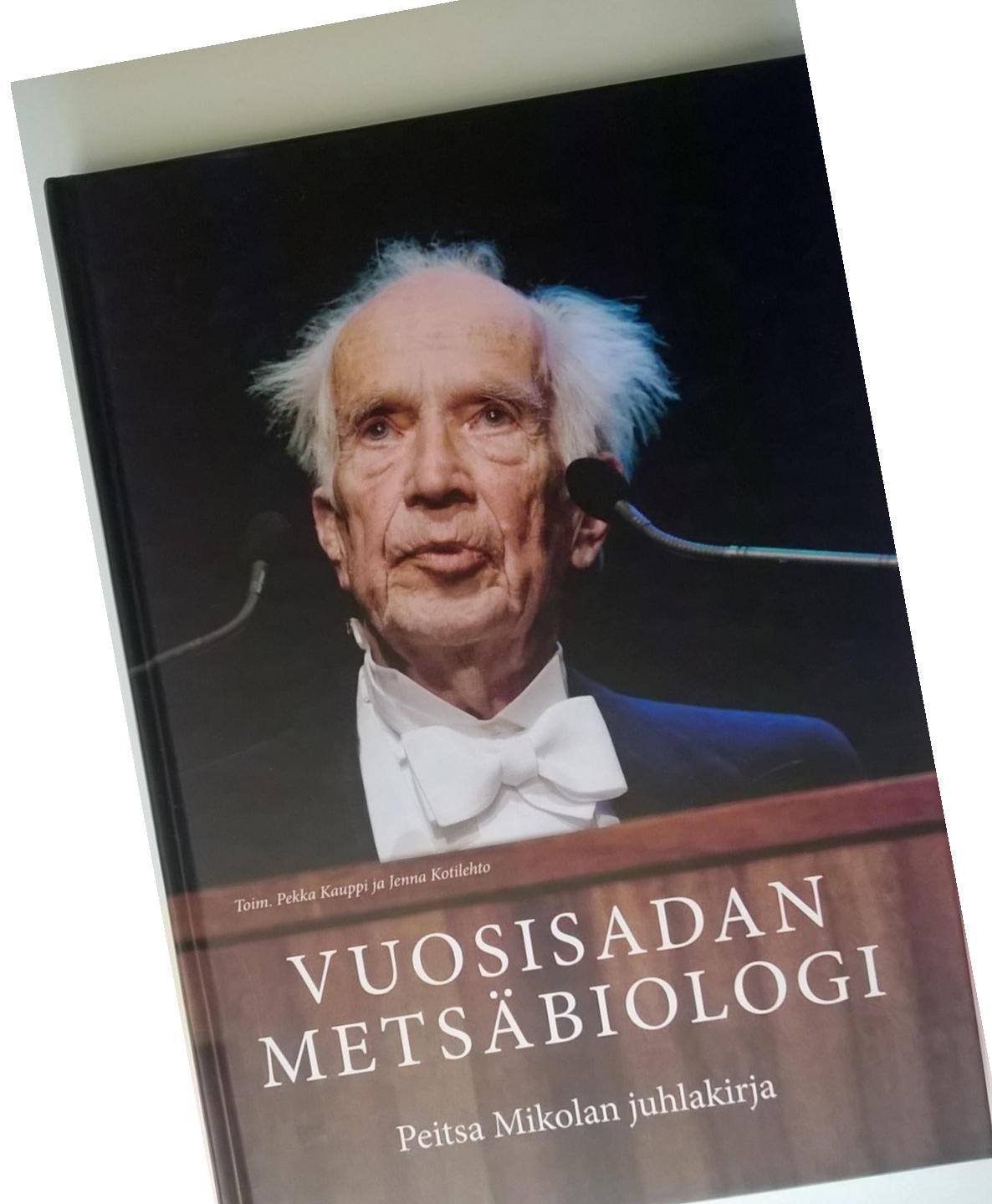


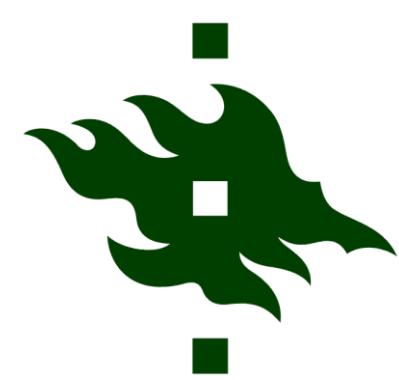
**Whole-Rotation Carbon Budgets in Swedish Forests –
Background, current trends, and the future
The Royal Swedish Academy of Agriculture and Forestry
Friday 23 September 2016, Stockholm**

Short and long term mitigation options – how forest management can contribute to reduced CO₂ in the atmosphere

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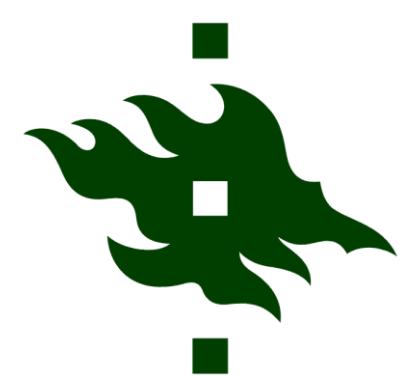
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- forest expansion in wealthy nations
- forest contraction in less advanced nations

