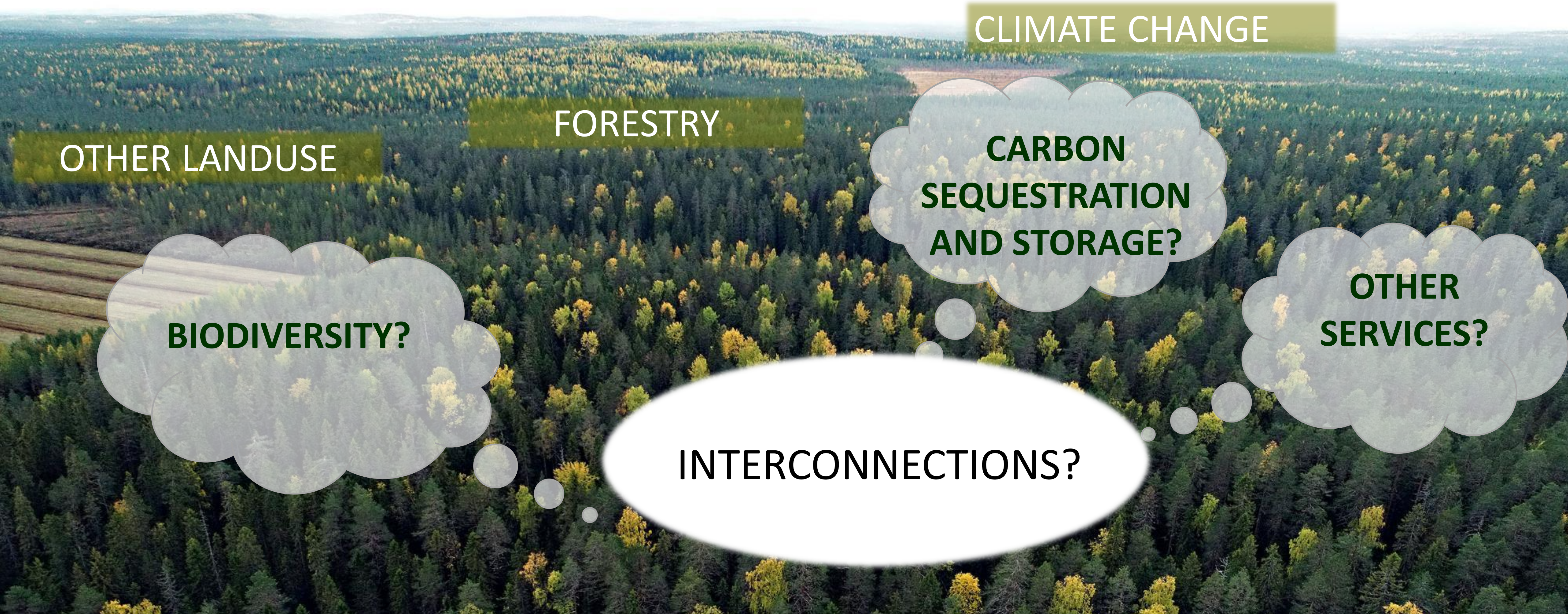

Forested ecosystems: Carbon sequestration and biodiversity impacts

Funded by the European Union
NextGenerationEU

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strategicRESEARCH

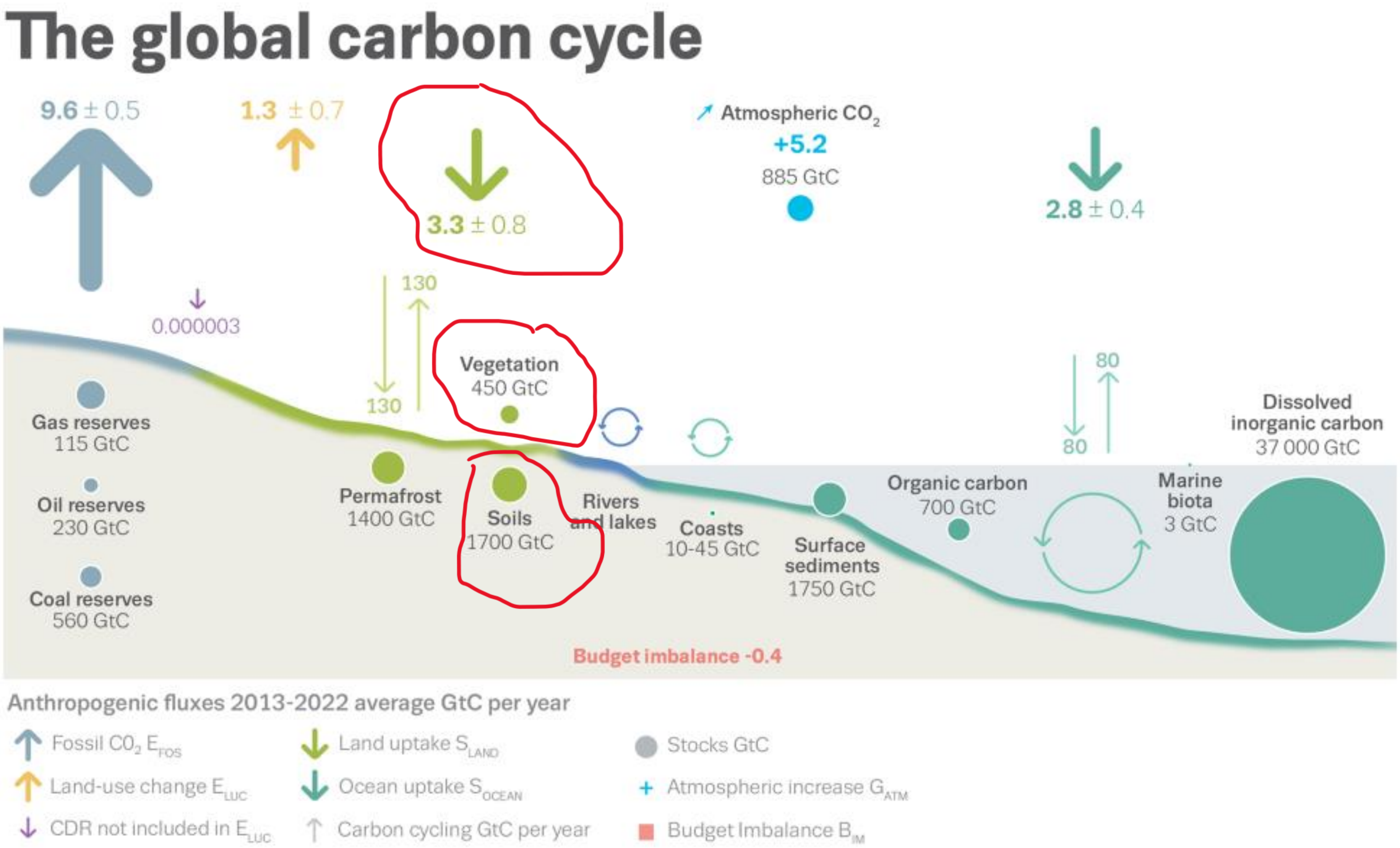
Content

1. Short introduction:

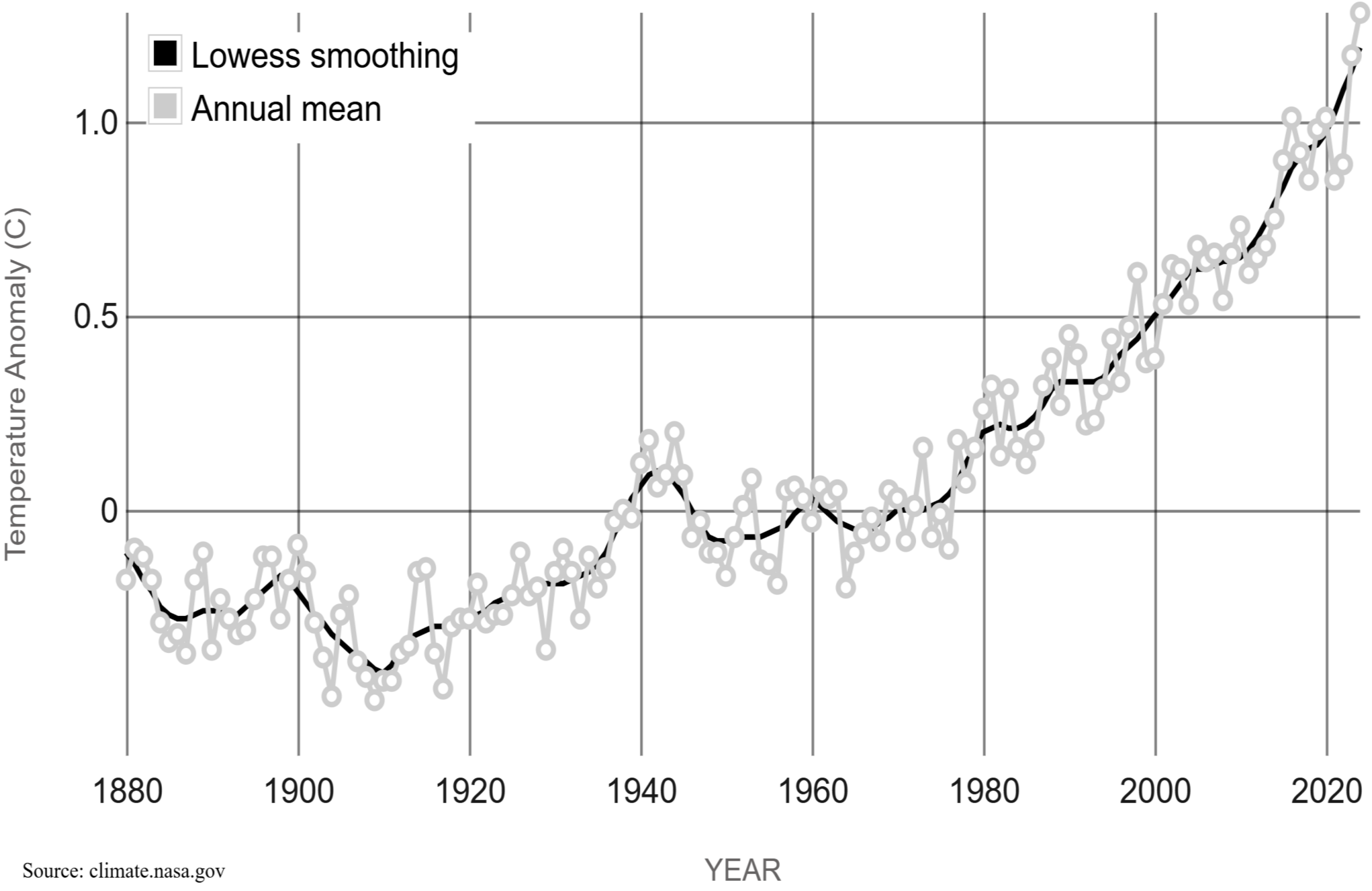
- Carbon cycle and climate change
- Biodiversity crisis
- Identifying pathways for change

