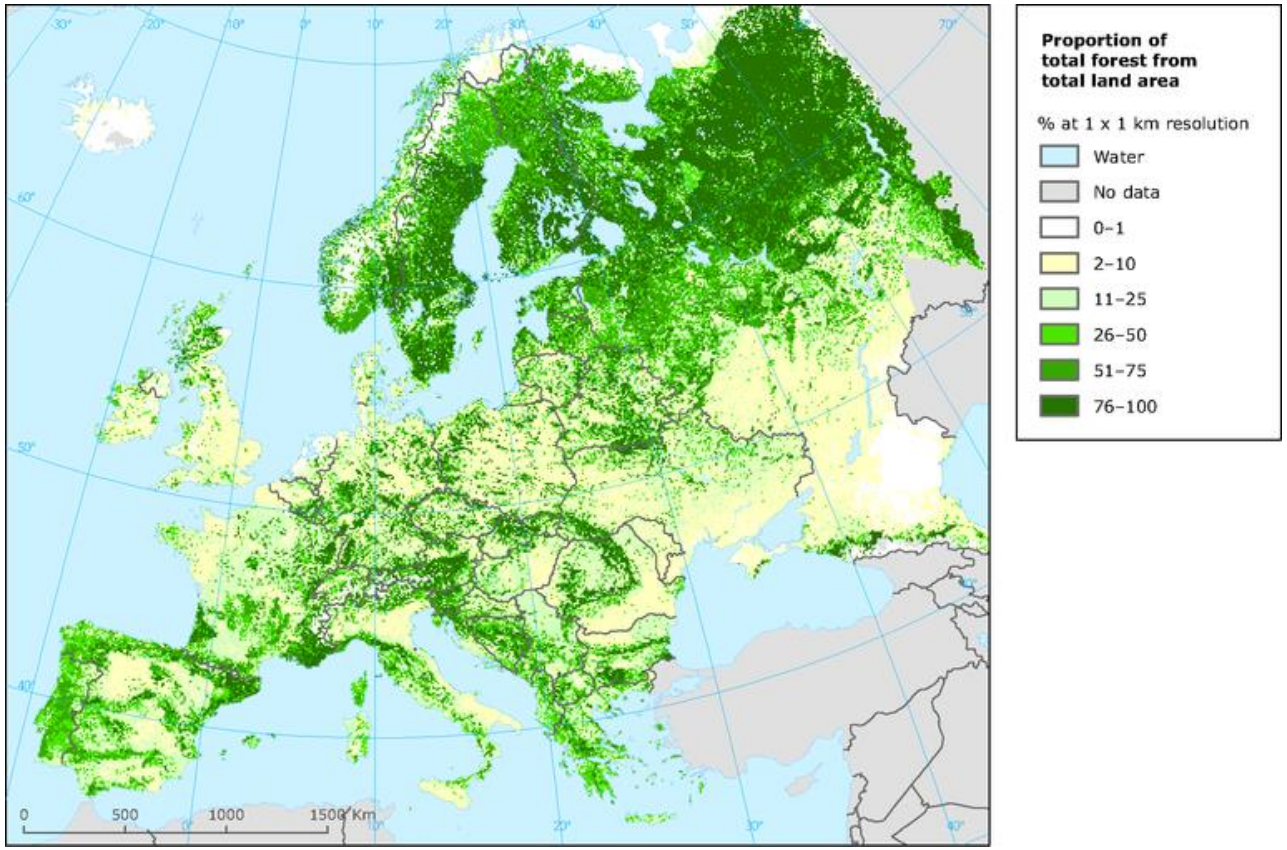
How dry is too dry?
A retrospective analysis on how global change-type droughts are driving mortality in European forests

Jan-Peter George
Tartu Observatory
Tõravere
Estonia

UNIVERSITY OF TARTU
1632

TARTU OBSERVATORY
space research centre

Forests in Europe

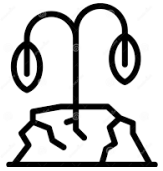


Source: European Environment Agency

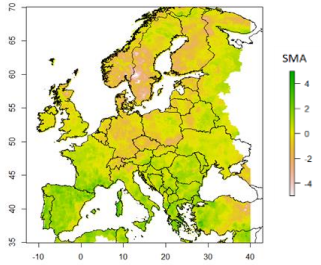
-160 million ha in the EU-27
-27 billion m^3 growing stock (over bark)
-27 billion EUR total gross value added
(forestry & logging Industry)
-0.5 million people employed in
forestry & loggig Industry
-10% increase in forested area since 1990

