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NATURAL RESOURCES
INSTITUTE FINLAND

Environment induced growth changes in forests of Finland

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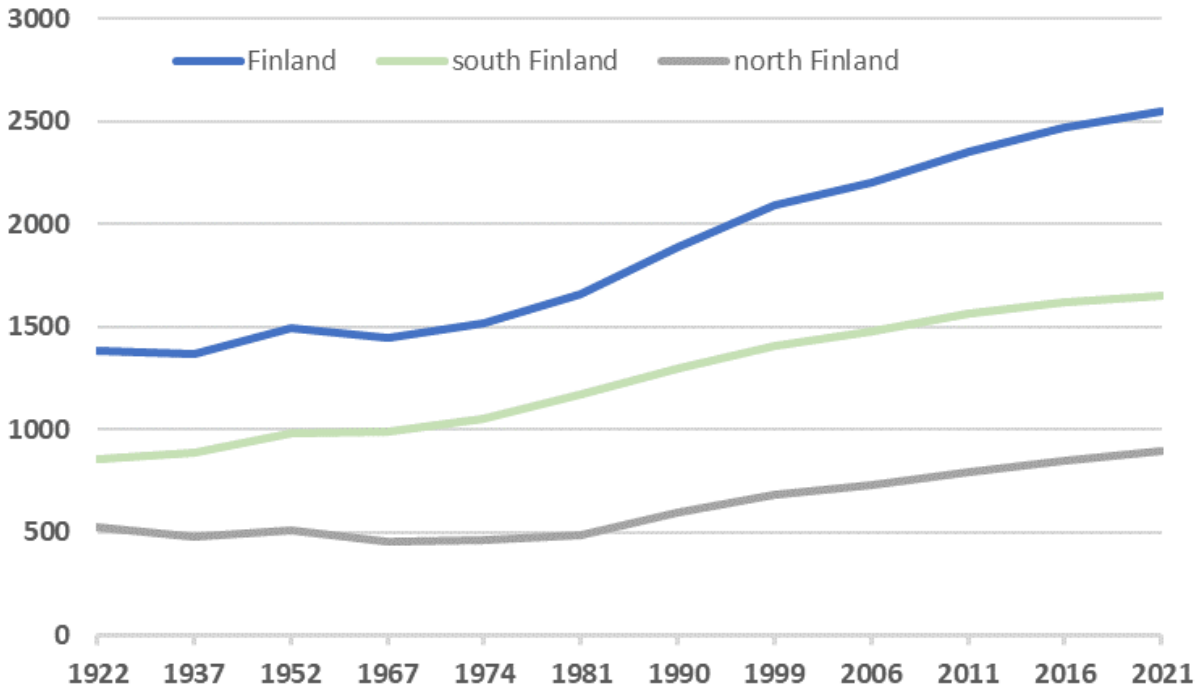
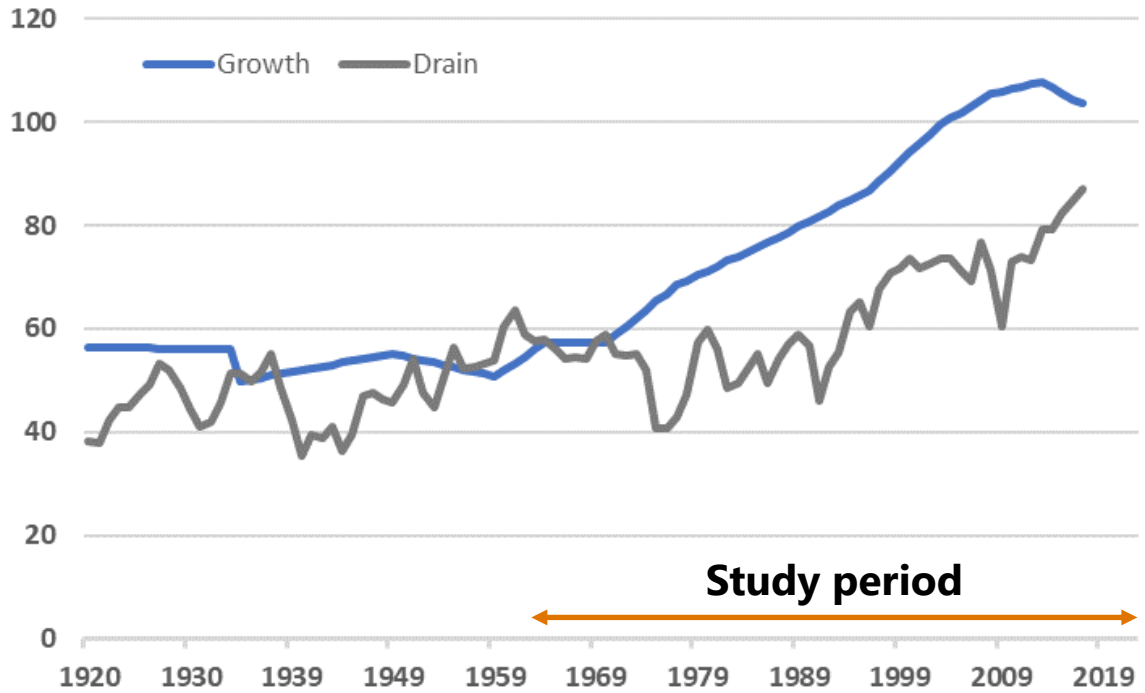
Growing stock and volume increment