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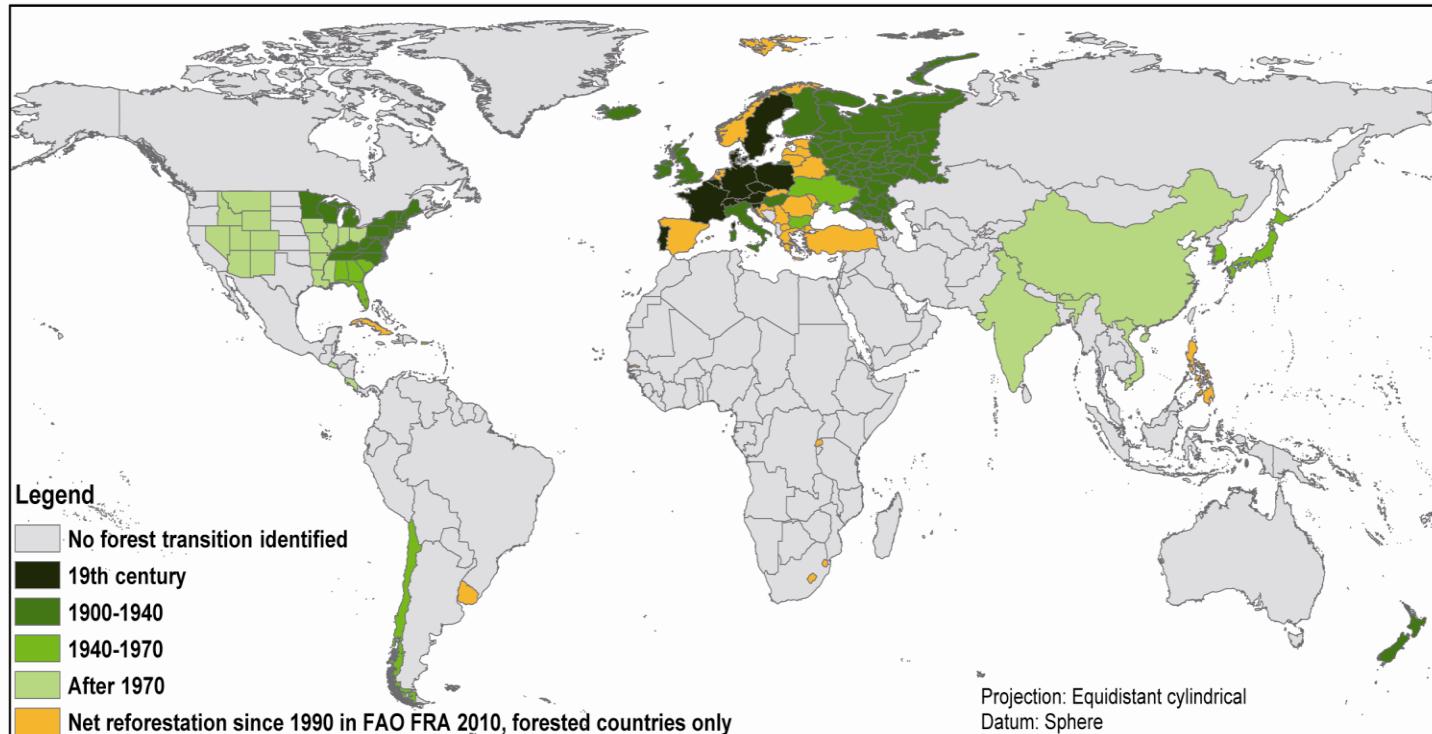
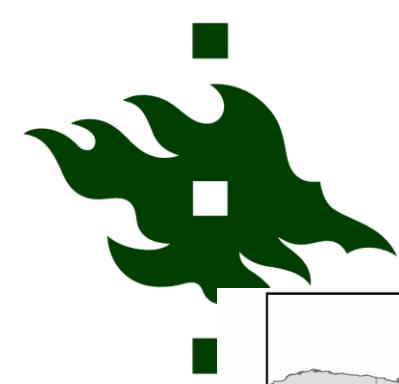
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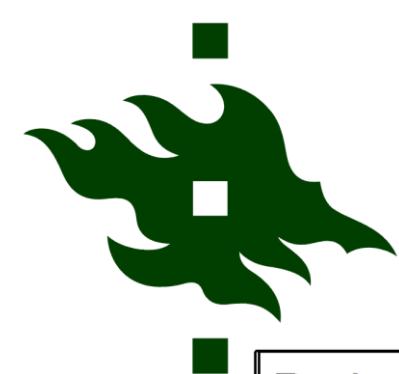
