



7th ICP Forests Scientific Conference - European forests in a changing environment:
Air pollution, climate change and forest management

Effects of climate and management on productivity and mortality of European beech and Norway spruce in Europe

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Riga, 22.05.2018

Gefördert durch:



Bayerische Landesanstalt
für Wald und Forstwirtschaft



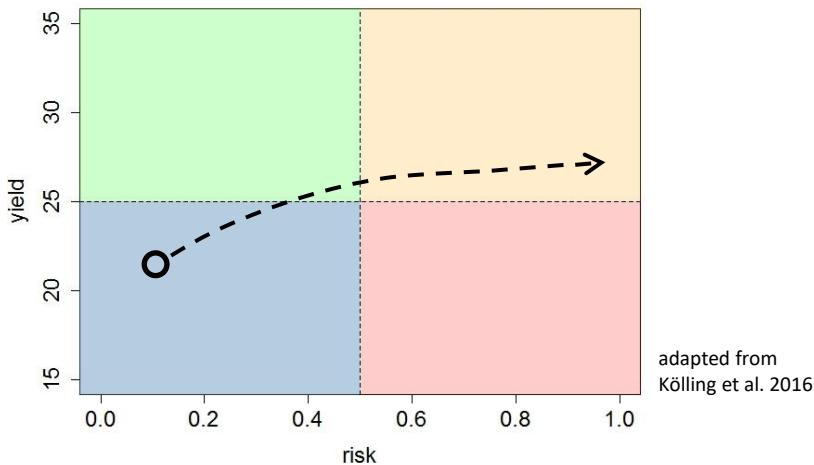
Bundesministerium
für Ernährung
und Landwirtschaft

Bundesministerium
für Umwelt, Naturschutz
und nukleare Sicherheit

aufgrund eines Beschlusses des Deutschen Bundestages

Motivation

- Tree species suitability under climate change
 - Productivity
 - Mortality
- Aim: combine productivity and mortality



- Tool: Statistical models
- „Big picture“

Structure

- Mortality
 - Theory
 - Data and Method
 - Results for spruce and beech
- Productivity
 - Data and Method
 - Results for spruce and beech
- Productivity and Mortality

Mortality

„decline disease“ theory (Manion 1981)

predisposing factors

climate
Soil moisture
Soil nutrients
Genetic disposition
Air pollutants
competition

...

Long-term

-> reduced vitality
-> reduced growth

inciting factors

Insect defoliation
Frost
Storms
drought
Mechanical injury
...

Short-term

-> affect physiological functioning
-> reduce vitality and potential for pathogen defense, rapid growth decline

contributing factors

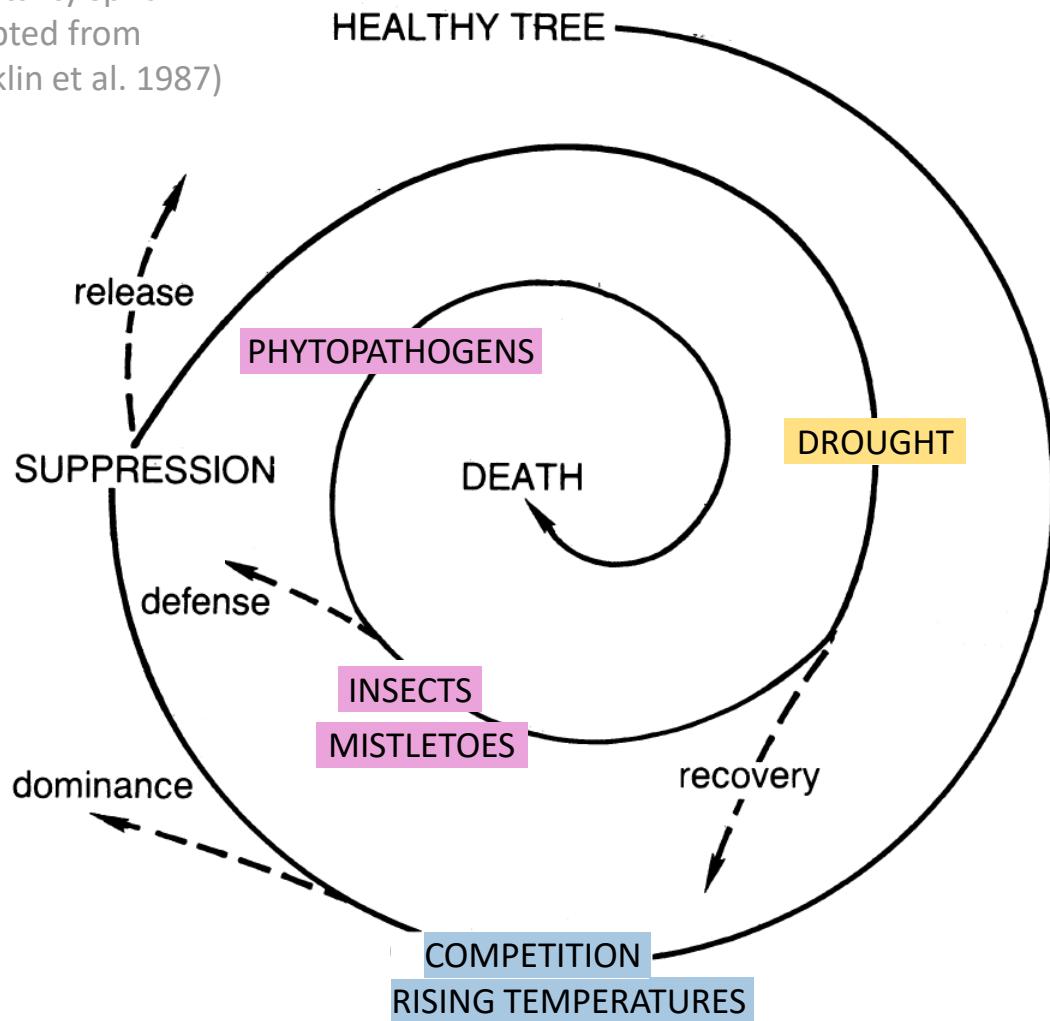
Bark beetles
fungi
Viruses
...