Volume, million m^3



Annual increment, million m^3



Study aim

- Quantify the growth component not explainable by changes in growing stock and stand structure.

- How growth of trees
    - of the same size
    - growing in the same type of stands
    - in the same geographical region

has changed in 1964 – 2022.

Material

- Nine consecutive NFIs (NFI5 – NFI13, 1964-2022)
- 272 072 cored trees, sampled as a part of NFI
- Radial increments from the cores
- Height increments from the standing sample trees

- Peatlands and paludified mineral soils excluded
- Volume increments generalised to inventory regions (m^3/ha/a)

Methods

- **Models predicting volume increment of a tree** based on species, tree size, geographical location, regeneration method, and competition
- GAM models fitted separately for NFI6 – NFI12 data
- Predictions for NFI5 – NFI13 data, averaged
- Difference between the model-predicted and measured volume increment may be **due to changes in variables not included in the models**, e.g., changing environment

Models

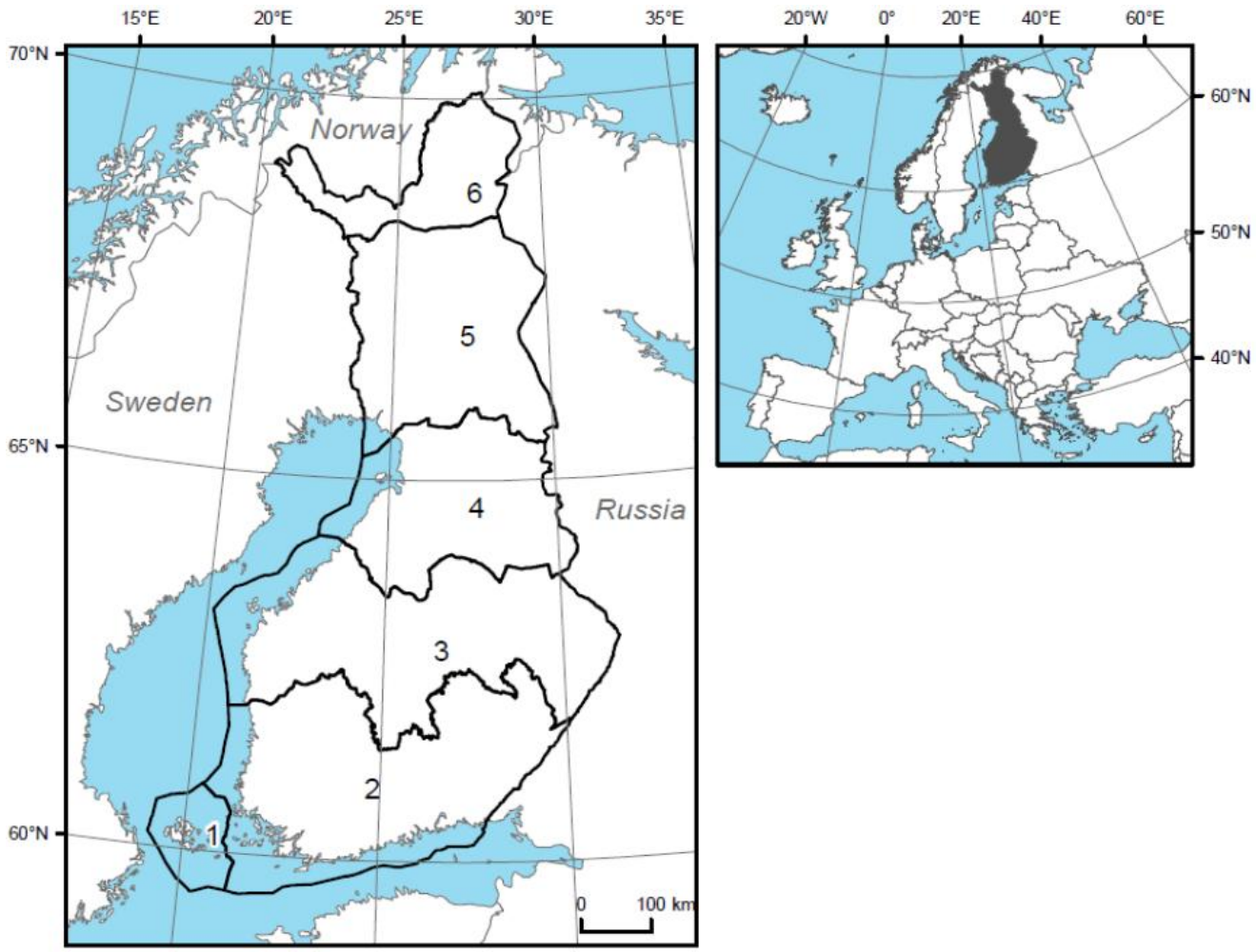
- Independent variable: **iV/G** (volume increment / basal area of a tree)
- Dependent variables:
  - tree species
  - stem diameter
  - mean stem diameter
  - stand basal area
  - time since the last thinning
  - regeneration method
  - soil stoniness
  - altitude
  - average temperature sum (1991 – 2020)