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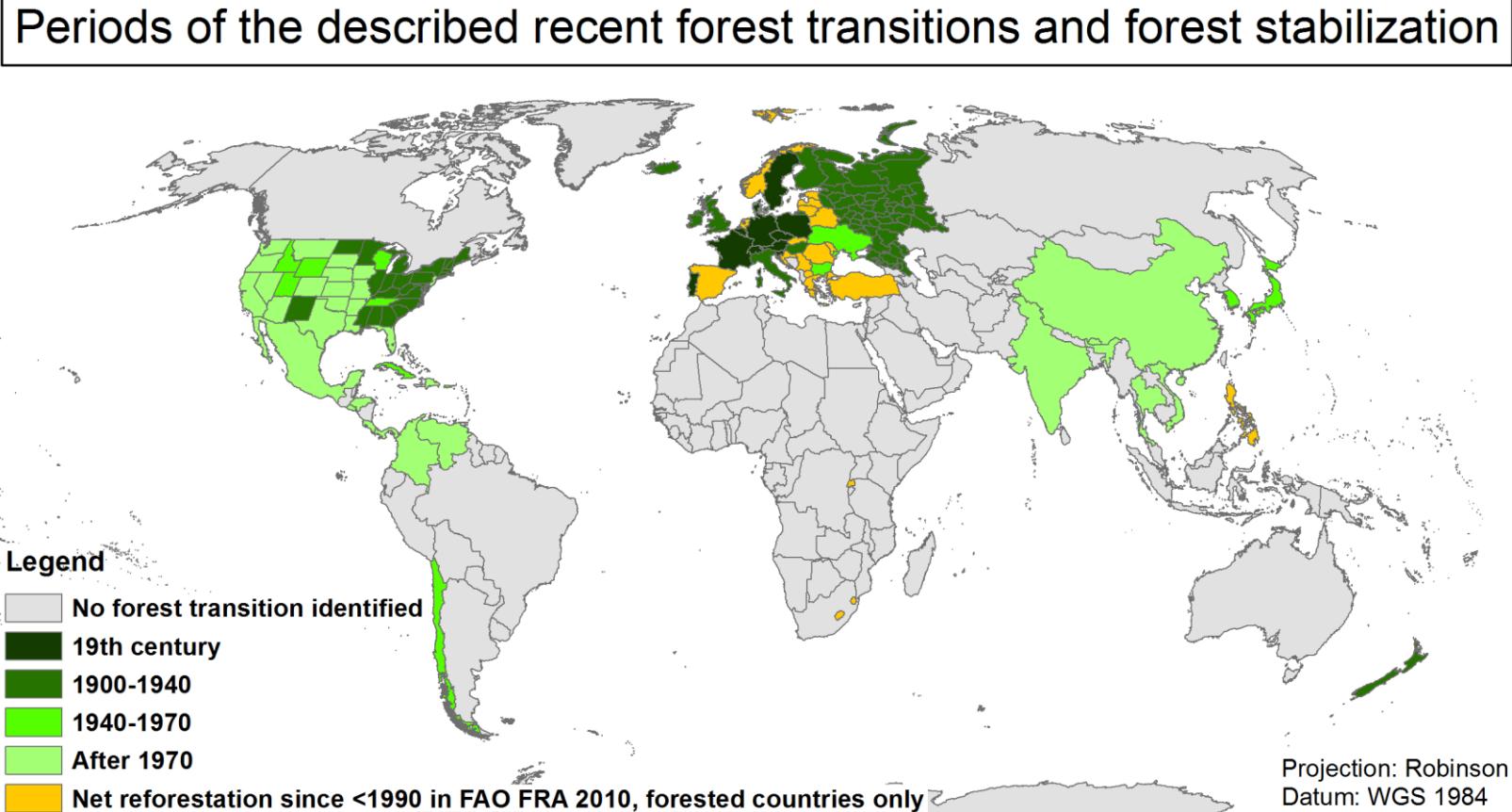
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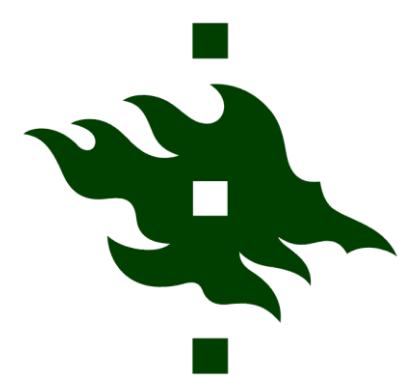