Research Questions

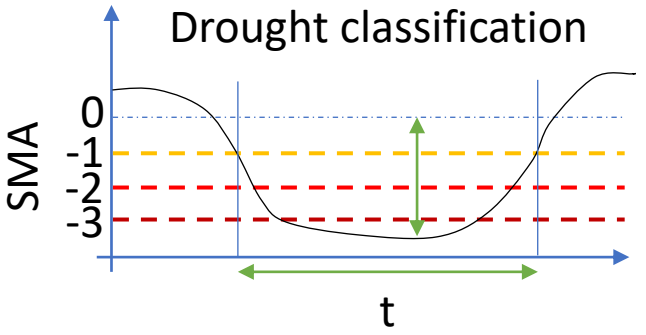
Q1: Has mortality been increasing across the last 25 years in European forests?



Q2: Are global change-type droughts driving increasing mortality?



Global change-type droughts



Light droughts

2001

2002

2003

Min. intensity

-1

-2

-3

-4

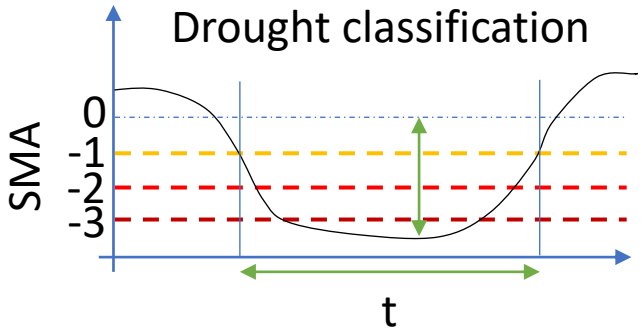
Harmful droughts

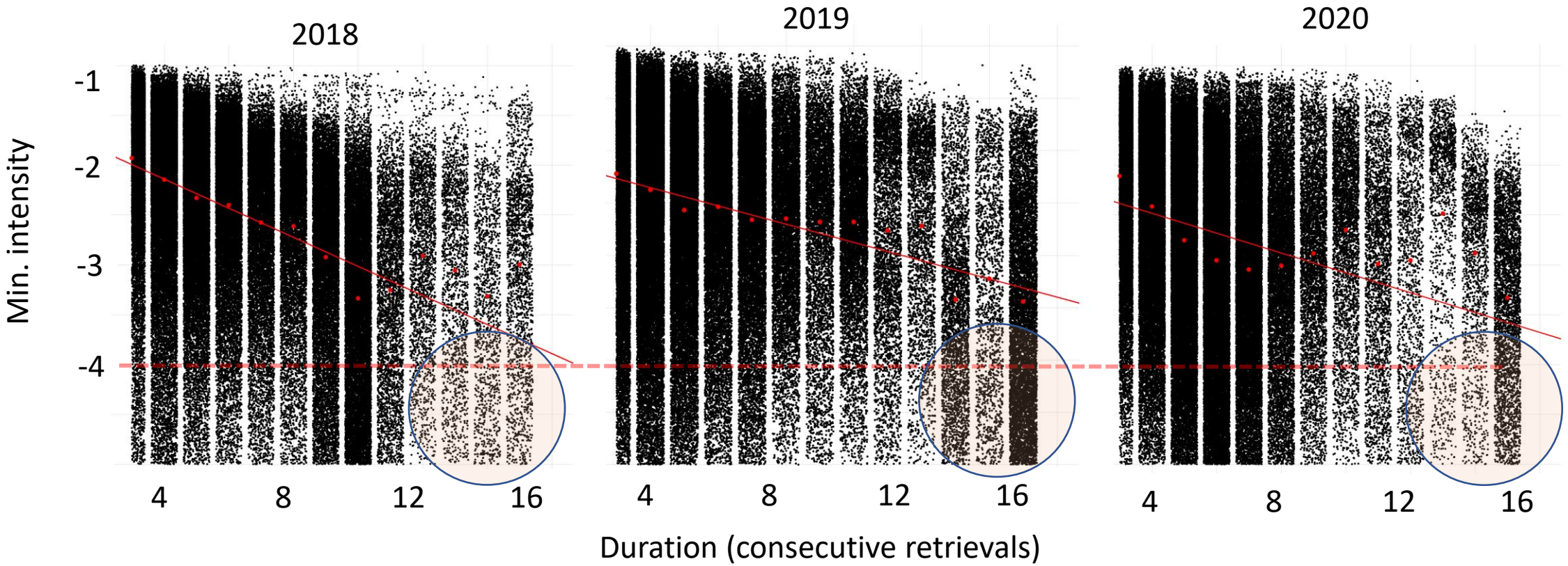
4 8 12 16 4 8 12 16 4 8 12 16

Duration (consecutive retrievals)