$$\log(E[\frac{iv_{ijk}}{g_{ijk}}]) = f_{1,sp_{ijk}}(dbh_{ijk}, \overline{dbh}_{i.}, BA_i) + f_{2,sp_{ijk}}(fh_{ijk}) + f_3(alt_i) + \beta_1 \log(ets_i)$$

$$+\beta_2 sp.1_{ijk} + \beta_3 sp.2_{ijk} + \beta_4 sp.3_{ijk} + \beta_5 birch_{ijk} + \beta_6(ct4_{ij}) + \beta_7 stone_{ij},$$

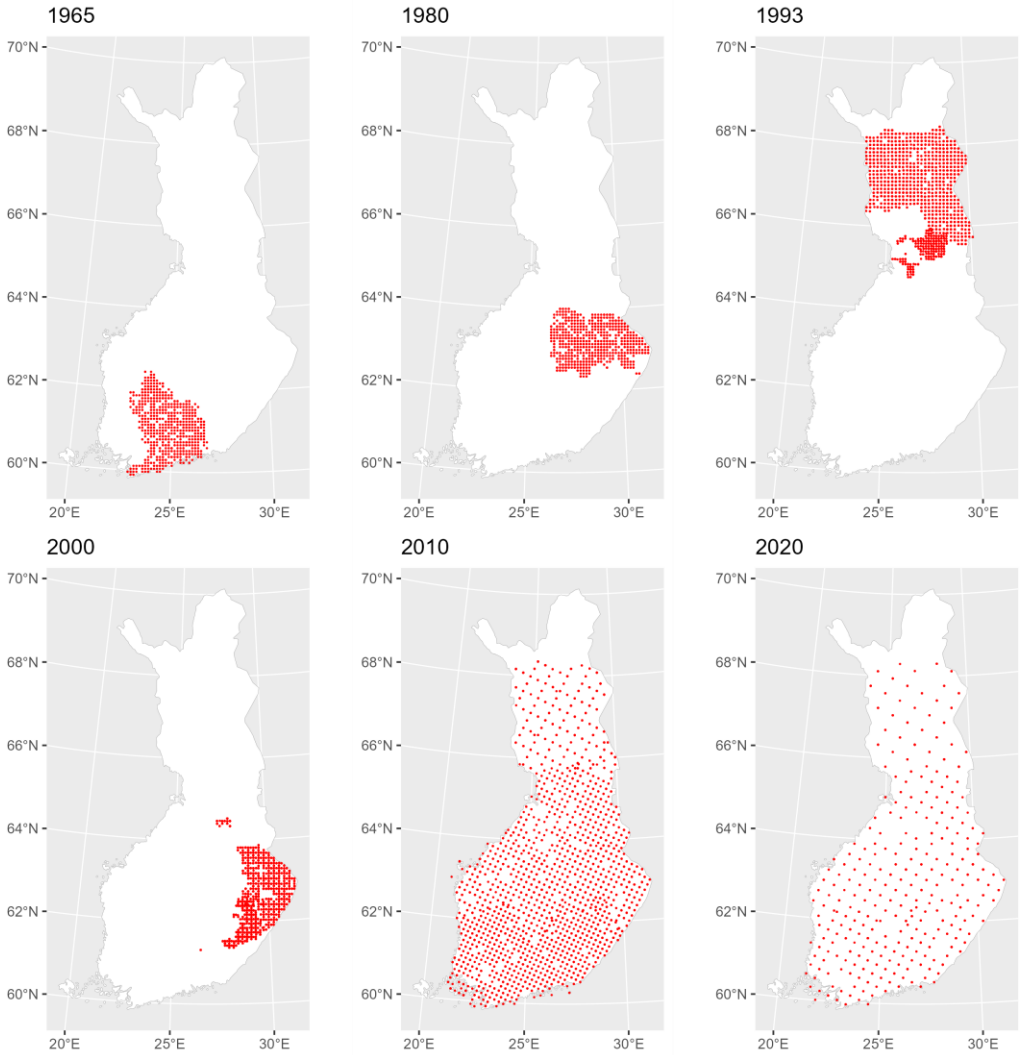
$$\frac{iv_{ijk}}{g_{ijk}} \sim \text{Gamma}, \qquad (1)$$