2. Results from large-scale studies in Finland

3. Concluding remarks

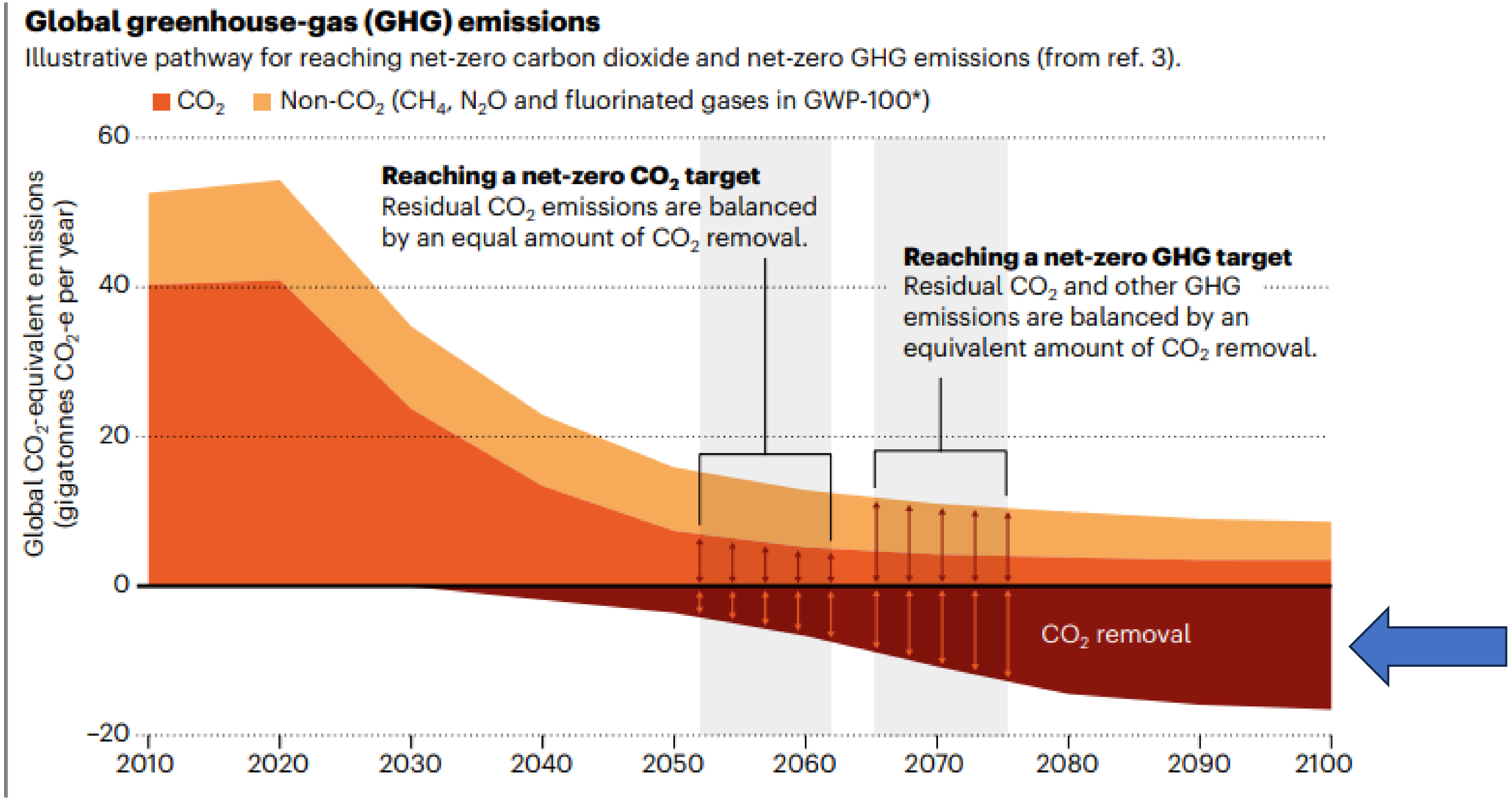

The global carbon cycle
9.6 ± 0.5
1.3 ± 0.7
3.3 ± 0.8
Atmospheric CO2
+5.2
885 GtC
2.8 ± 0.4
0.000003
130
130
Vegetation
450 GtC
80
80
Dissolved
inorganic carbon
37 000 GtC
Gas reserves
115 GtC
Permafrost
1400 GtC
Soils
1700 GtC
Rivers
and lakes
Coasts
10-45 GtC
Organic carbon
700 GtC
Marine
biota
3 GtC
Oil reserves
230 GtC
Surface
sediments
1750 GtC
Coal reserves
560 GtC
Budget imbalance -0.4
Anthropogenic fluxes 2013-2022 average GtC per year
Fossil CO2 EFOS
Land-use change ELUC
CDR not included in ELUC
Land uptake SLAND
Ocean uptake SOCEAN
Carbon cycling GtC per year
Stocks GtC
Atmospheric increase GATM
Budget Imbalance BIM

GLOBAL LAND-OCEAN TEMPERATURE INDEX



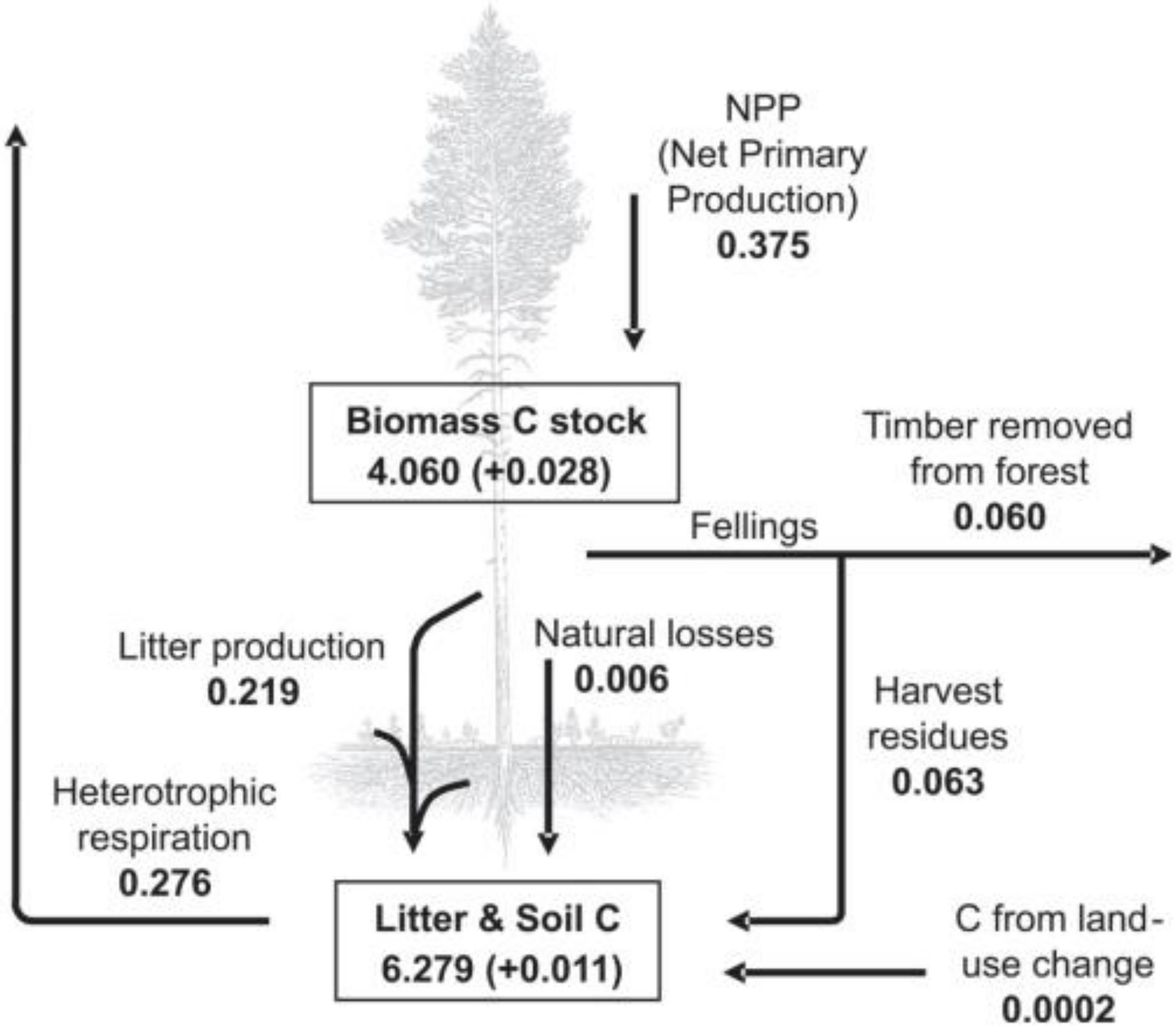
Source: climate.nasa.gov

Large increases in CO_2 removal needed to reach global net-zero greenhouse gas (GHG) emissions