George *et al*. (in preparation)

Global change-type droughts



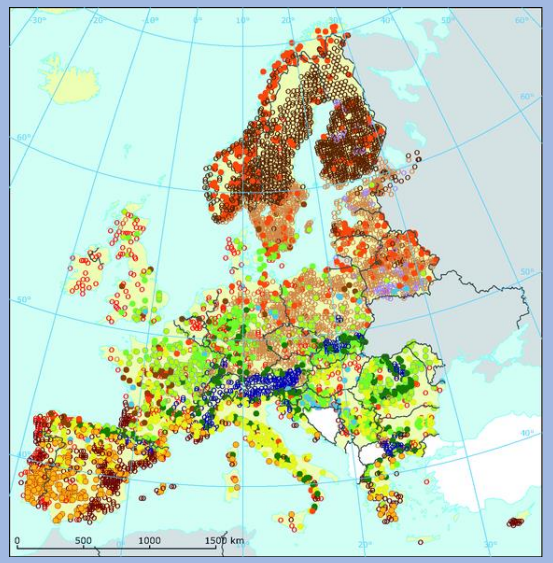


George *et al*. (in preparation)

Datasets

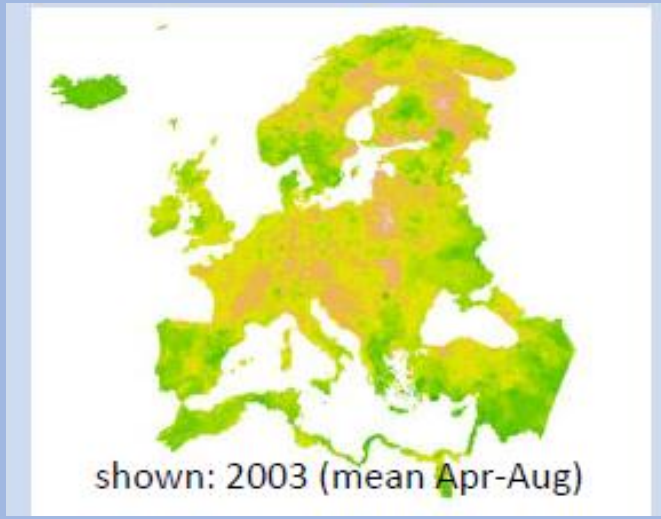
Tree mortality

ICP Level I crown condition survey
3.7 million repeated observations for
Europe at 16 x 16km
1987-2020