short- or longterm

-> often crucial

Mortality

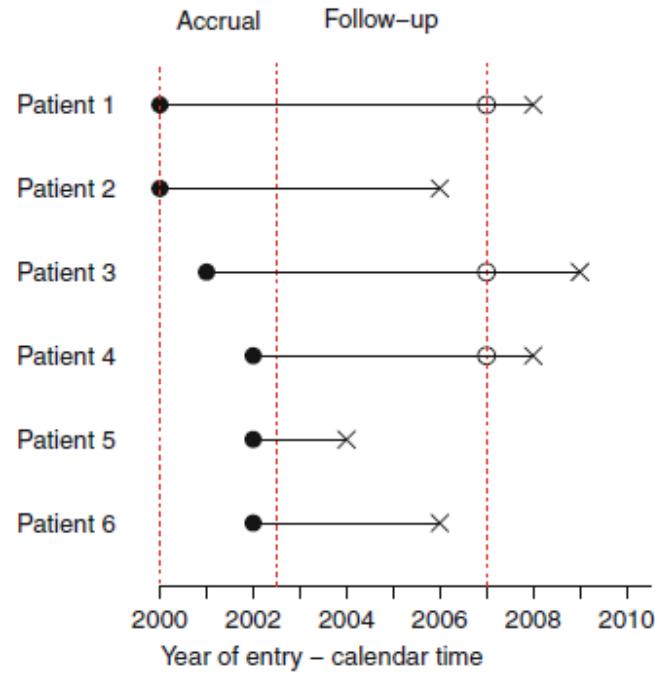
„Mortality spiral“
(adapted from
Franklin et al. 1987)



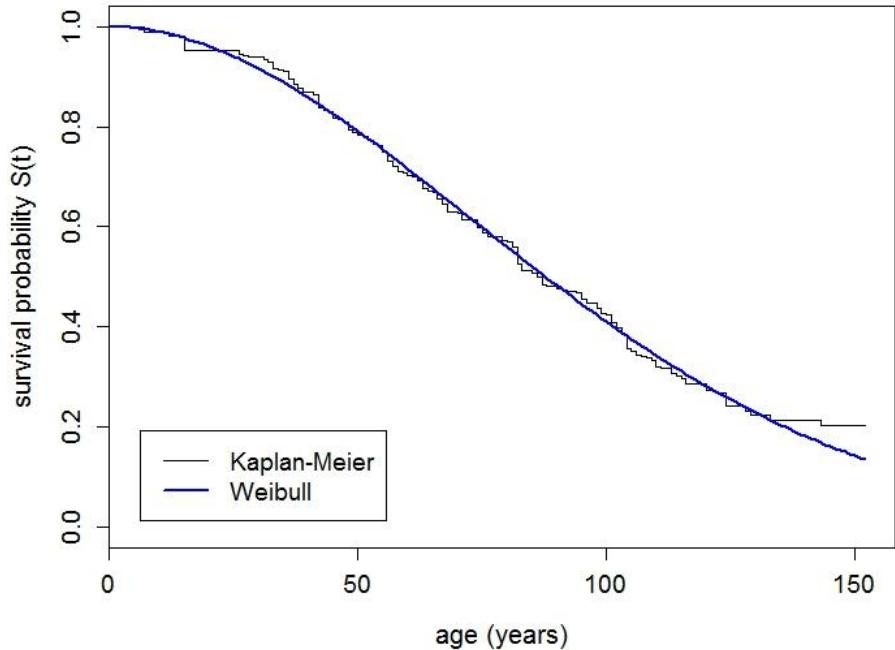
example:
Scots pine in the Valais
(Bigler et al. 2006)