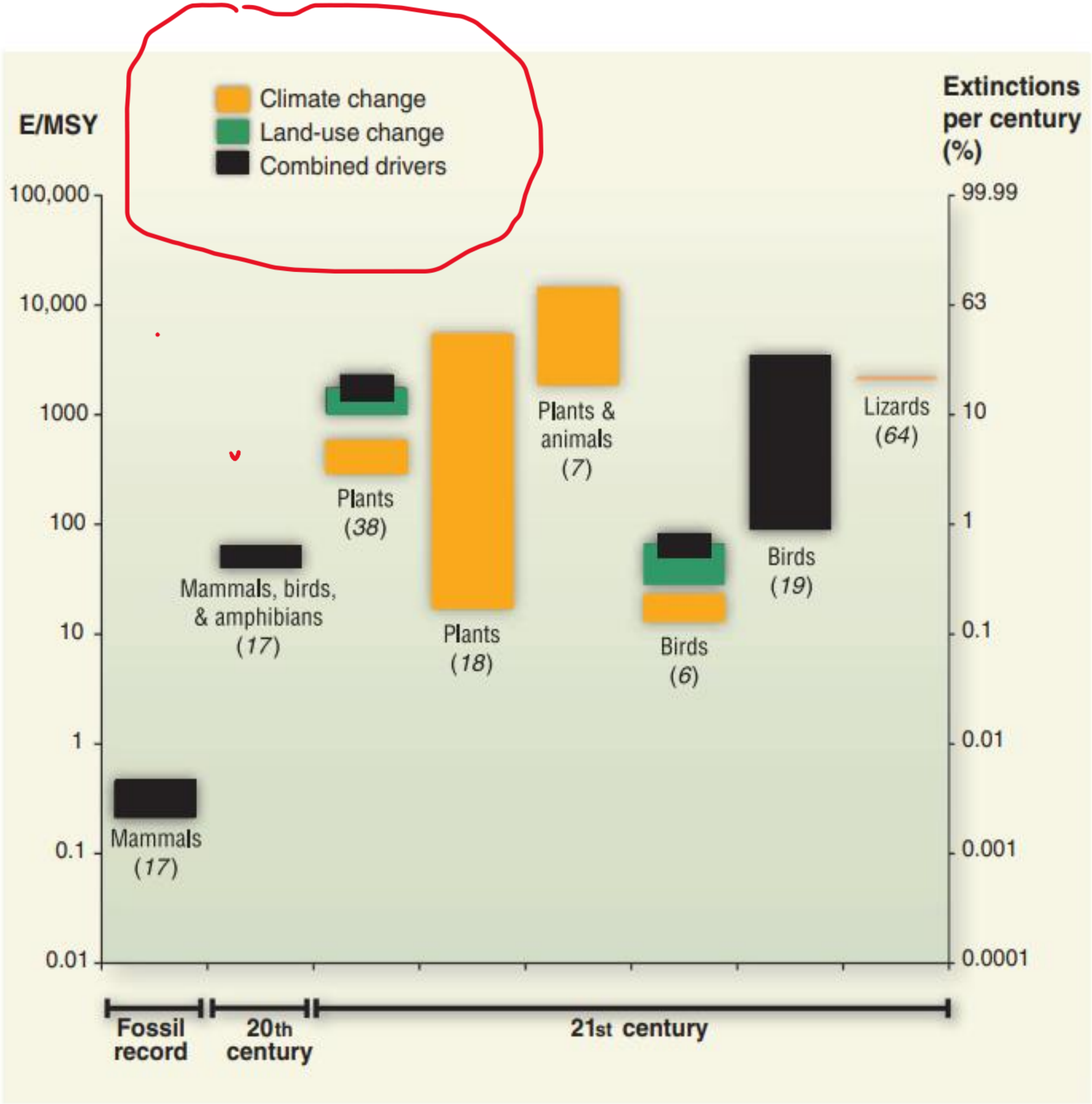
Rogelj et al. 2021
Nature 591: 365-368

Average carbon budget of Finnish forests



fluxes kg/m^2/year
stocks kg/m^2

Liski et al. 2006

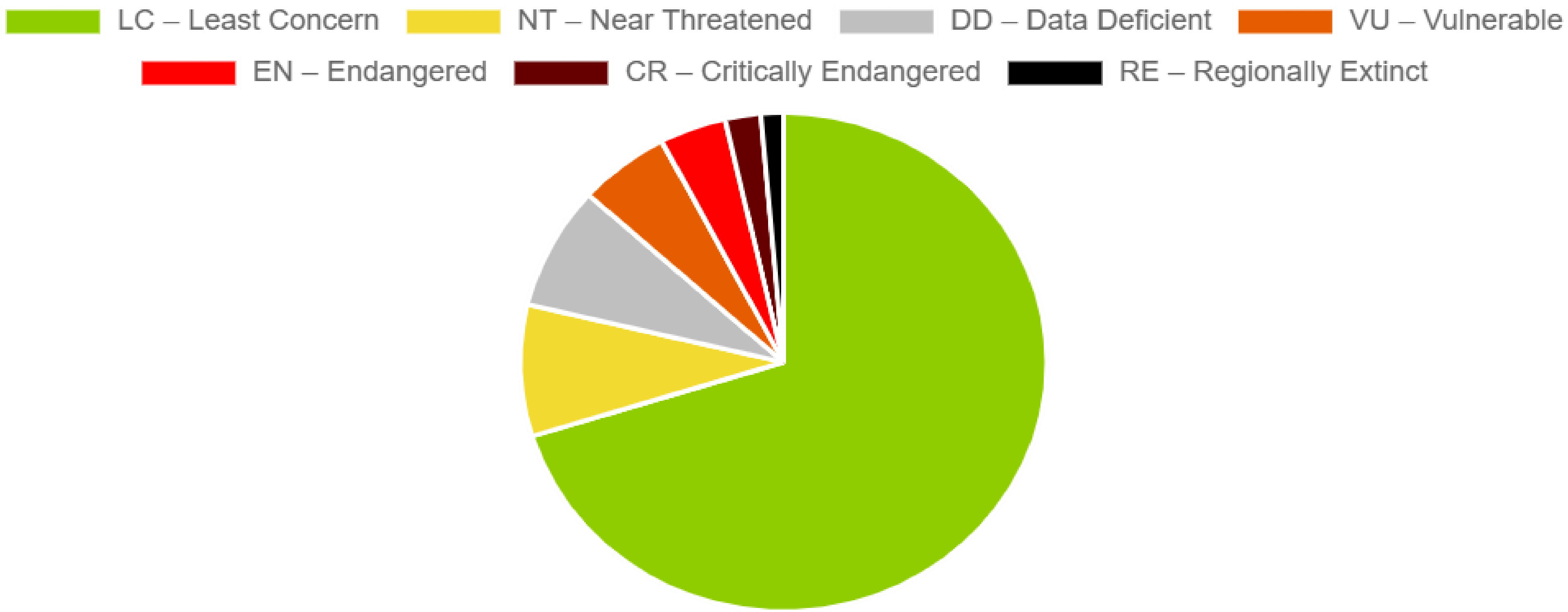


Biodiversity:
Comparison of recent and distant past extinction rates with rates at which species are "committed to extinction" during the 21st century