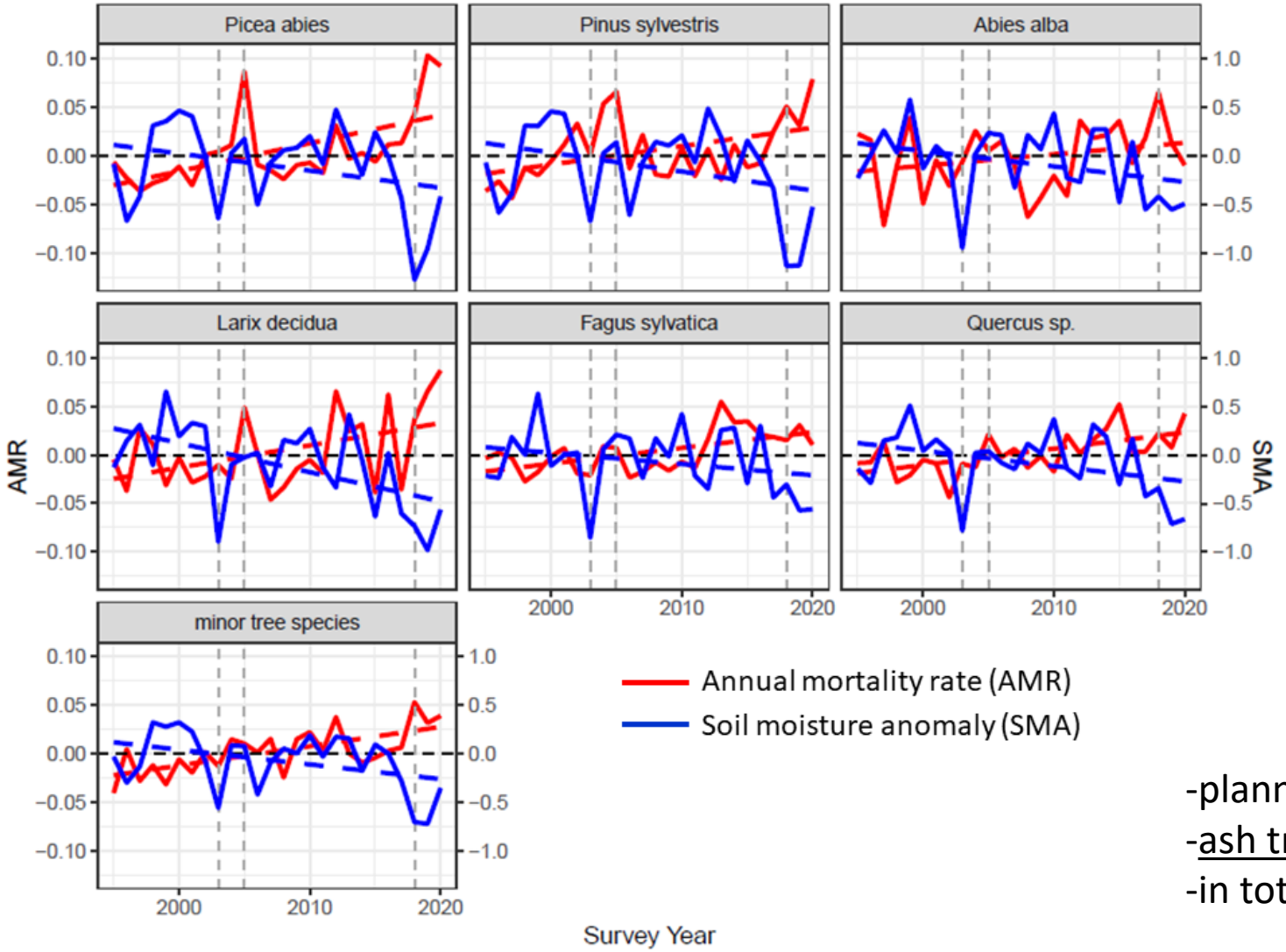


Drought

Soil moisture anomaly (SMA)
Hydrological rainfall-runoff model
based on daily meteorological data
every 10-days at 5km^2 resolution