Mortality – Method

- Mortality risk = function(age, climate, other site factors, species mixture)
- Survival analysis
- Time until an event occurs
 - time = age
 - event = death



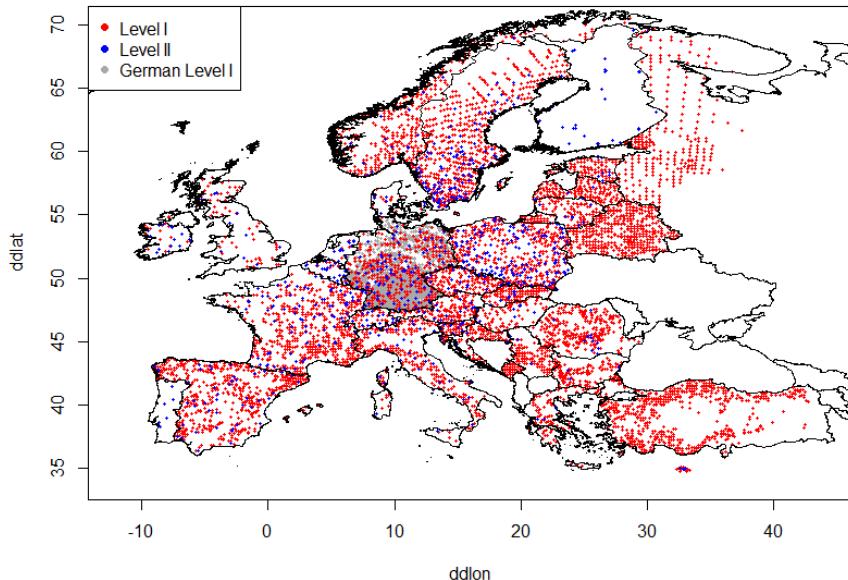
Mortality – Method



$$S(t) = \prod_{t_i \leq t} \frac{n_i - d_i}{n_i}$$

$S(t)$: probability that tree reaches age t
 t_i : age
 n_i : observed trees
 d_i : dead trees

Mortality – Data



Level I

- yearly crown condition survey
- 16 x 16 km

Germany

- Regionally condensed grid
(4 x 4 km, 8 x 8 km)

Level II

Essential:

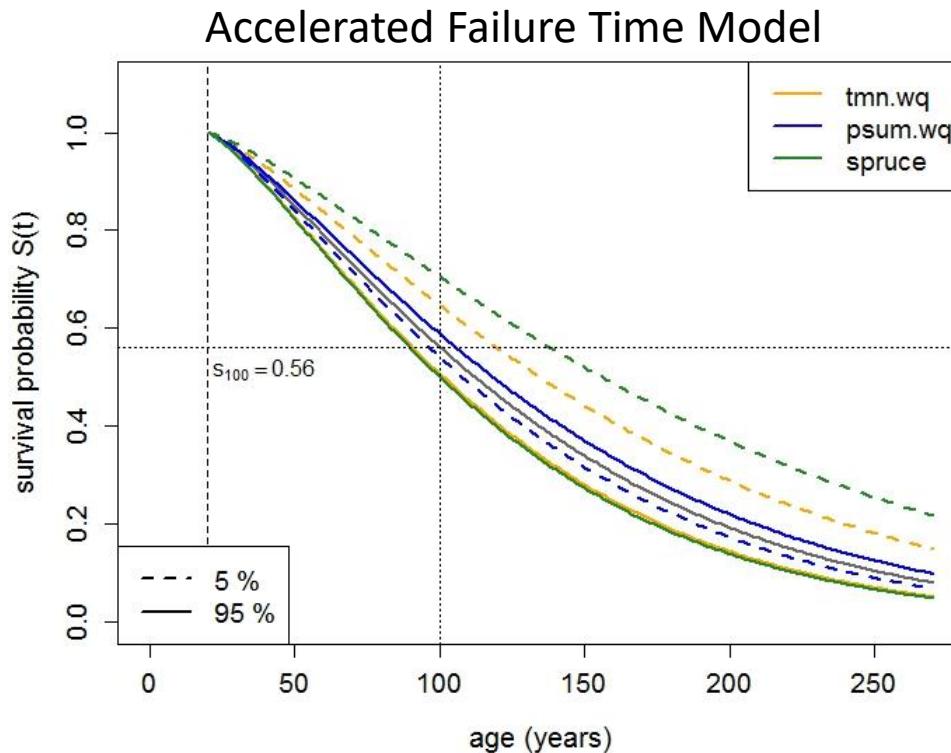
- Repeated measurements
- Distinction between mortality and planned utilization
- Social class
- Age