Pereira et al. 2010

https://www.science.org/doi/10.1126/science.1196624

12% of Finnish species classified as threatened



Red List of Finnish species 2019

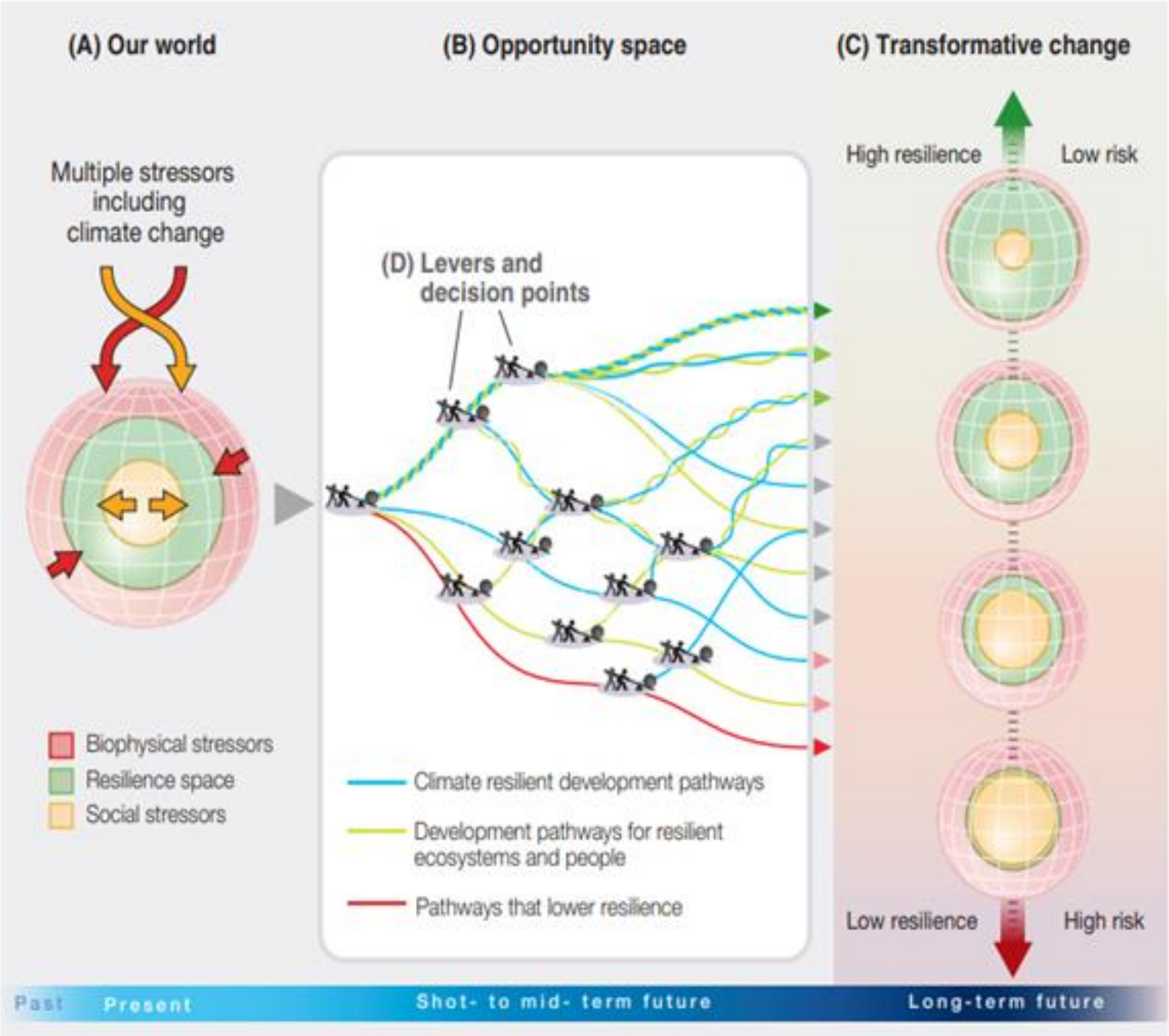


Figure 7 Moving governance towards transformative change.

Adapted from English original Figure 1-5 from Burkett *et al.* 2014.

Identifying pathways for transformative change

→ Resilient, low-risk pathways for climate, ecosystems and people needed

Pörtner et al. 2021
IPCC-IPBES workshop
https://zenodo.org/records/5101125

Motivation for integrated Finnish studies

- Climate Act: Finland carbon neutral by year 2035 after which greenhouse gas (GHG) emissions should be negative.
- The landuse sector (LULUCF) was for the first time a GHG emission source in 2020 in Finland (11.8 TgCO_2eq in 2023).
- Growth of forests is decreasing.
- EU biodiversity strategy: 30% of land area should be protected, of which 10 % strictly protected.
- Proposal of Finnish Nature Panel: Implement additional protection of forested areas so that the 10% target is reached in each administrative region.

→ Integrated evaluation of targets → optimal/win-win solutions.

→ Impacts of protection measures on carbon sinks and storages.

→ Net GHG budgets for different scenario combinations.

Model systems used in national-scale GHG- and biodiversity modelling

PREBAS

- Simulation of forest growth, harvesting scenarios and C processes
- Harvesting scenarios:
  - Current measures, BaseHarv
  - Low intensity, LowHarv (0.6 x BaseHarv)
  - Intensive measures, MaxHarv (1.2 x BaseHarv)
  - No harvesting, NoHarv

Forsius et al. 2021
https://doi.org/10.1016/j.scitotenv.2021.145847

Forsius et al. 2023
https://doi.org/10.1007/s13280-023-01860-1

Zonation

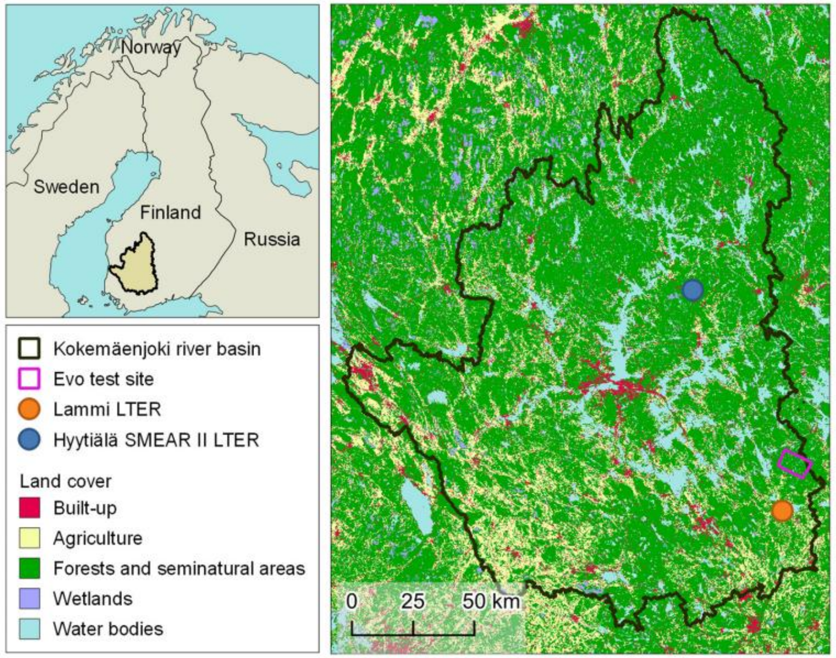
- Identification of new forested areas for protection using prioritization
- Biodiversity and carbon
- 10 % protection target/region

FRES

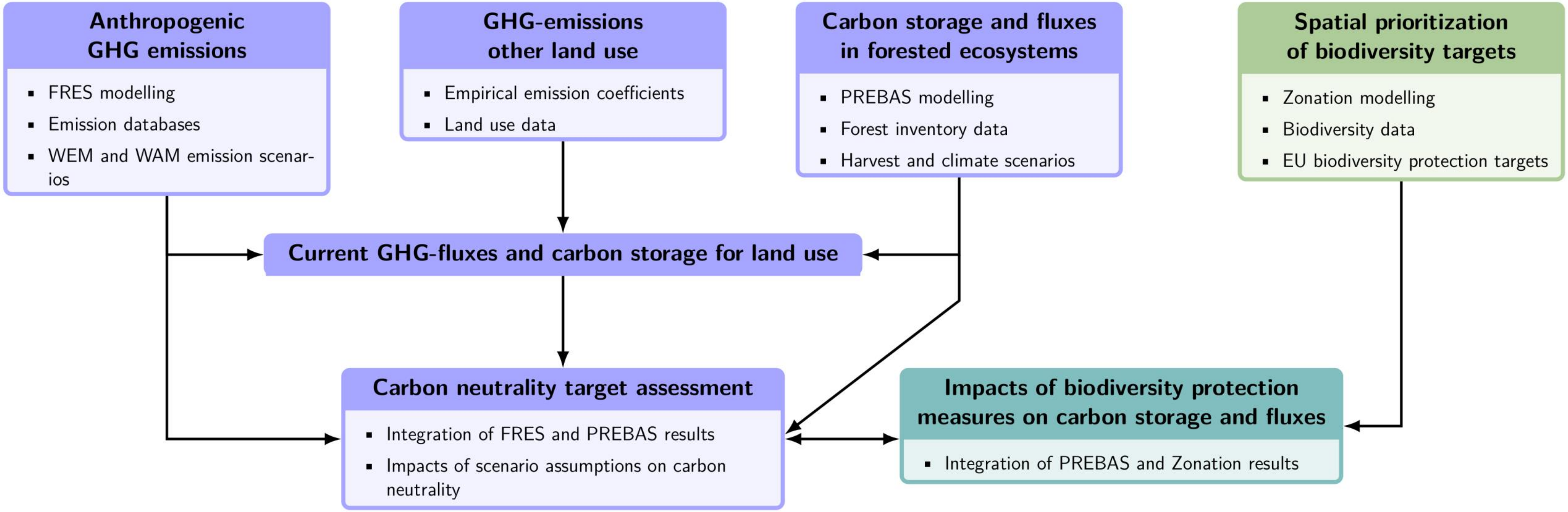
- Simulation of anthropogenic GHG emissions.
- Emission scenarios:
  - WEM (with existing measures)
  - WAM (with additional measures)