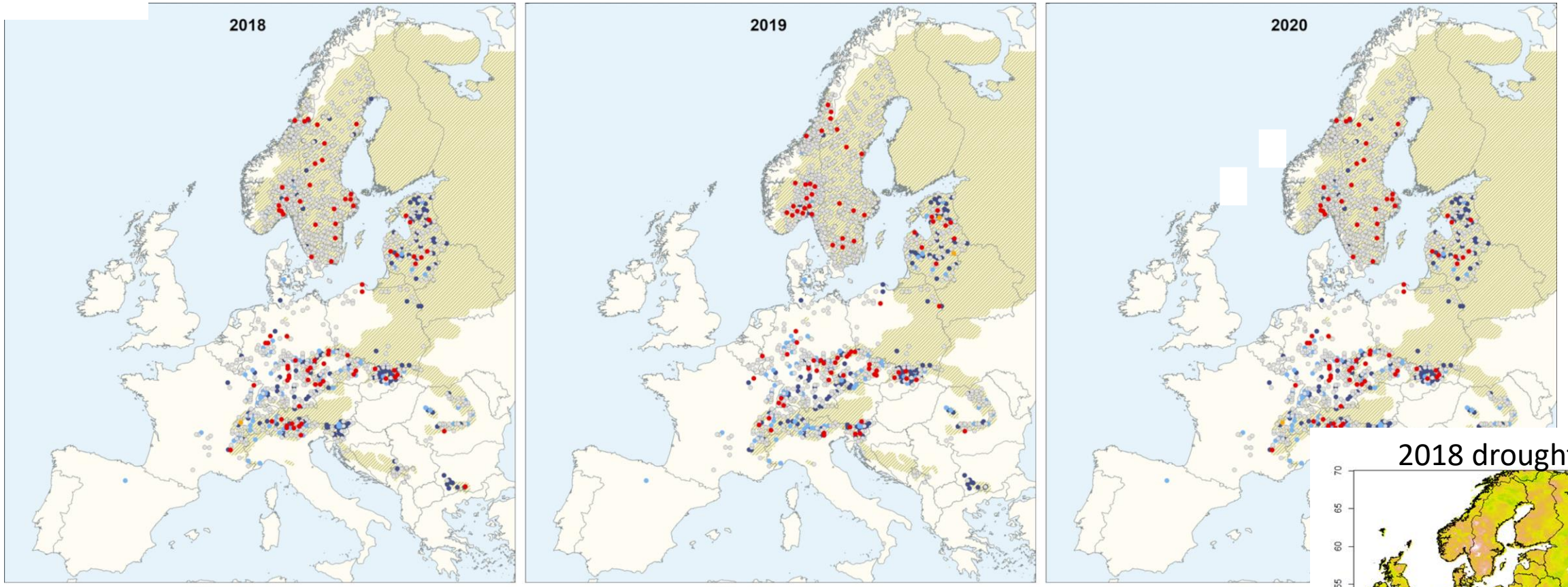
Results (1) : Annual mortality rate



-planned utilizations removed
-ash trees (*Fraxinus spec.*) removed
-in total: 3.7 million observations

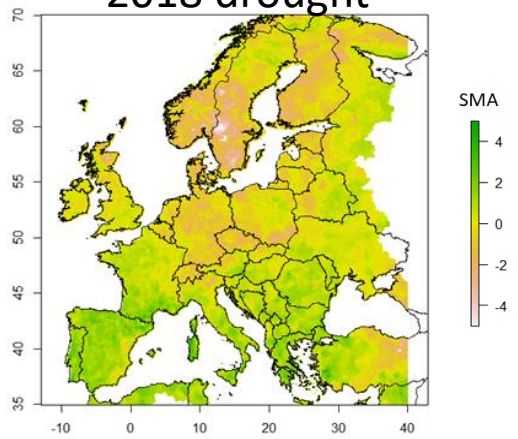
Results (2) : Spatial variation in mortality

Norway spruce (*Picea abies*)



AMR > 0.235
AMR 0.235 to > 0.004
AMR ≤ 0.004 to ≥-0.004
AMR ≤ -0.004 to > -0.235
AMR ≤ - 0.235
} Mortality higher than average
} Mortality lower than average
Norway spruce natural distribution *