A Meyfroidt P, Lambin EF. 2011.
R Annu Rev. Environ. Resour. 36:343–71



Update (Mayfroidt, 2016, unpublished)

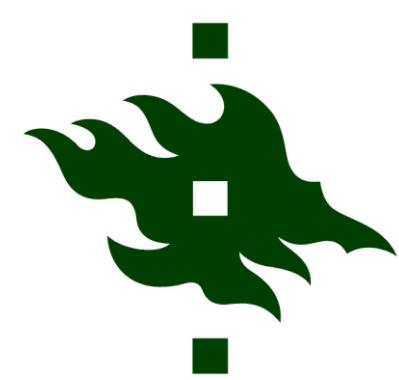




Prospect for a global forest transition?

For hundreds of years, World's forest area diminished.

Will it soon begin to expand?



Forest area expands in wealthy countries.

Is forest area expansion a prerequisite for forest biomass expansion (= carbon sequestration)?

- No, it is not.

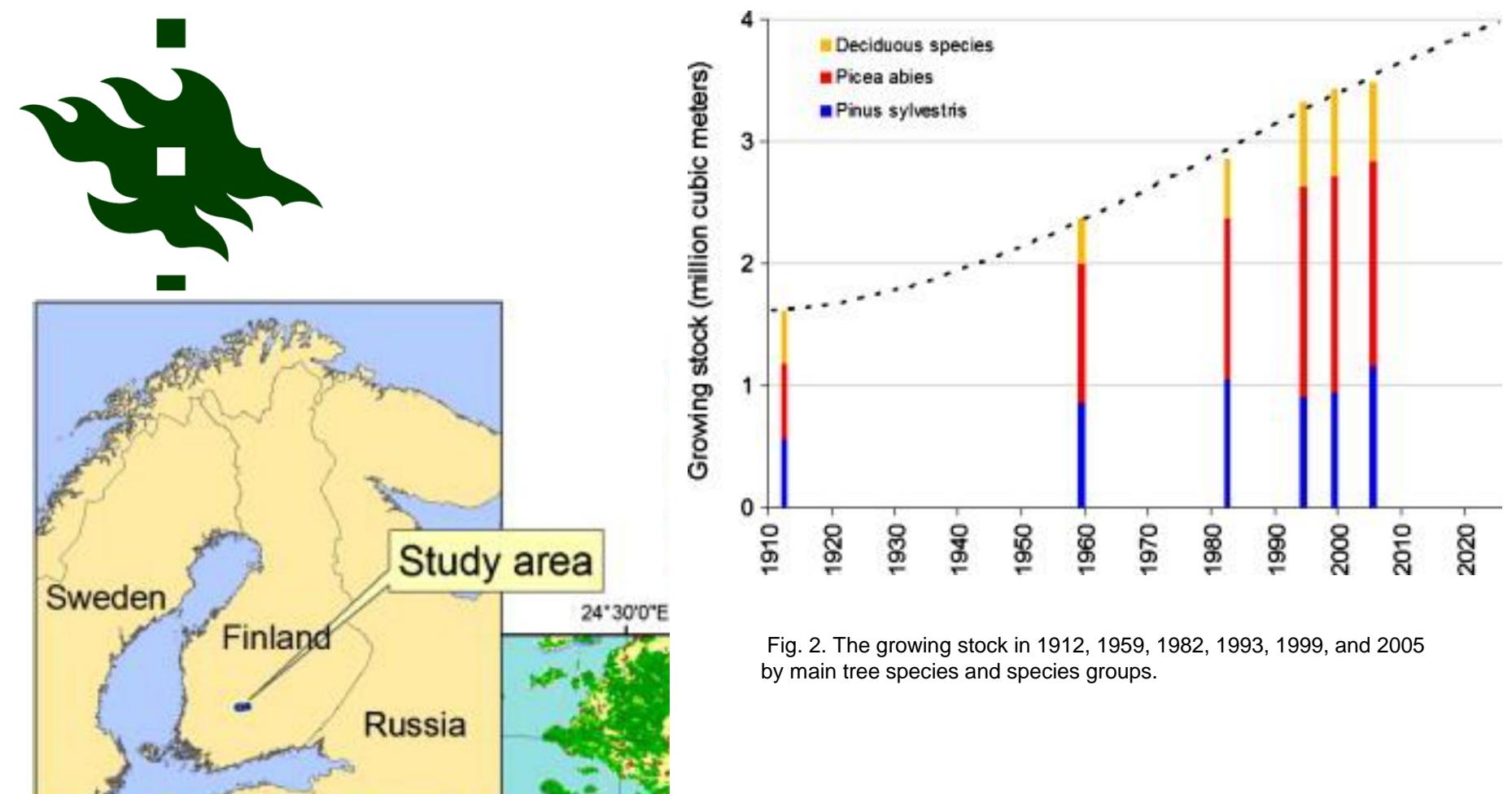


Fig. 2. The growing stock in 1912, 1959, 1982, 1993, 1999, and 2005 by main tree species and species groups.

Pekka E. Kauppi, Aapo Rautiainen, Kari T. Korhonen, Aleksi Lehtonen, Jari Liski, Pekka Nöjd, Sakari Tuominen, Markus Haakana, Tarmo Virtanen

Changing stock of biomass carbon in a boreal forest over 93 years

Forest Ecology and Management, Volume 259, Issue 7, 2010, 1239–1244

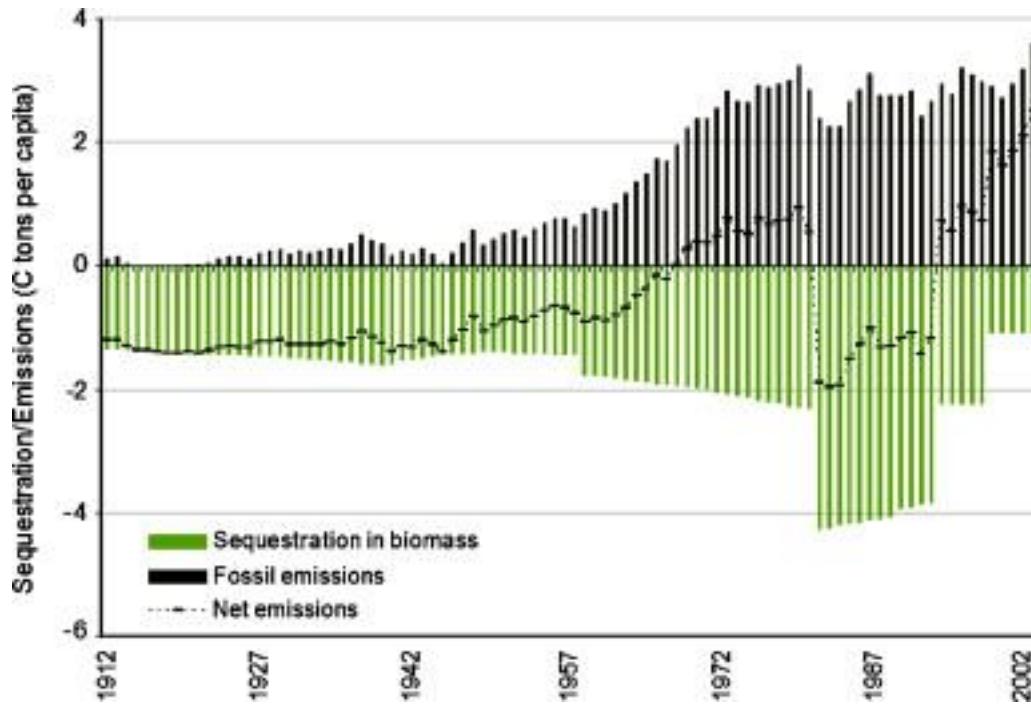
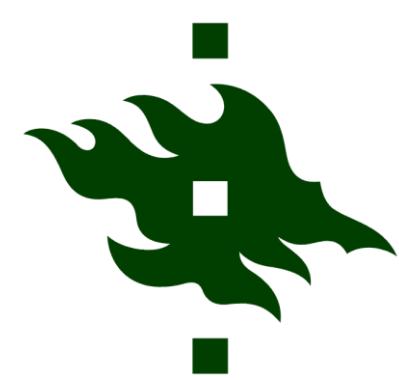
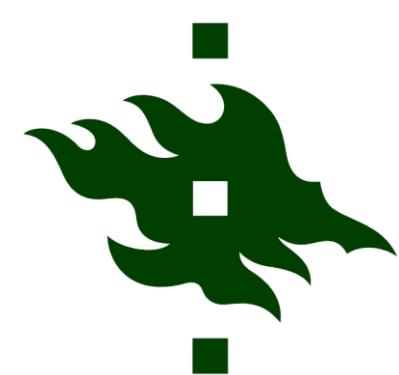


Fig. 3. Carbon sequestration (green) vs. fossil carbon emission (black), both within this region.