Empirical coefficients for landuse sectors

- mires, agricultural areas, freshwaters



Integration of model results in regional-scale studies



Forsius et al. 2023 https://doi.org/10.1007/s13280-023-01860-1

Net GHG emissions by land cover type, current situation

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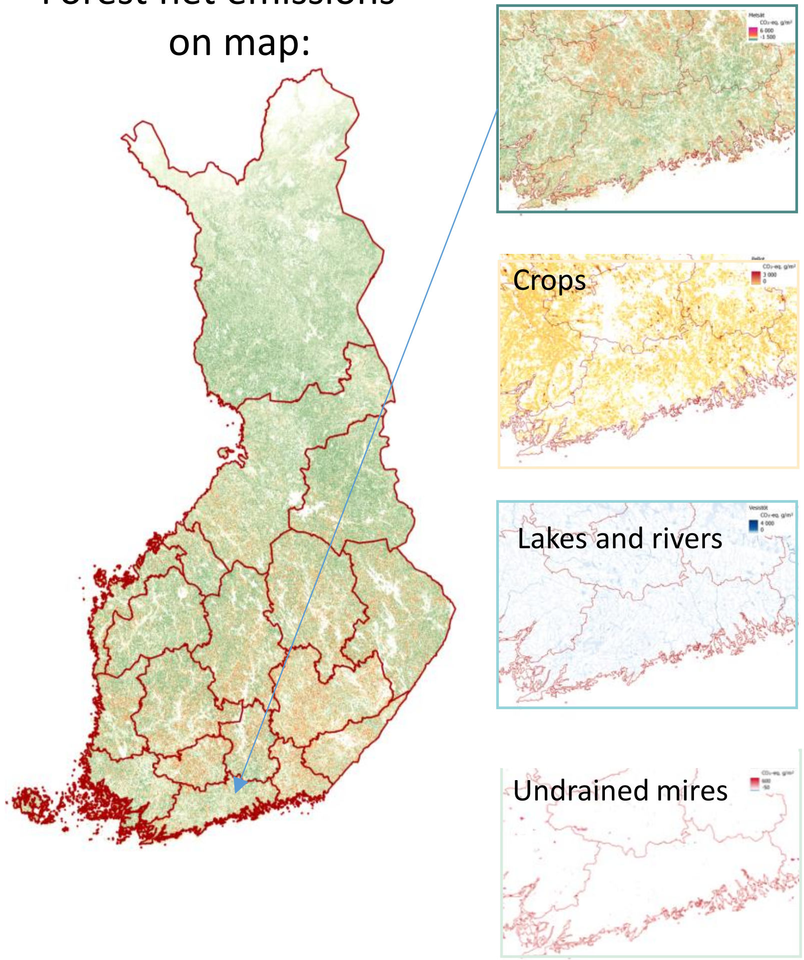
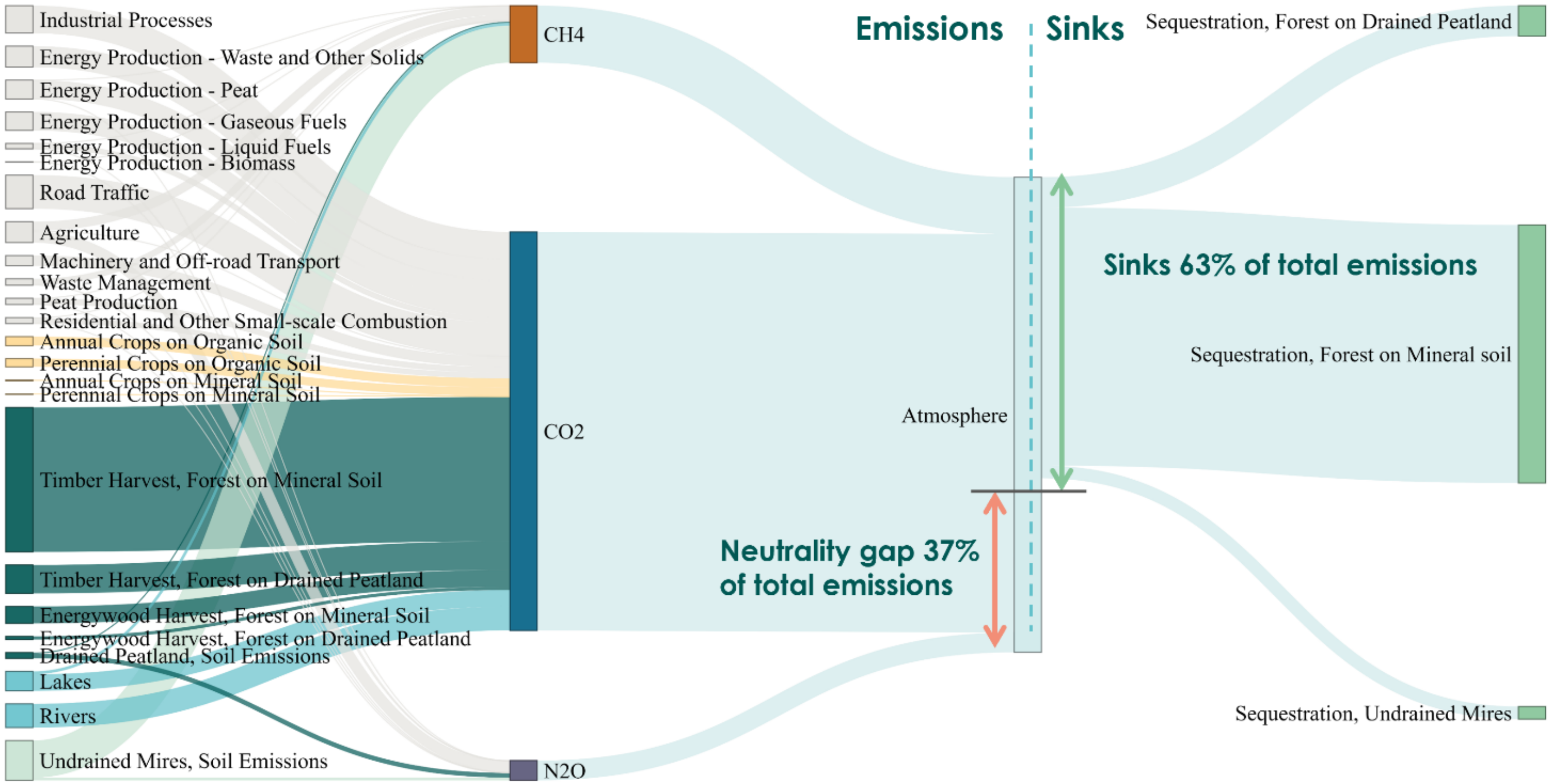
Forest net emissions on map:

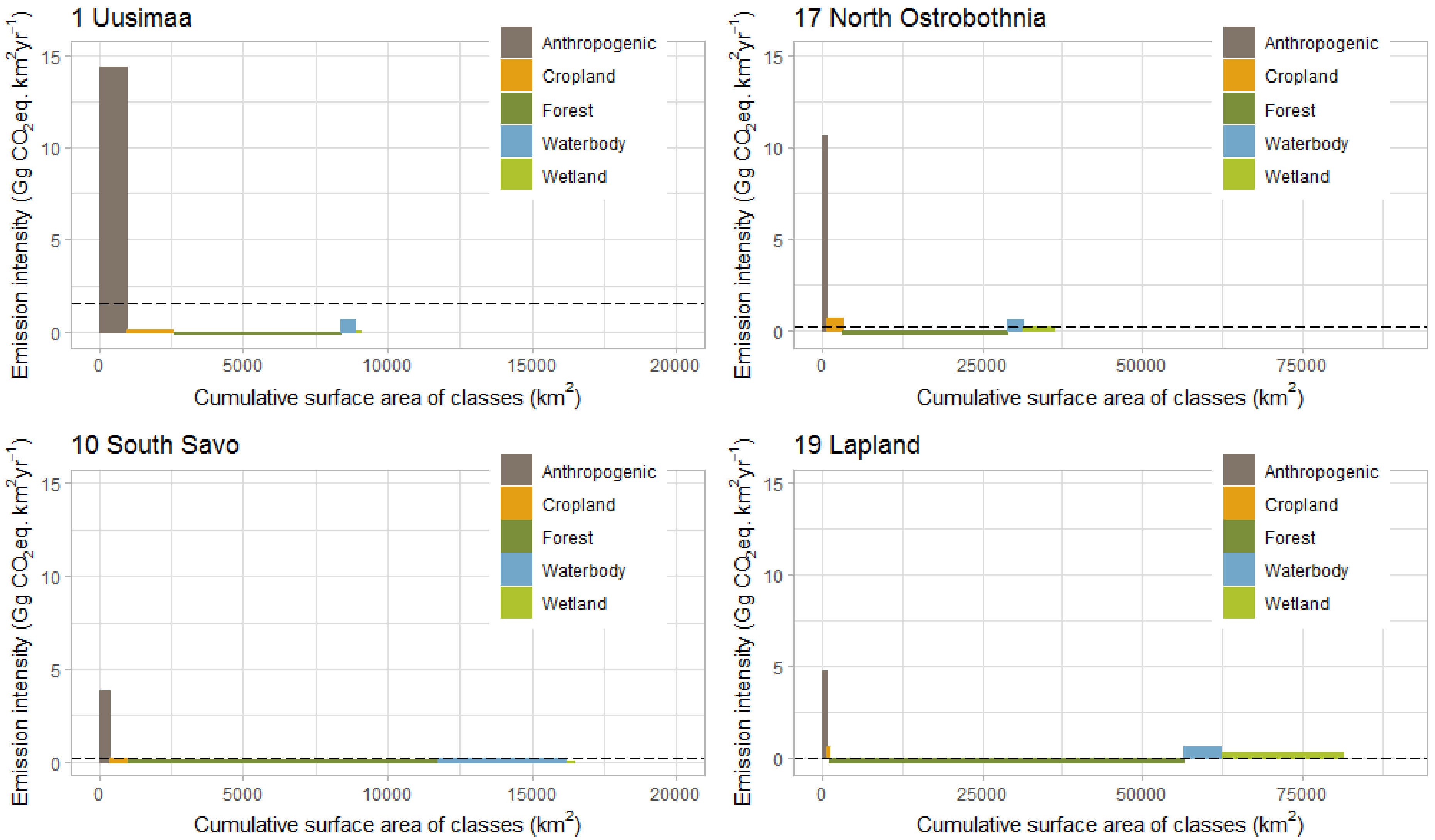




All results available for each region!