Sampling regions



Sampling

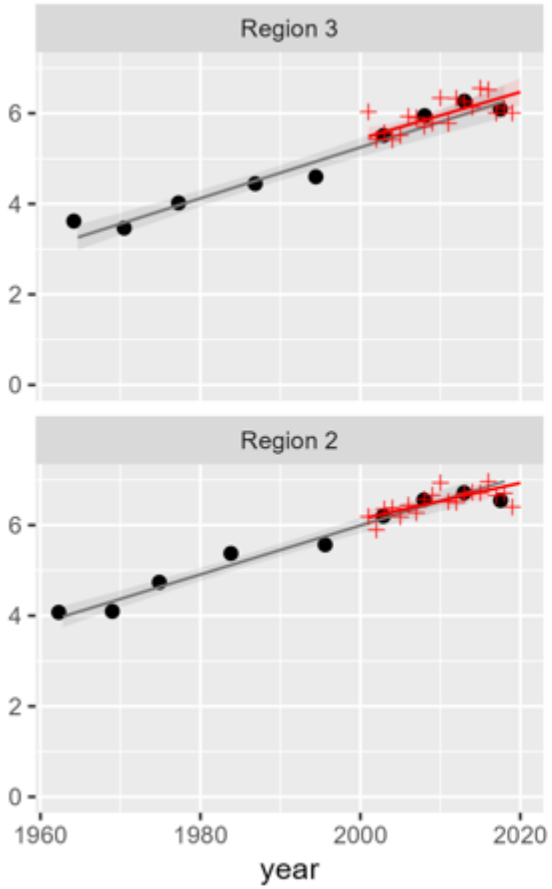
- Sampling proceeded by region
  - NFI5 – NFI9, 1964 – 2003
  - 1 – 3 administrative regions each year
  - whole country in 6 – 9 years
  - we present means for each NFI
- Since NFI10, whole country each year
  - inventory cycle 5 years
  - we present also annual values