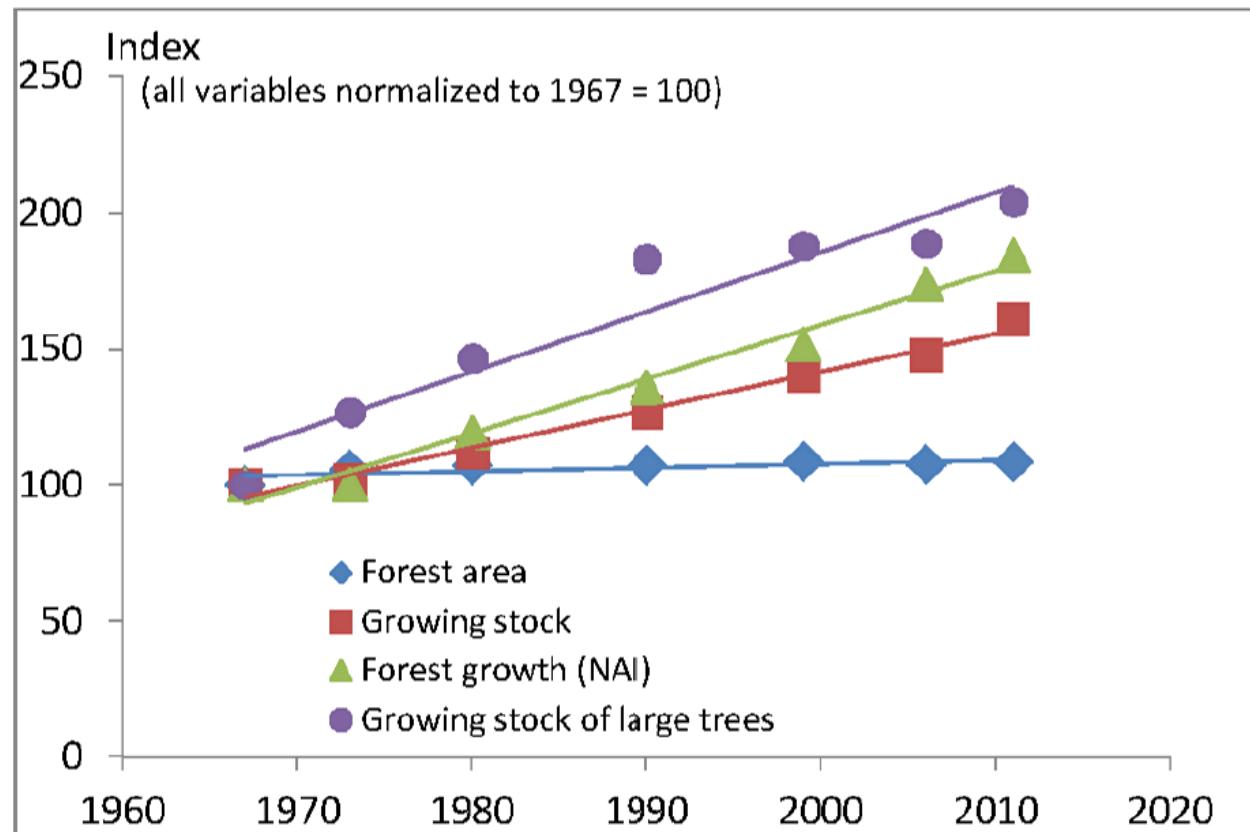
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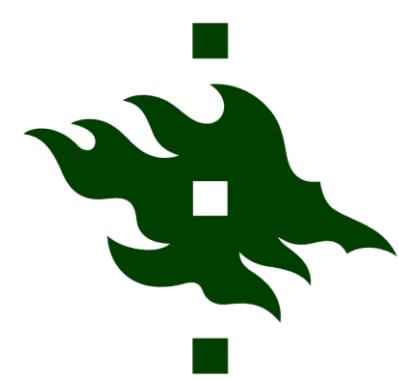
Forest Ecology and Management, Volume 259, Issue 7, 2010, 1239–1244



In Finland, tree biomass attributes have increased at much faster rates than the forested area (Inventory data, Kauppi et al., 2016 unpublished).

Can we co-author a Nordic paper (Sweden, Finland, Norway)?
- Hans Fredrik Hoen has the Norwegian data.





In Finland, change of forest area is a highly misleading estimate for carbon sequestration.

The same is true in the US...