Holmberg et al. 2023
https://doi.org/10.1007/s13280-023-01910-8

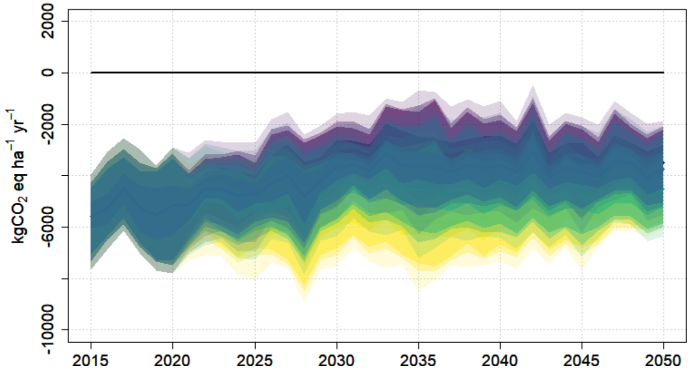
Emission intensity vs. area of landuse classes in different regions

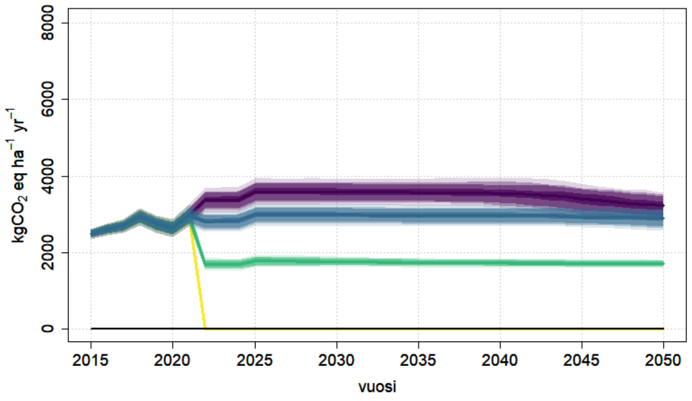


Holmberg et al. 2023
https://doi.org/10.1007/s13280-023-01910-8

Scenarios for forests with uncertainties

Harvest and climate scenarios until year 2050



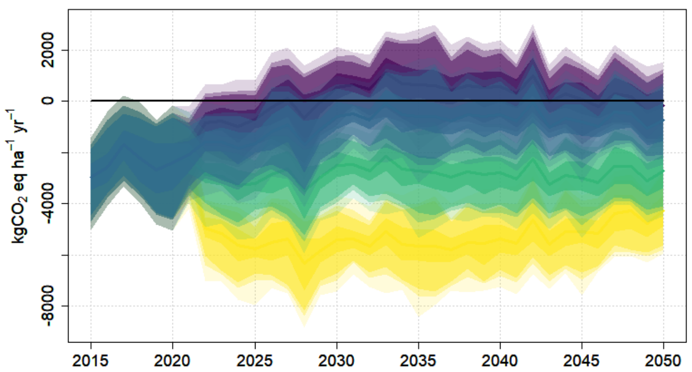


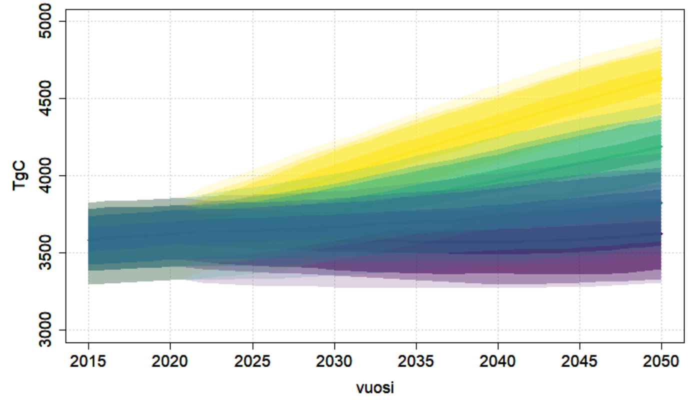
Net ecosystem exchange (with RCPs 2.6, 4.5 and 8.5)

\+ **Biomass removal by harvests (harvest scenarios)**

= **Net biome exchange**

→ **Forest ecosystem carbon stock**





- More intensive harvests
- Current level of harvests
- Less intensive harvests
- No harvests

Scenarios available for each region!
Model development for wind, fire and bark beetle disturbances going on!

Junttila et al. 2023, Forsius et al. 2023

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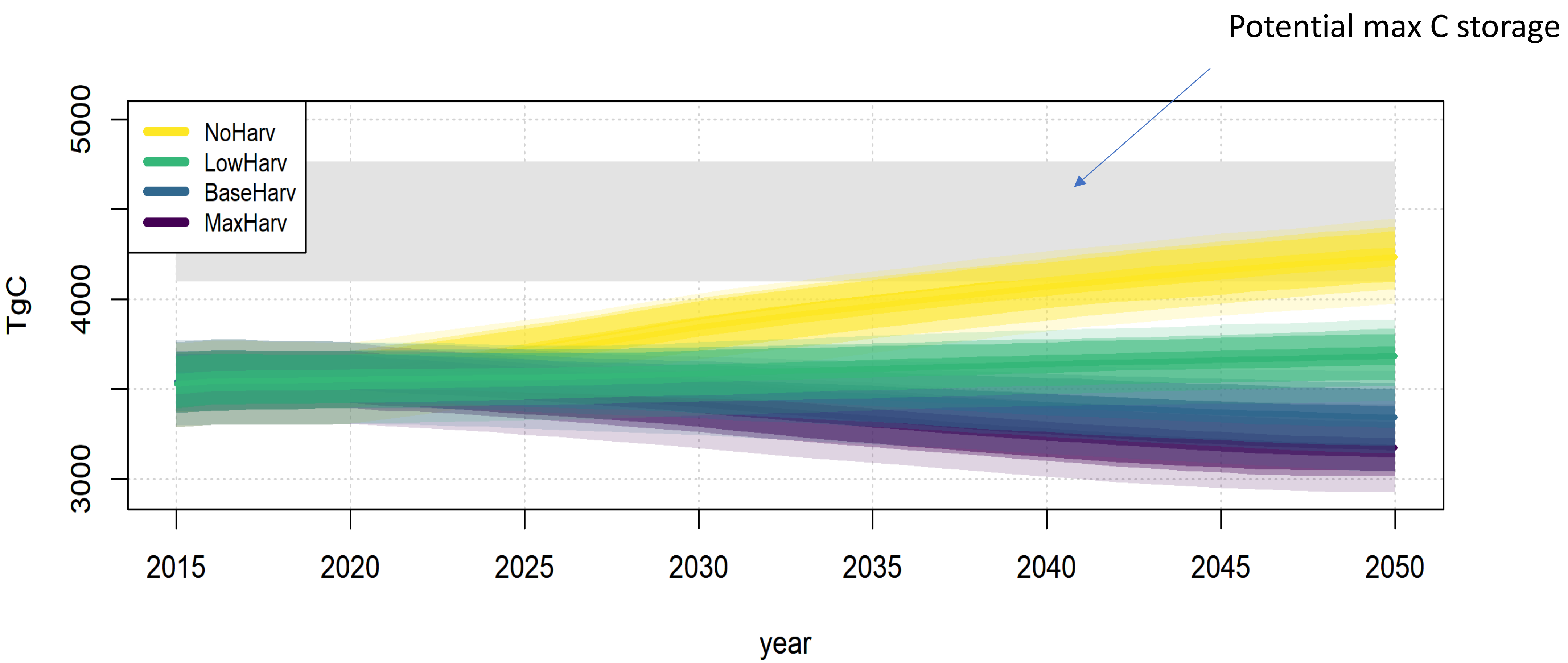
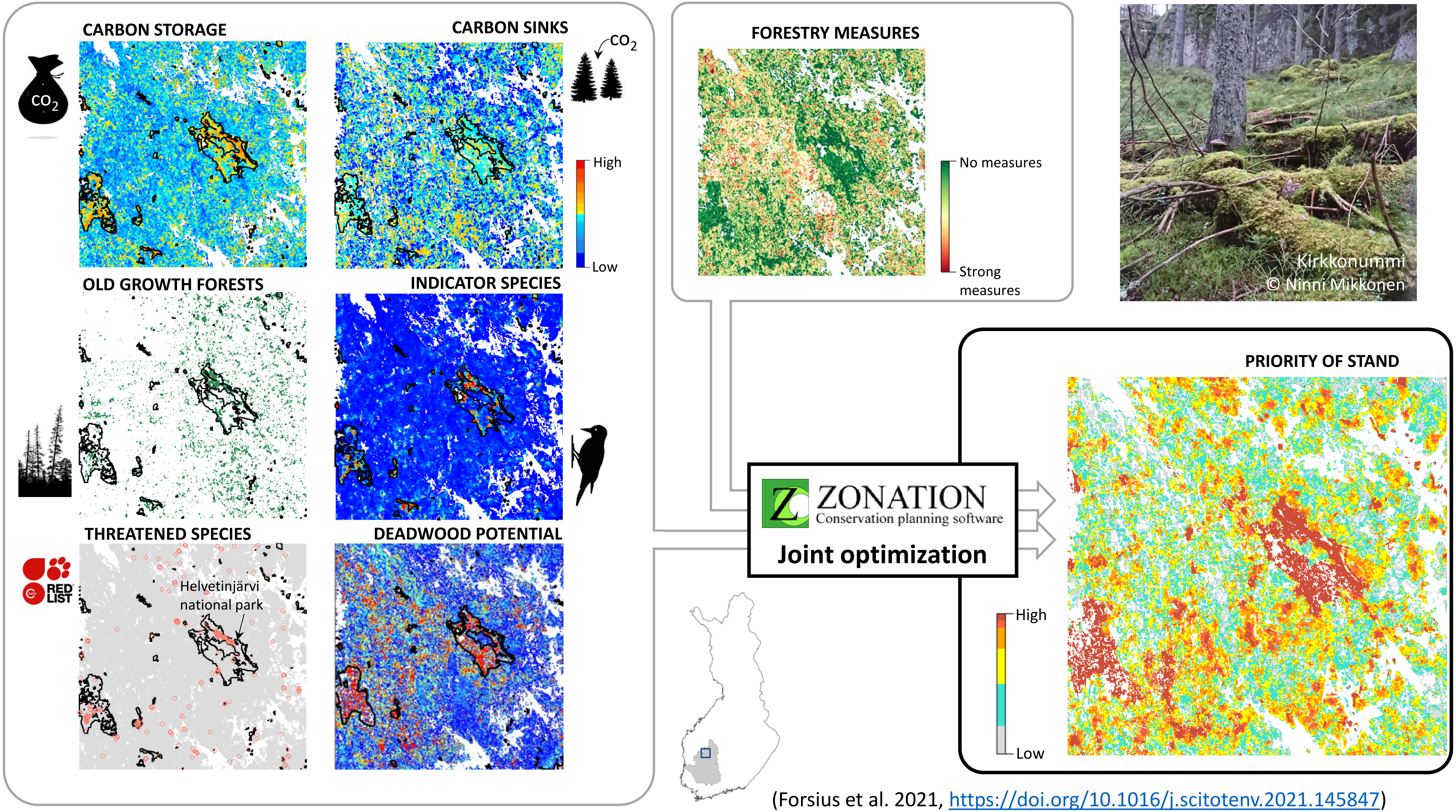
Development of carbon storage of Finnish forests assuming different harvesting scenarios