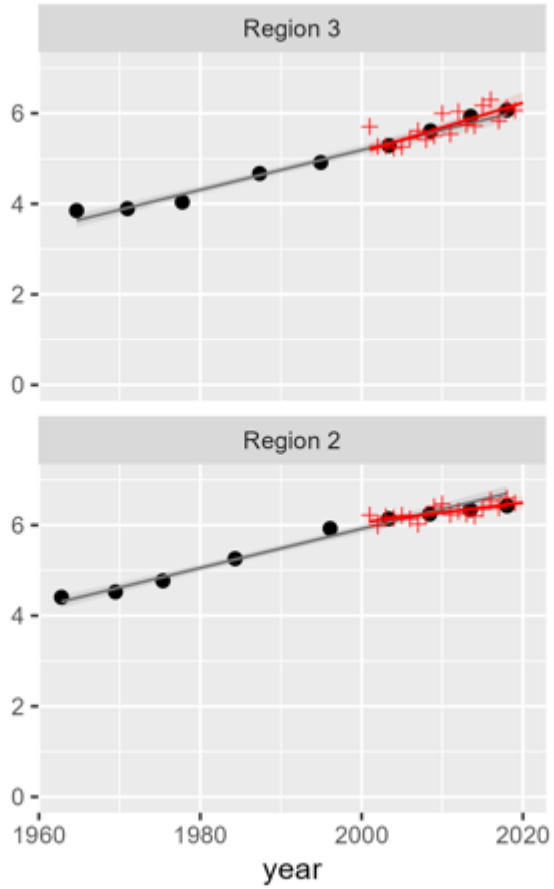
Southern Finland, all tree species

$m^3/ha/a$

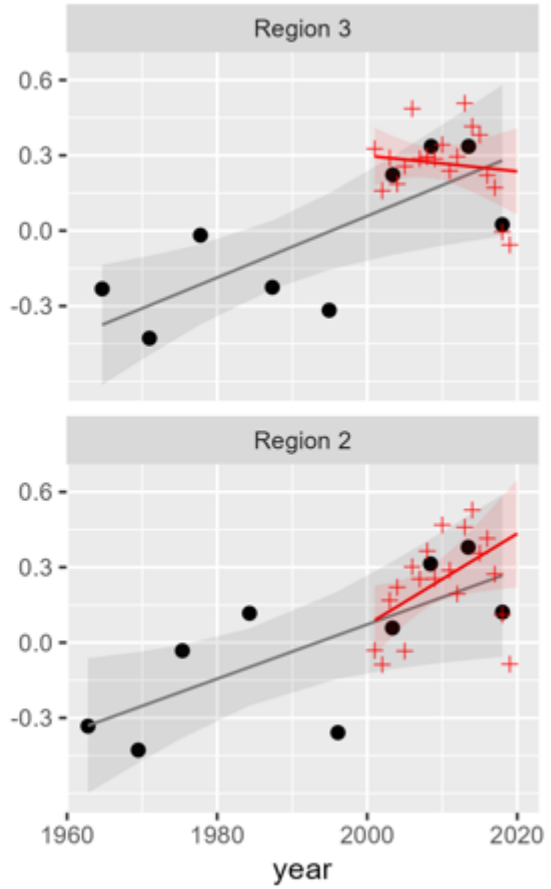
Measured



Predicted



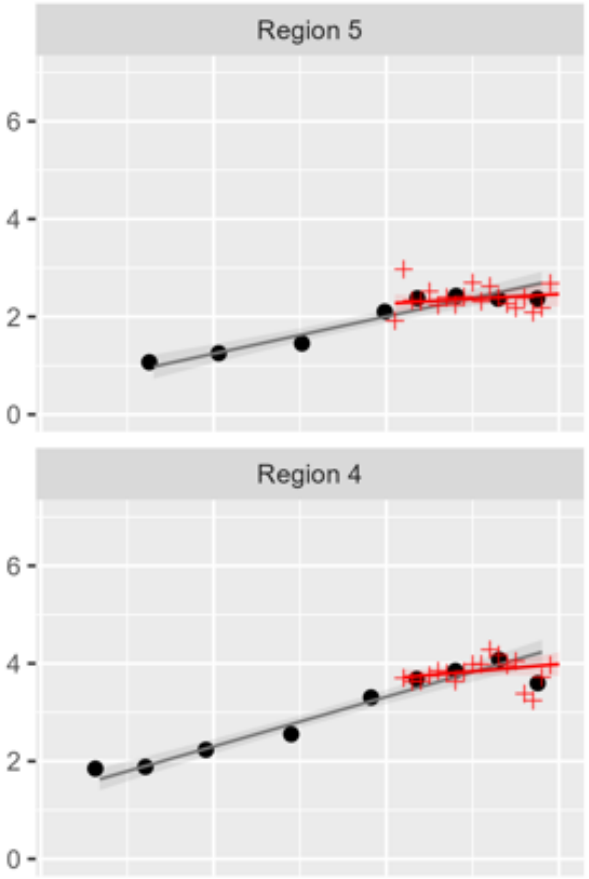
Measured-Predicted



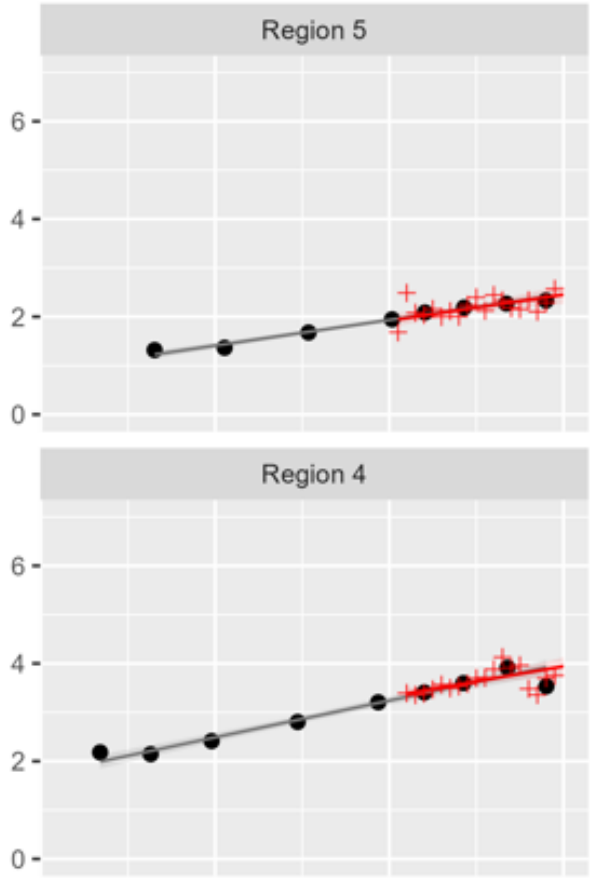
Northern Finland, all tree species

$m^3/ha/a$

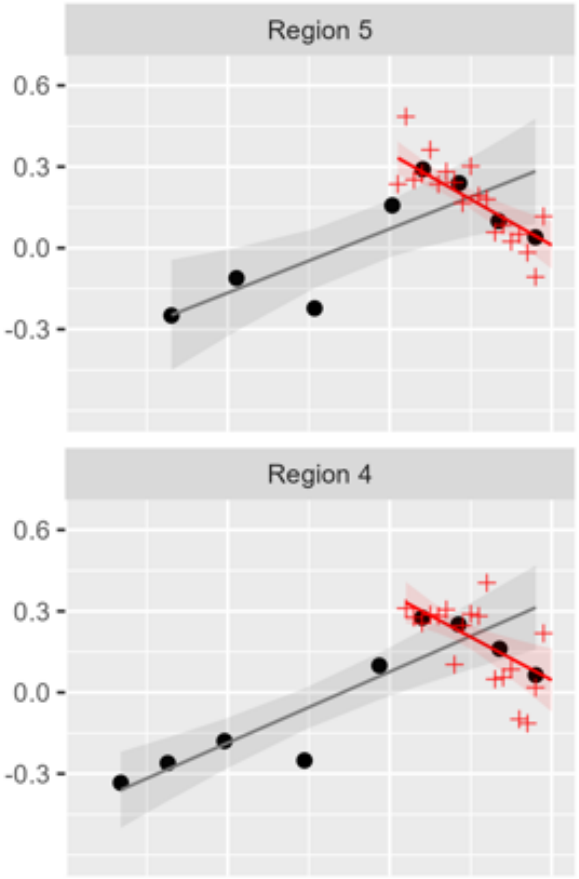