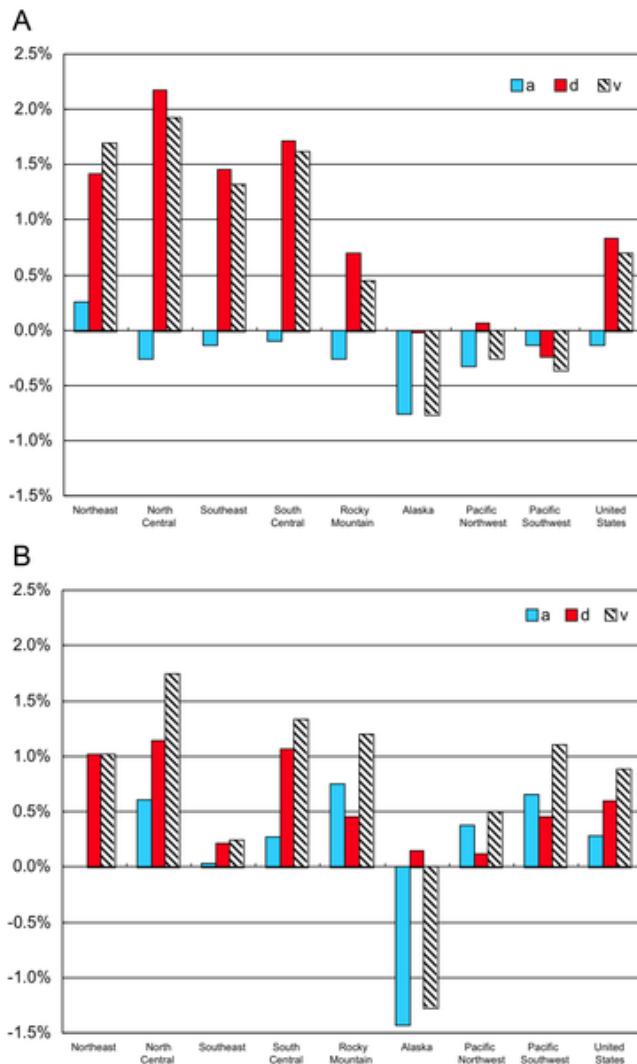
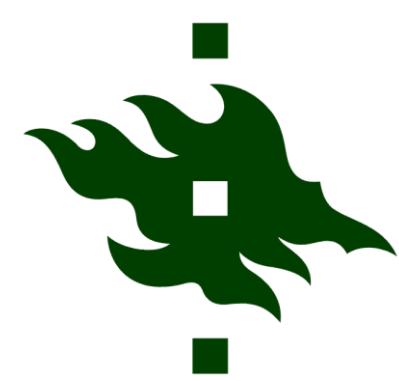
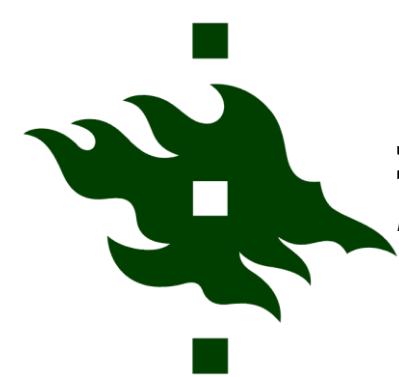
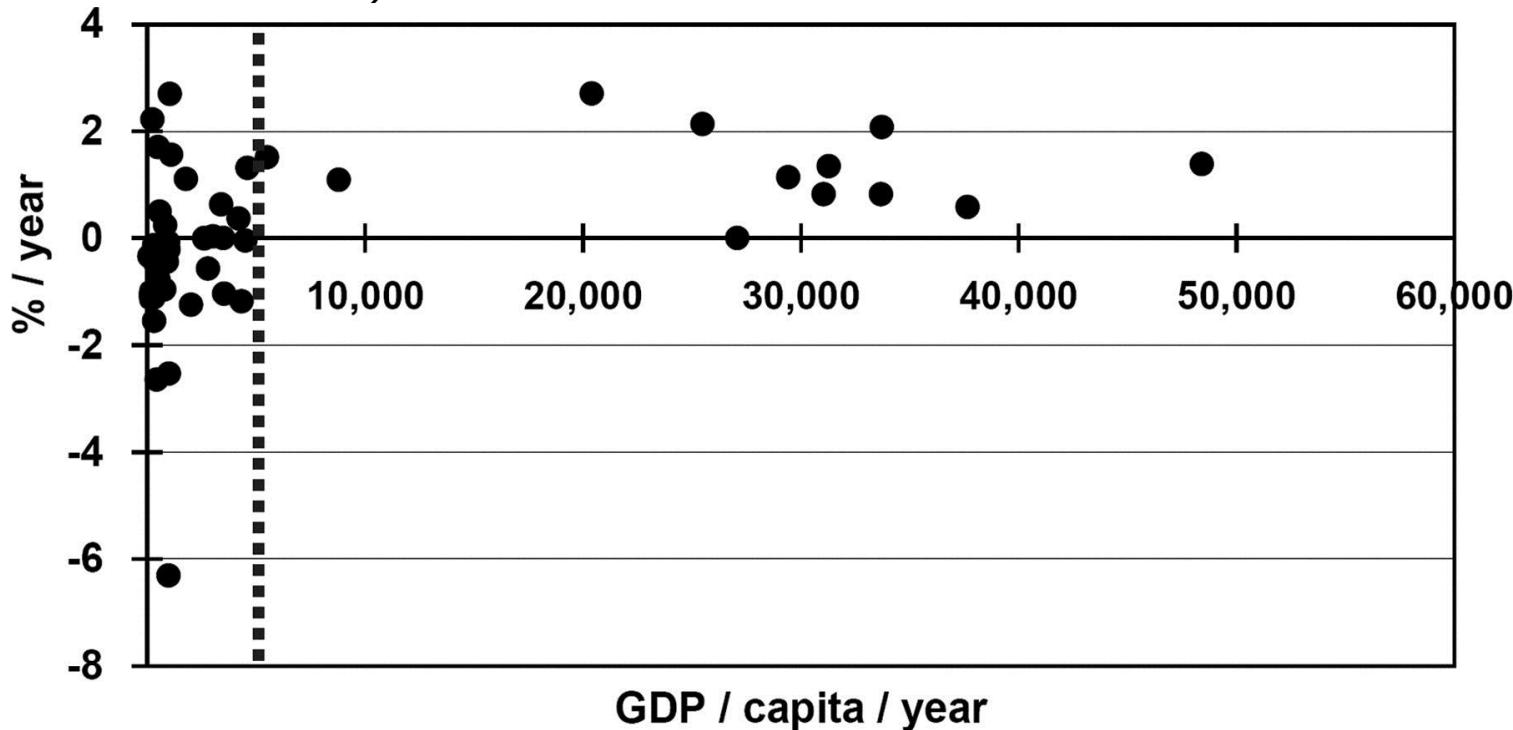


Figure 3. Annual change in timberland area a, density d, and timberland volume v in the United States (a) 1953–1987 (b) 1987–2007.

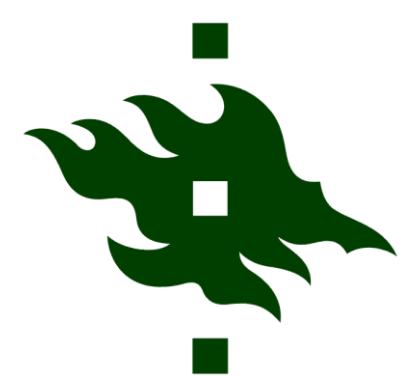
Rautiainen A, Wernick I, Waggoner PE, Ausubel JH, Kauppi PE (2011) A National and International Analysis of Changing Forest Density. PLoS ONE 6(5): e19577.



In a nation, if GDP per capita of a nation was
> 5,000 USD, forest biomass expanded. (Data from the
FAO and World Bank)



Kauppi, P. E., Ausubel, J. H., Fang, J., Mather, A. S., Sedjo, R. A., & Waggoner, P. E. (2006). Returning forests analyzed with the forest identity. *Proceedings of the National Academy of Sciences*, 103(46), 17574-17579.