PREBAS model, present climate assumed

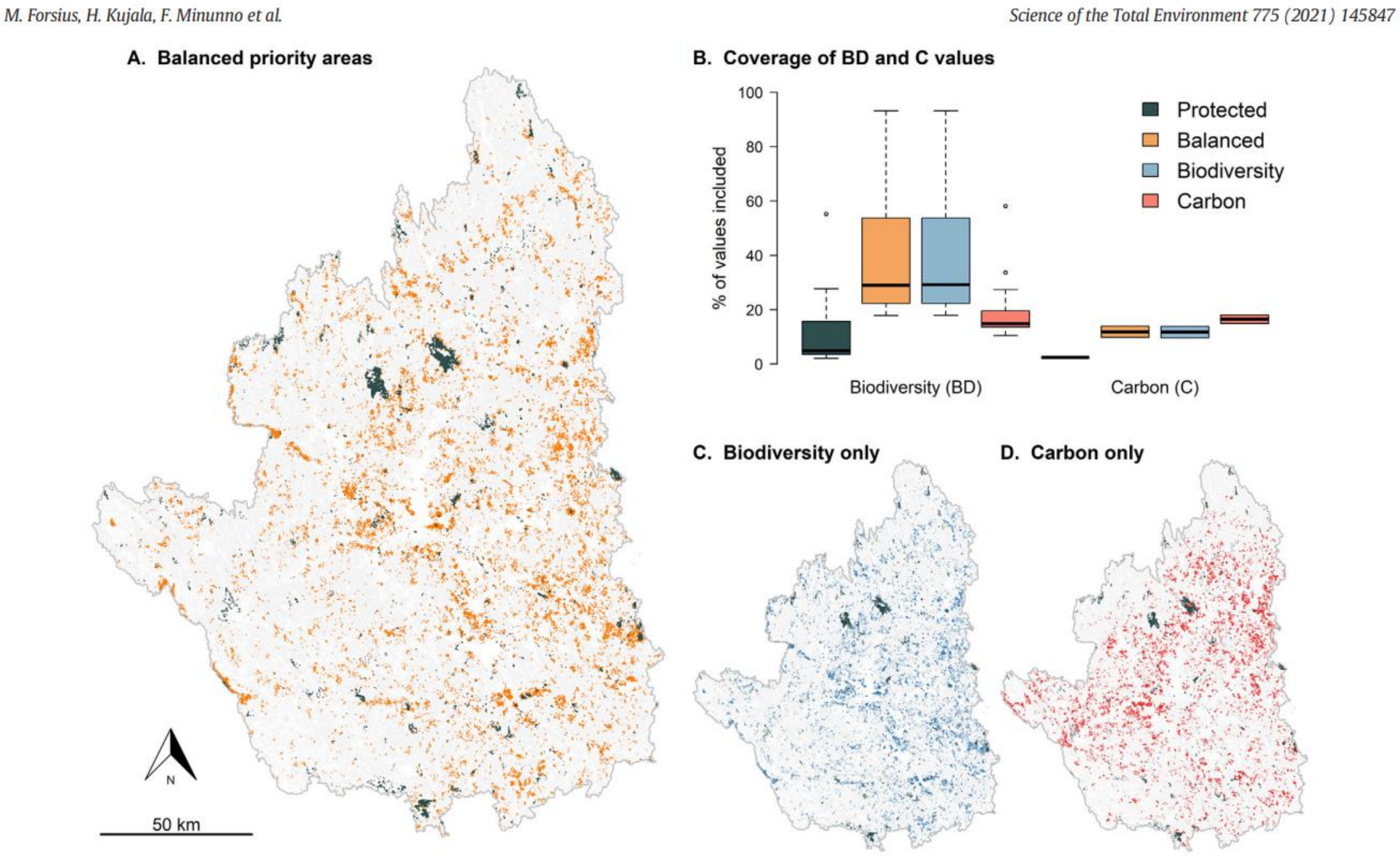


Forsius et al. 2023 https://doi.org/10.1007/s13280-023-01860-1
Junttila et al. 2023 https://doi.org/10.1007/s13280-023-01906-4
Mäkelä et al. 2023 https://doi.org/10.1007/s13280-023-01899-0



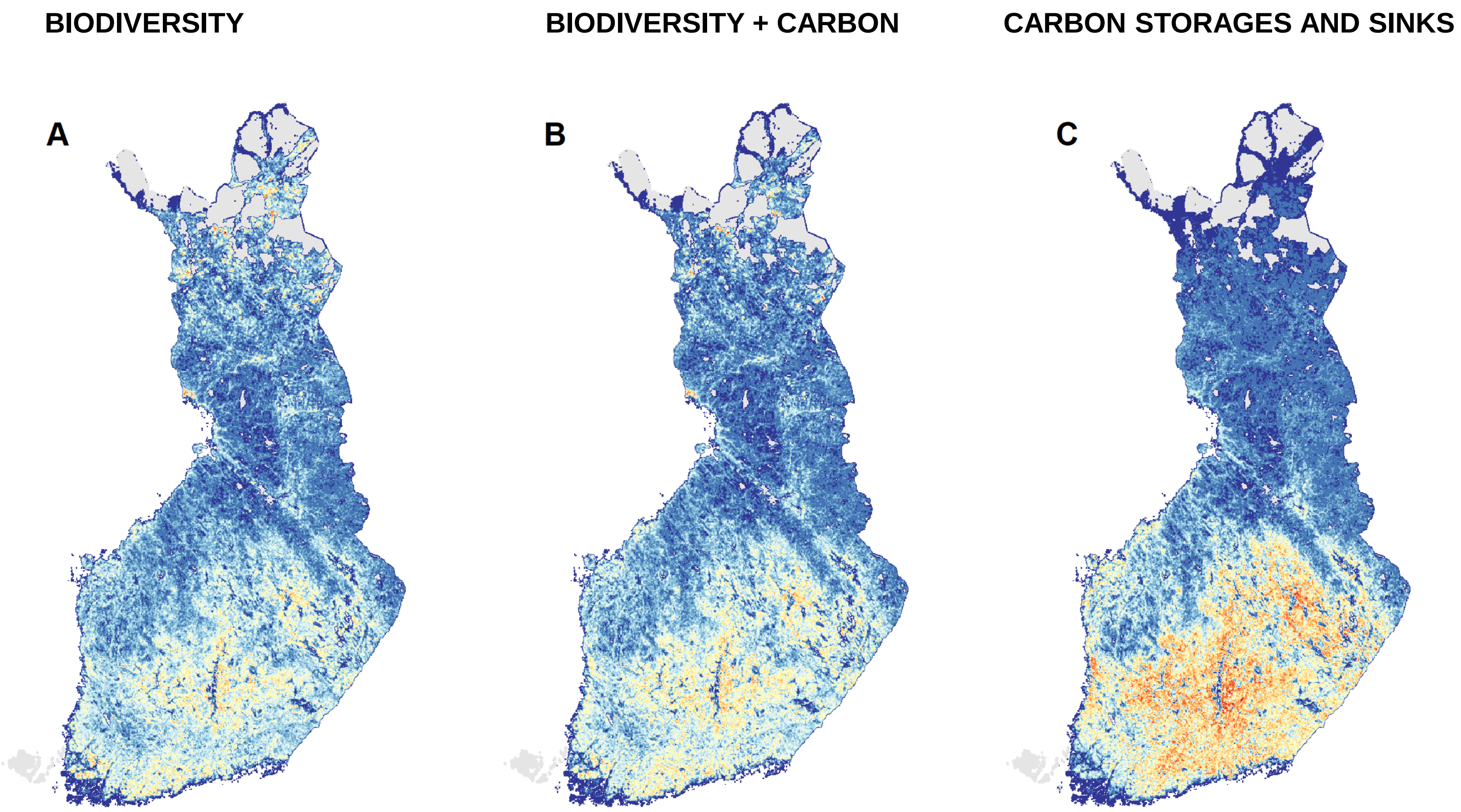
(Forsius et al. 2021, https://doi.org/10.1016/j.scitotenv.2021.145847)