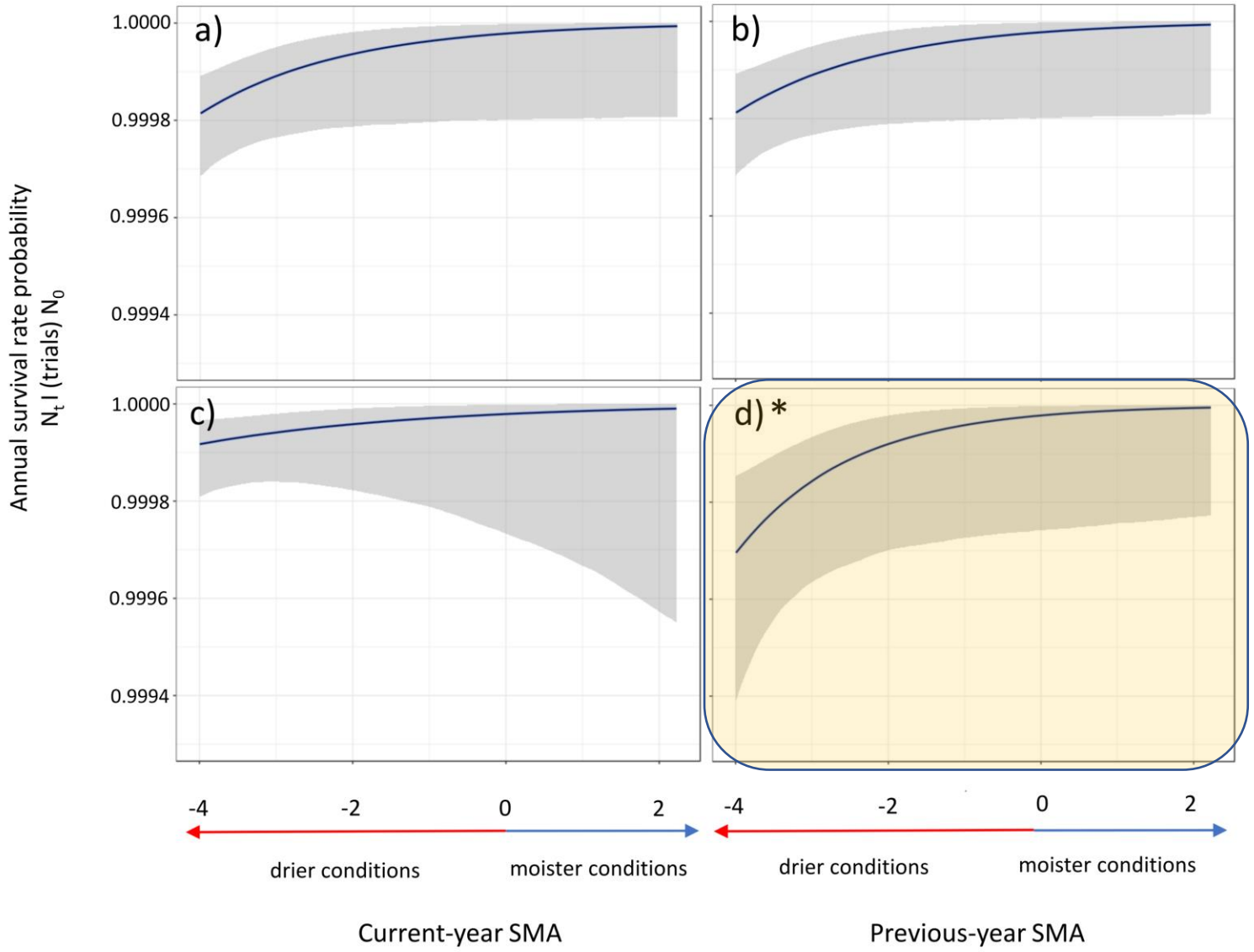
2018 drought



* this product was developed using materials from the Joint Research Centre (JRC), Giovanni Caudullo, Erik Welk, Jesús San-Miguel-Ayanz;