GDP per capita based on PPP

current international \$

143 Lao P.D.R.	5,650.58
144 Samoa	5,247.11
145 Tonga	5,225.86
146 Nicaragua	5,213.53
147 Pakistan	5,173.96
148 Timor-Leste	5,097.01
149 Moldova	5,082.09
150 Honduras	4,986.28
151 Mauritania	4,515.49
152 Sudan	4,416.53
153 Ghana	4,390.97
154 Zambia	3,917.74
155 Sub-Saharan Africa	3,869.26
156 Bangladesh	3,841.03
157 Cambodia	3,711.32
158 Tuvalu	3,546.19

2016



1990

2000

2005

2011

2012

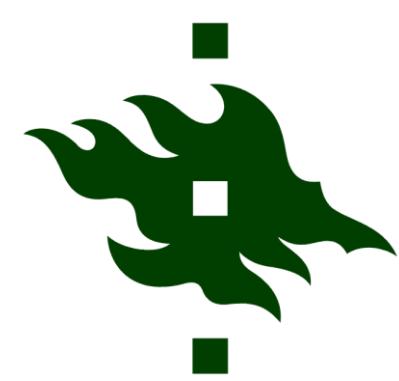
2013

2014

2015

2016

based on PPP



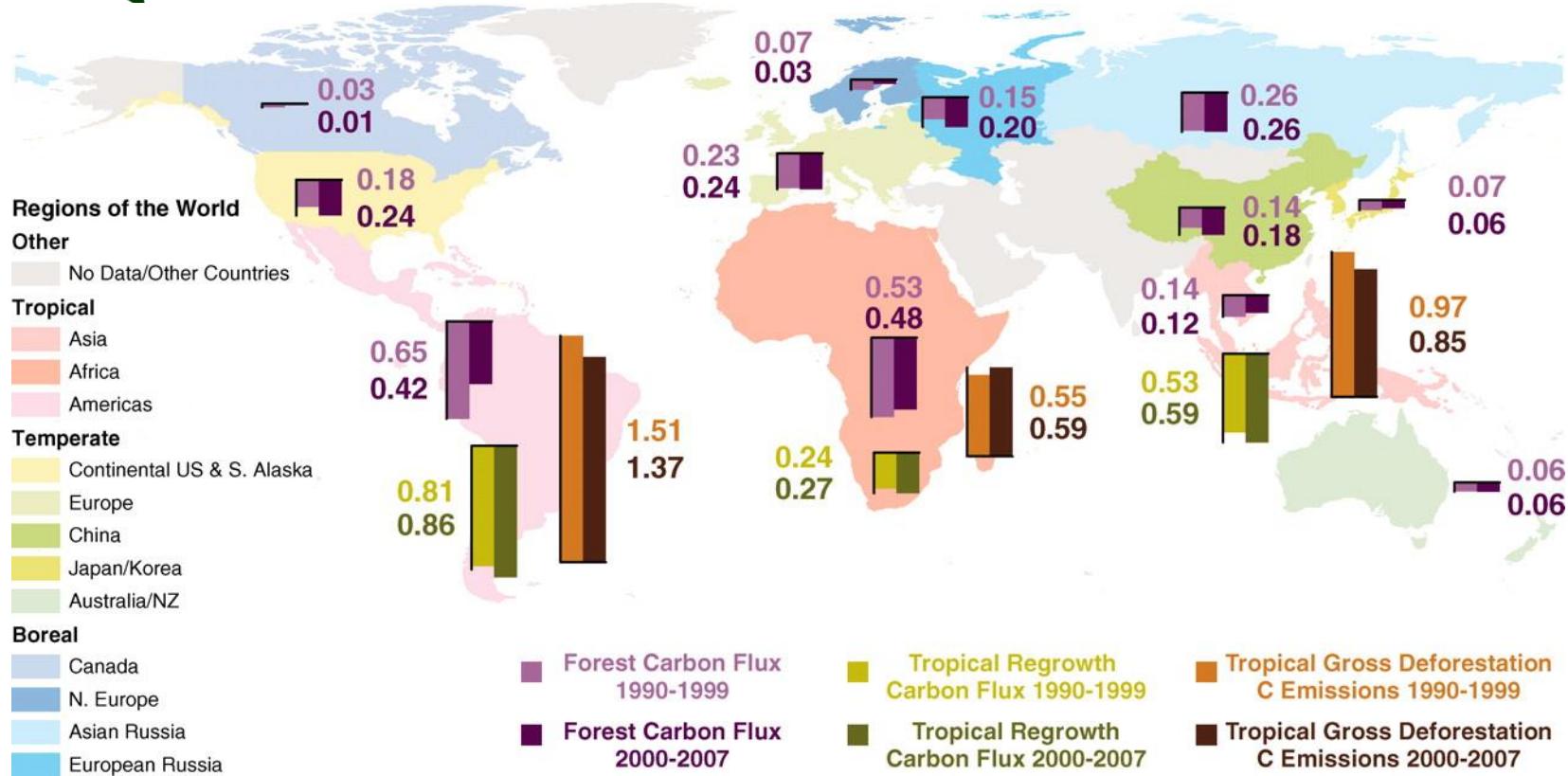
At the global level...

...forest area shrinks (but for how long?)

...and forest biomass expands.



Fig. 1 Carbon sinks and sources (Pg C year⁻¹) in the world's forests.