Measured



Predicted



Measured-Predicted

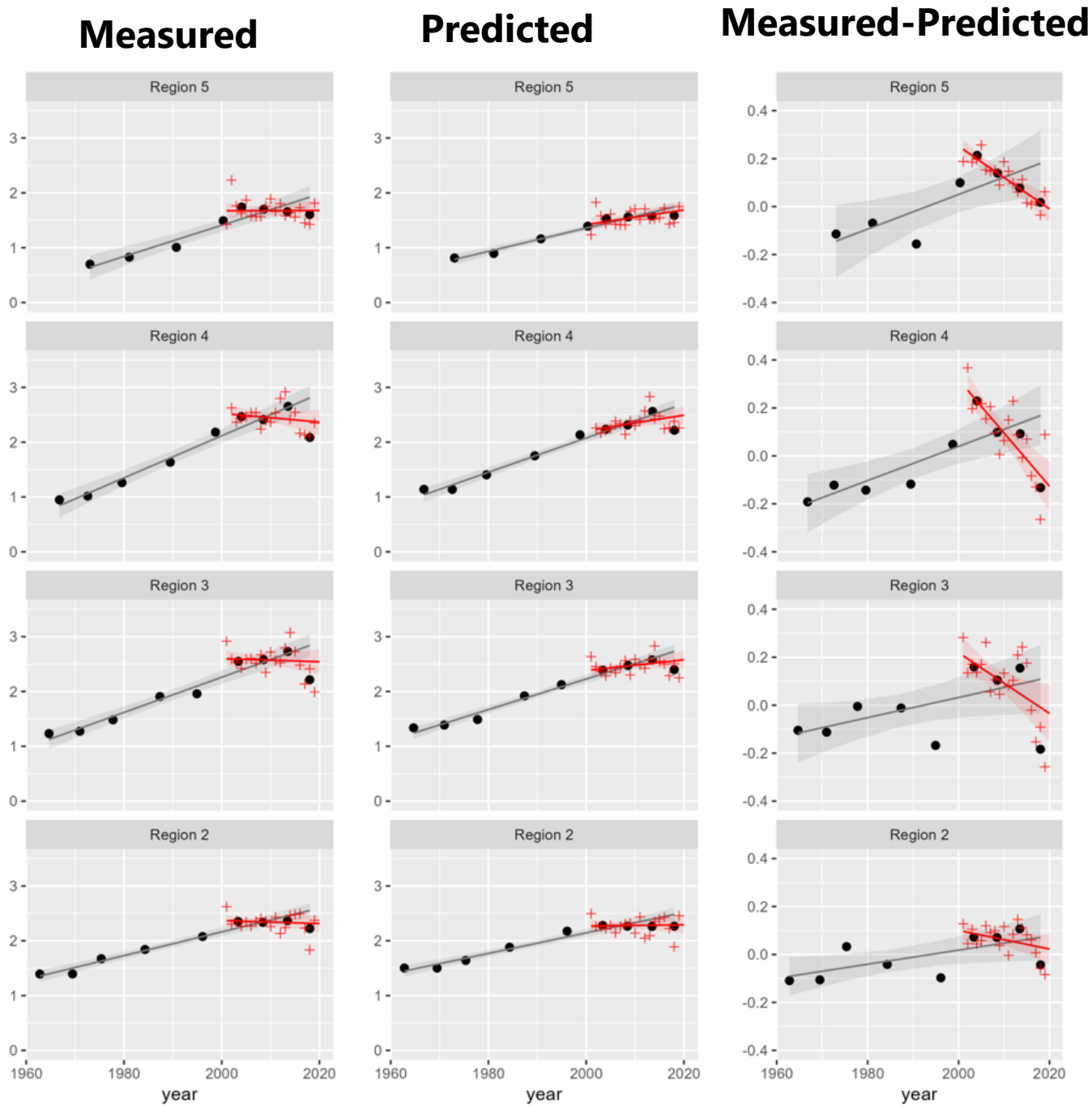


Results, all tree species

- Long-term growth trend (measured, predicted, difference) rising
- Predicted growth, NFI12 (2014 – 2018) → NFI13 (2019 – 2022)
  - increased in three regions out of four (2, 3, 5)
  - decreased in northern part of central Finland (region 4)
- Measured growth, NFI12 → NFI13
  - decreased clearly in regions 2, 3, 4, decreased slightly in Lapland (5)
- In recent years, growth close to the predicted level in all regions
  - i.e., close to average level (1971 – 2018)
- Beginning of 21st century favourable for growth, recent years moderate