Results (3) : SMA as driver of survival rate

Conifers



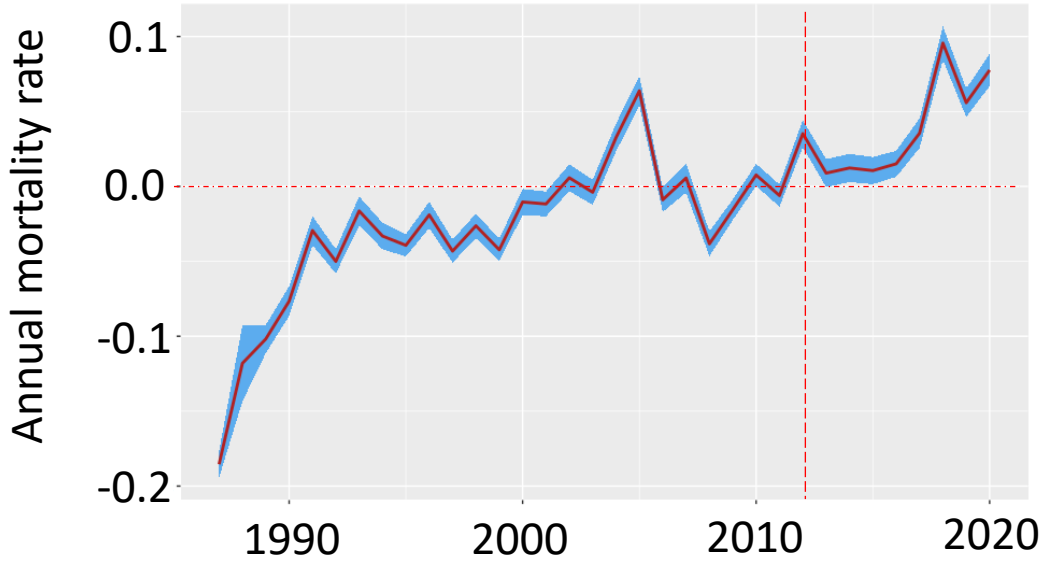
Varying intercept model

Varying slope model

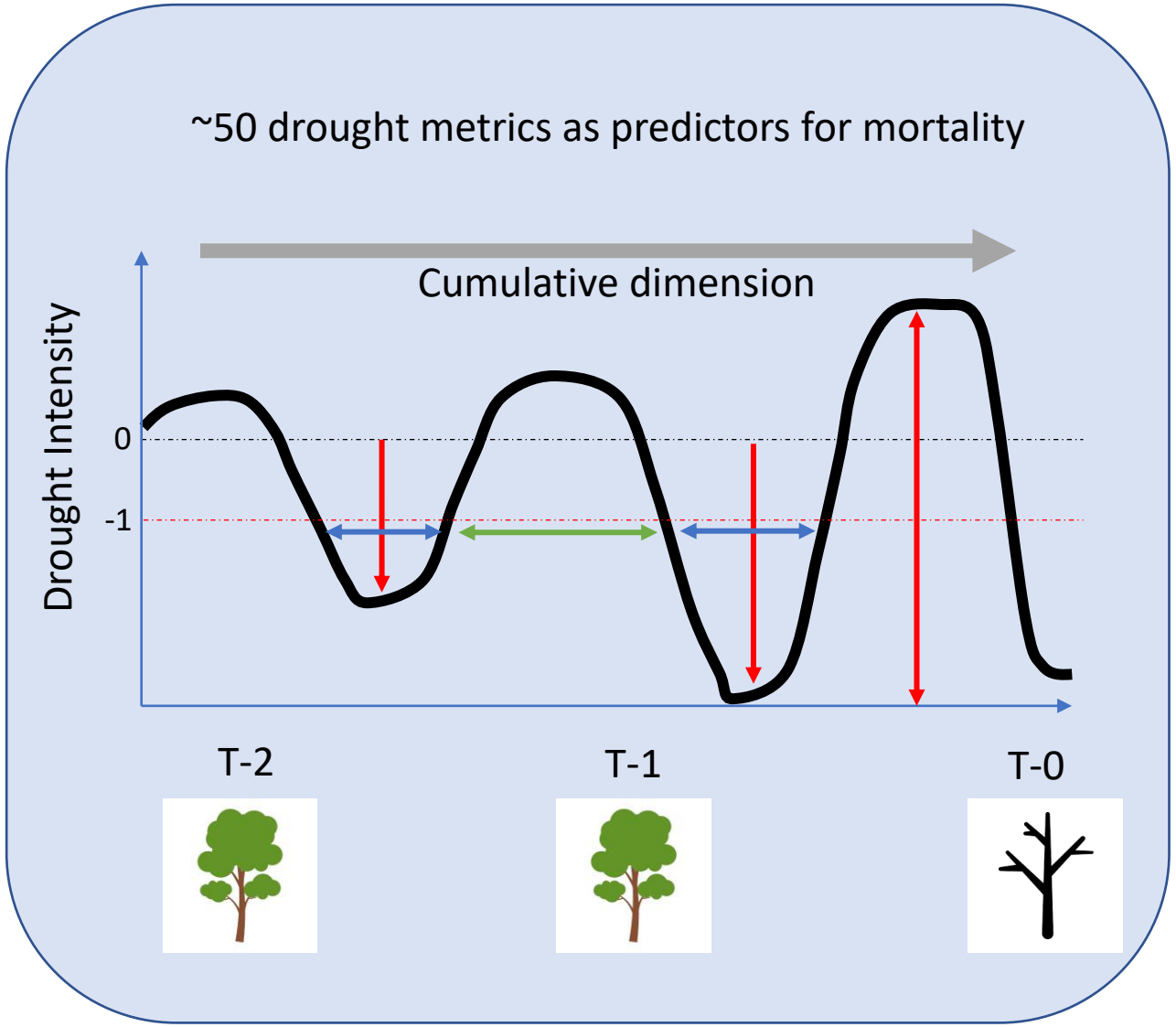
Take-home figures

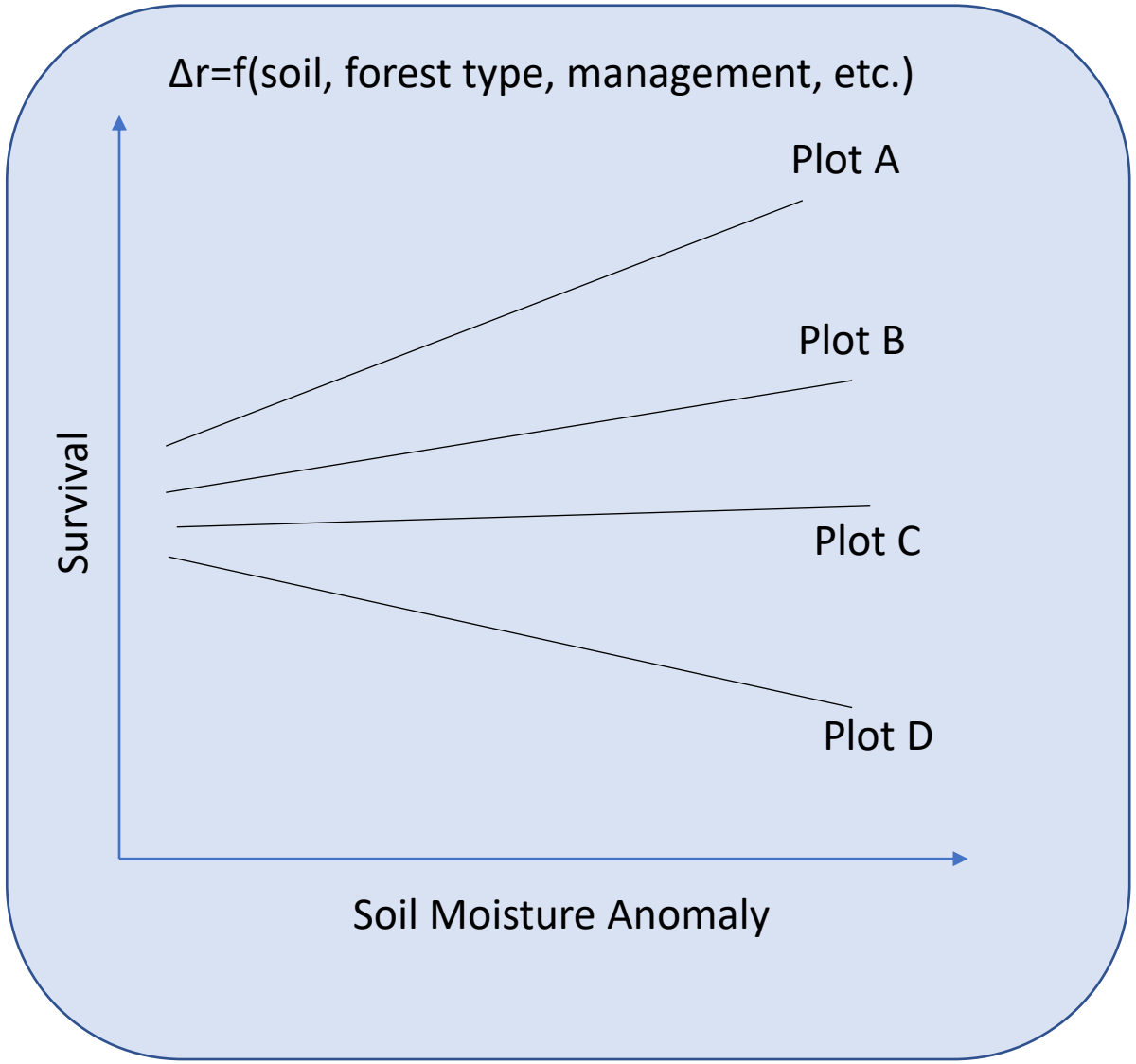
- Norway spruce: 60% increase in mortality rate in **2010-2020 compared to 1995-2009**
- Scots pine: 40%
- European Beech: 36%
- Oak: 3.5%

- Since 2012 annual mortality rate across all species and regions is **continously positive**!



Outlook


~50 drought metrics as predictors for mortality
Cumulative dimension
Drought Intensity
0
-1
T-2
T-1
T-0


Δr=f(soil, forest type, management, etc.)
Survival
Plot A
Plot B
Plot C
Plot D
Soil Moisture Anomaly

Credits to….

Mait Lang

Mathias Neumann

Tanja Sanders

Carmelo Cammalleri

Jürgen Vogt

UNIVERSITY OF TARTU
Tartu Observatory

Universität für Bodenkultur Wien
University of Natural Resources and Applied Life Sciences, Vienna

THÜNEN

Joint Research Centre
JRC

Volkmar Timmermann

NIBIO
NORSK INSTITUTT FOR BIØØKONOMI

Nenad Potocic

Hrvatski šumarski institut
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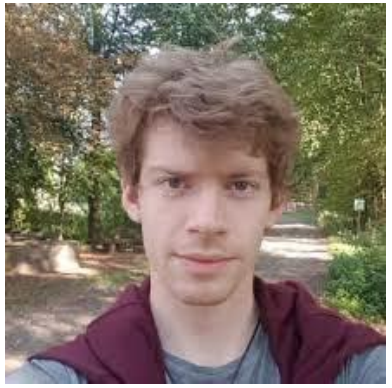
Paul-Christian Bürkner



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Thank you very much for your attention!

Contact: jan.peter.george@ut.ee