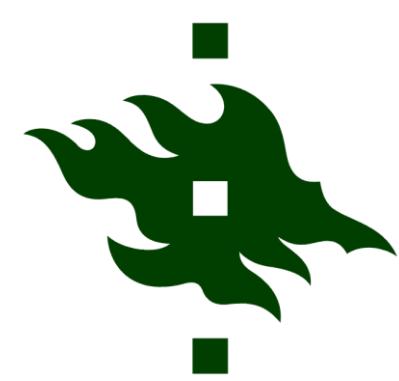
Yude Pan et al. Science 2011;333:988-993

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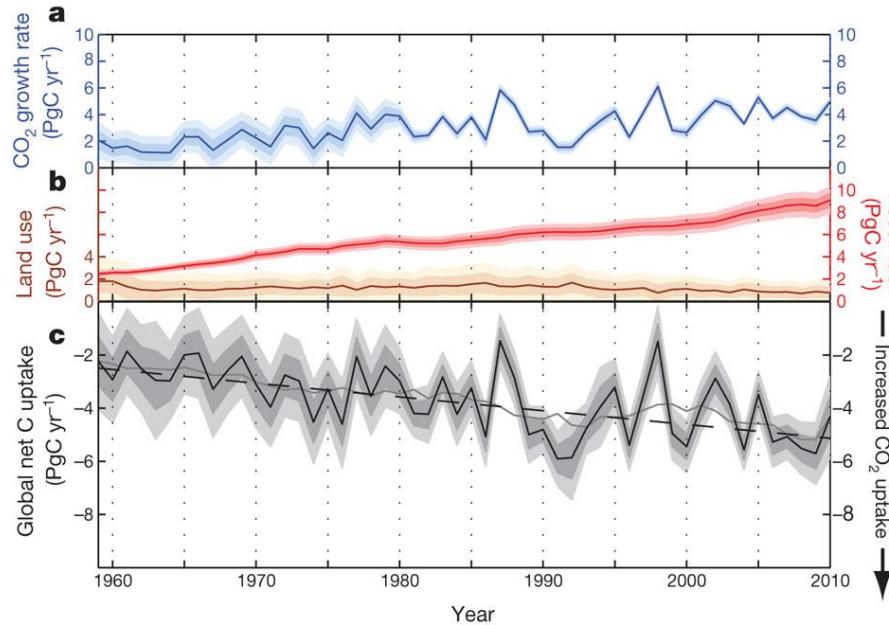
Published by AAAS

www.helsinki.fi/yliopisto

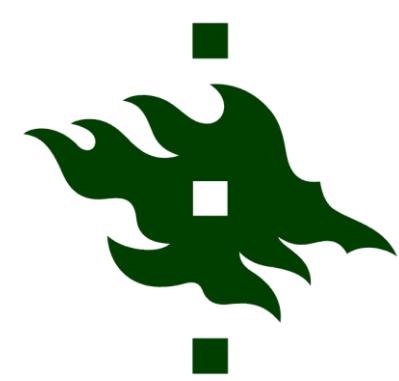
Science
AAAS



Trends in the global carbon budget from 1959 to 2010.



AP Ballantyne *et al.* *Nature* **488**, 70-72 (2012) doi:10.1038/nature11299



Observations/facts

1) The divided World:

- **forest expansion in wealthy nations**
- **forest contraction in less advanced nations**

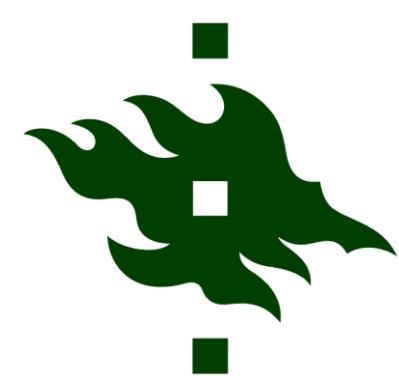
2) Prospect for a global forest transition

3) Carbon sequestration in forests is mainly driven by density change



At the global and national levels, the expansion of forest biomass is a very positive trend, lending support to improved woody biomass allocation for various purposes.

Where should the increasing biomass reserves become allocated?

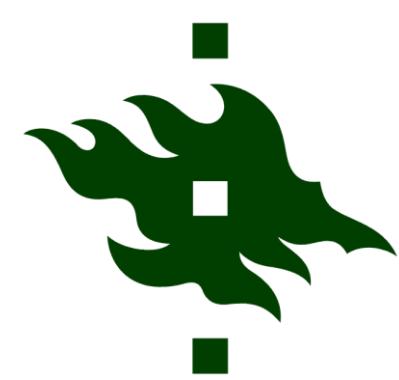


Fossil resources:

A finite reserve

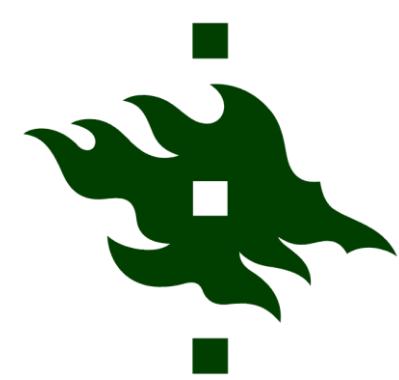
Forest carbon stock:

A finite reservoir



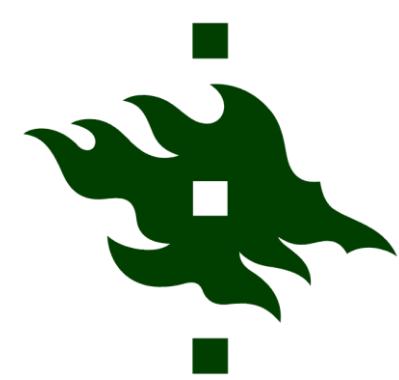
How forest management can contribute to reduced CO₂ in the atmosphere?

- **Policy recommendations**
- **Proposed allocation hierarchy of using wood in CO₂ mitigation**



EU'S WASTE HIERARCHY





Hierarchy of woody biomass allocation?

Biomass for industrial applications	Sustainable	Increasing conversion efficiency and diversity of ecosystem services
Biomass for CPH	Sustainable	
Biomass for heat	Sustainable	
Biomass for liquid fuels	Sustainable	
B. for C sink	Non-sustainable	

A photograph of a serene landscape at sunset. The sky is a gradient from yellow to orange and blue. In the foreground, dark silhouettes of tall grasses and reeds stand in a body of water. The middle ground shows the calm surface of the lake reflecting the sky. A dense forest of green trees lines the background on the right side.

Your comments and
questions much appreciated!

Kiitos!
Tack!
Thank you!