Joint optimisation of carbon and biodiversity



Forsius et al. 2021 https://doi.org/10.1016/j.scitotenv.2021.145847

Spatial prioritization of biodiversity and carbon values of forested areas

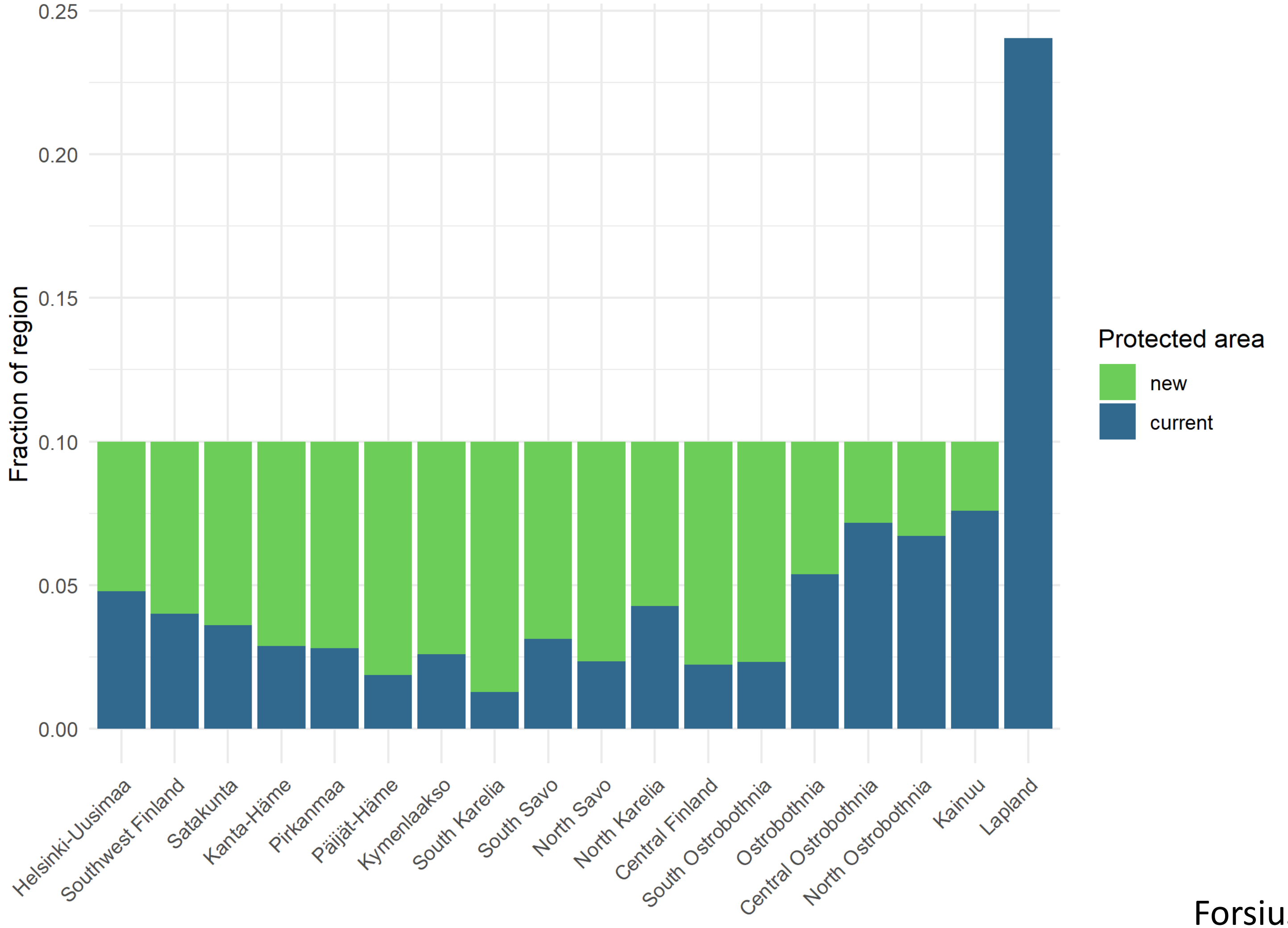


- The maps indicate concentration of valuable areas outside the protected areas.
- The carbon values are concentrated in southern Finland.
- Biodiversity values more equally distributed.
- Zonation model used for the analysis.

Kujala et al., manuscript
Forsius et al. 2024, http://hdl.handle.net/10138/572070

Fraction of new protected forested area needed in the administrative regions to reach the 10% protection target

(Zonation prioritization)



Forsius et al. 2023
https://doi.org/10.1007/s13280-023-01860-1

Development of C sinks and storages of protected areas

(PREBAS model, RCP4.5 climate change scenario)

Forsius et al. 2023
https://doi.org/10.1007/s13280-023-01860-1

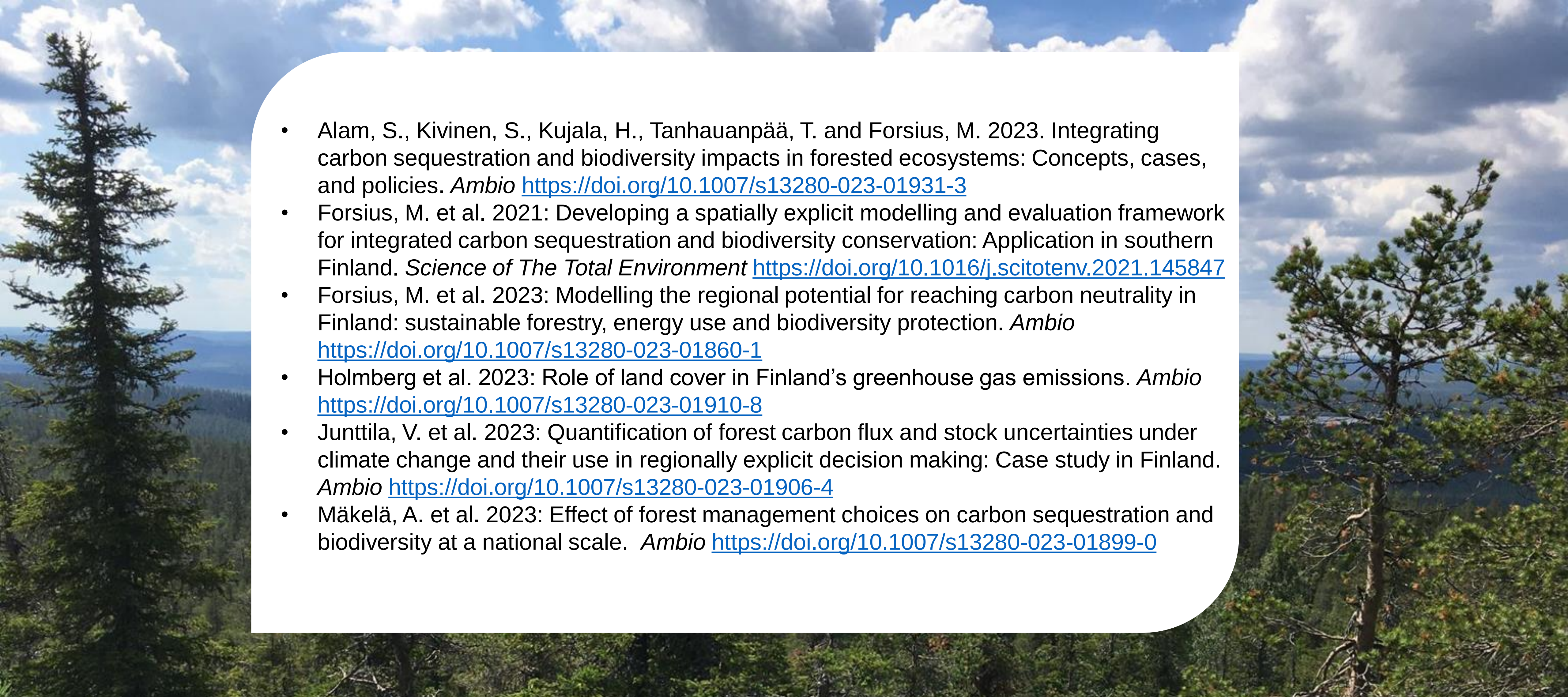
	Area km^2	Scenario	Time period	Carbon sink (95% uncertainty) $TgCO_2eq\ a^{-1}$	Carbon storage (95% uncertainty) TgC
Currently protected areas	16428	NoHarv	Present	-7.1 (-8.5, -5.8)	231.5 (216.8, 242.8)
Currently protected areas	16428	NoHarv	2034 – 2050	-9.4 (-11.3, -7.7)	271.8 (255.5, 286.6)
10% target	27053	NoHarv	Present	-16.2 (-18.4, -13.4)	378.1 (355.9, 394.9)
10% target	27053	NoHarv	2034 – 2050	-17.5 (-20.2, -14.7)	451.9 (431.3, 472.3)

Anthropogenic GHG emissions in 2050 = **9-18** $TgCO_2eq\ a^{-1}$ (FRES model)

Economic value of C sequestration of protected areas = **500** M€ a^{-1} (80 €/CO_2 ton, EU ETS)

Concluding remarks

- Application of spatially explicit model systems can assist in finding solutions to complex interconnected issues.
- Large difference between Finnish regions regarding GHG sources and sinks → need for regional cooperation.
- Reduced forest cuttings needed to reach national carbon neutrality target.
- Present and potential new protected forested areas are important carbon storages and sinks → potential economic value significant.
- Integrated evaluation of climate and biodiversity issues enables development of cost-efficient measures.
- Large uncertainties remain and require further work (e.g. climate change impacts on process rates and species distributions).



- Alam, S., Kivinen, S., Kujala, H., Tanhauanpää, T. and Forsius, M. 2023. Integrating carbon sequestration and biodiversity impacts in forested ecosystems: Concepts, cases, and policies. *Ambio* https://doi.org/10.1007/s13280-023-01931-3
- Forsius, M. et al. 2021: Developing a spatially explicit modelling and evaluation framework for integrated carbon sequestration and biodiversity conservation: Application in southern Finland. *Science of The Total Environment* https://doi.org/10.1016/j.scitotenv.2021.145847
- Forsius, M. et al. 2023: Modelling the regional potential for reaching carbon neutrality in Finland: sustainable forestry, energy use and biodiversity protection. *Ambio* https://doi.org/10.1007/s13280-023-01860-1
- Holmberg et al. 2023: Role of land cover in Finland's greenhouse gas emissions. *Ambio* https://doi.org/10.1007/s13280-023-01910-8
- Junttila, V. et al. 2023: Quantification of forest carbon flux and stock uncertainties under climate change and their use in regionally explicit decision making: Case study in Finland. *Ambio* https://doi.org/10.1007/s13280-023-01906-4
- Mäkelä, A. et al. 2023: Effect of forest management choices on carbon sequestration and biodiversity at a national scale. *Ambio* https://doi.org/10.1007/s13280-023-01899-0

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