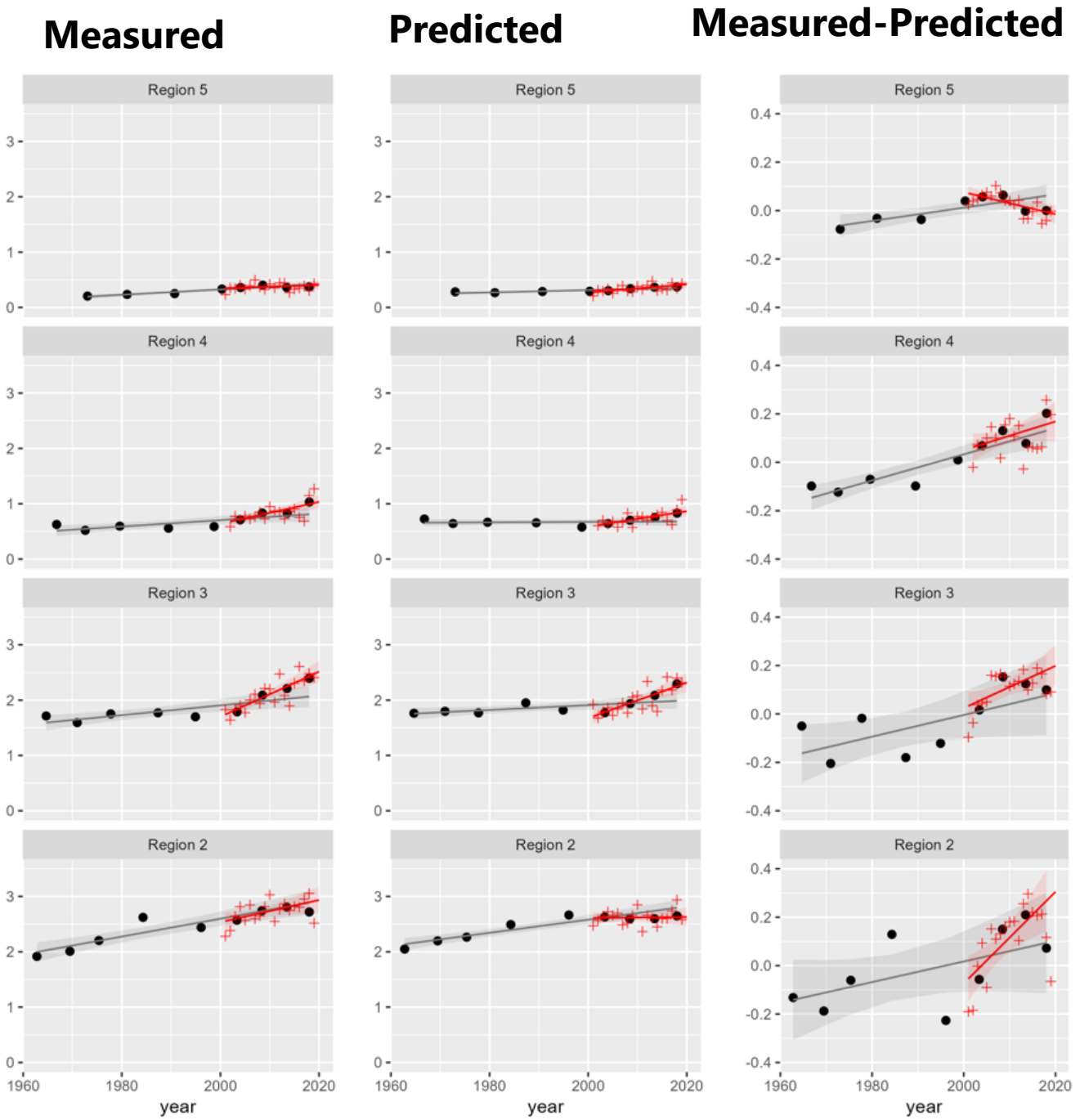
Scots pine

- In recent years, measured growth declined in regions 2–4, steady in 5
- Predicted growth declined in regions 3 and 4, steady in 2 and 5
- Measured growth clearly below the predicted one, except in region 5



Norway spruce

- In recent years, measured growth increased in regions 3 and 4, steady in 2 and 5
- Predicted growth as the measured
- Measured growth clearly above the predicted one, except in region 5



Conclusions: growth in recent years

- Scots pine: measured growth declined in relation to the predicted growth
  - environmental factors less favourable for growth than in the early 21st century
- Norway spruce: no growth decline
  - but difference between the measured and predicted growth lower than in the 21st century on average
- Changes in growing stock and stand structure as potential causes:
  - forests getting older; minor factor
  - recent thinnings too heavy; possible contributing factor
  - earlier final fellings; possible contributing factor
- Natural climatic variation as a potential cause:
  - exceptionally dry years 2018, 2019, 2021; no drought in 2003–2017
  - flowering, cone production; contributing factor

Thank you!

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Environment-induced growth changes in forests of Finland revisited - a follow-up using an extended data set from the 1960s to the 2020s

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