Mortality – Method

- variable selection
- differentiation:
 - Predisposing factors: average climate conditions, age, mixture, soil
 - Inciting factors: climatic variability, climatic extremes, disturbances
- covariates
 - summer temperature: tmn.wq, tmax.wm
 - winter temperature: tmin.cm, tmn.cq
 - precipitation: psum.yr, psum.wq
 - species mixture: *species*
- correlation between predisposing and inciting factors

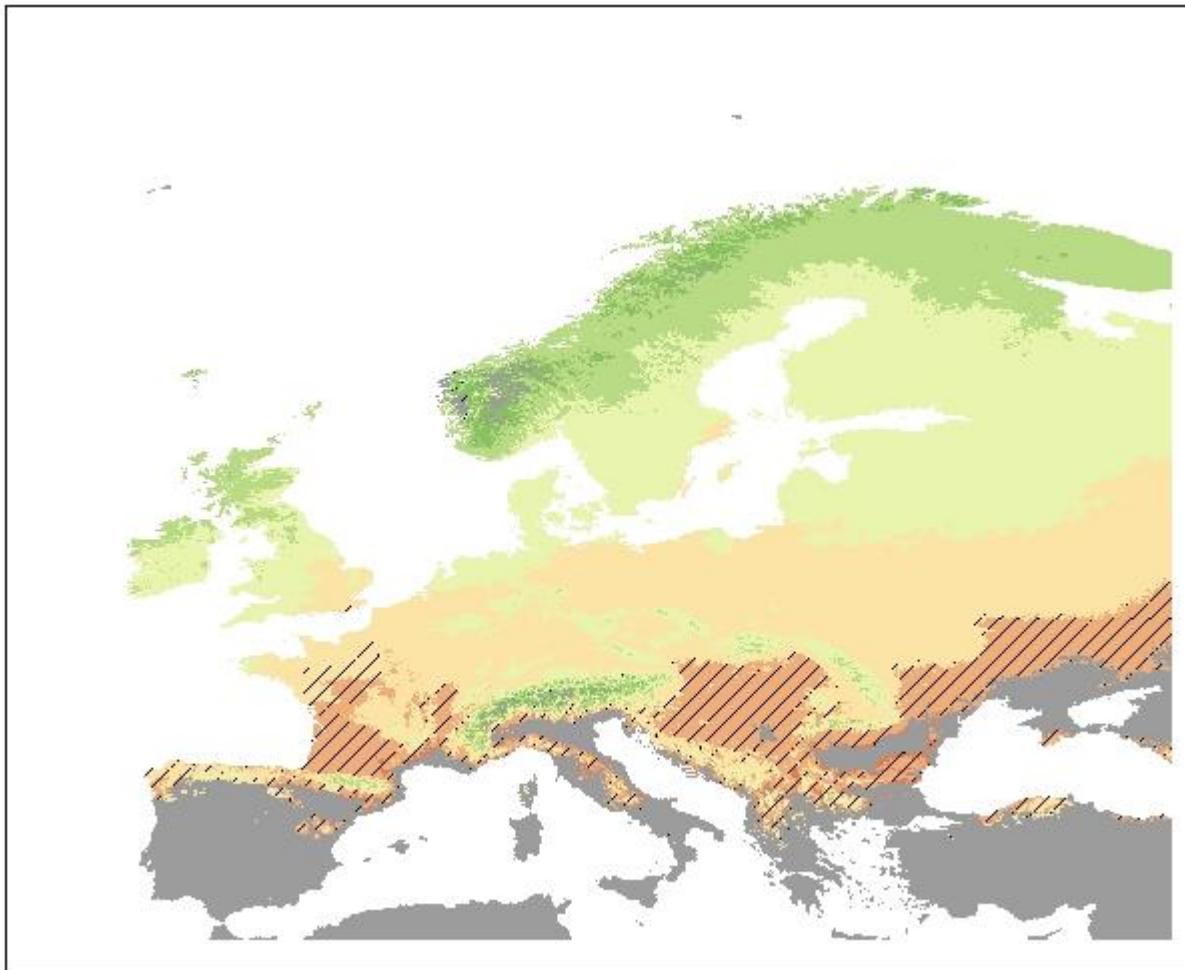
Mortality – Results for spruce

$S(t) \sim \text{proportion of spruce} + \text{temperature warmest quarter} + \text{precipitation warmest quarter}$



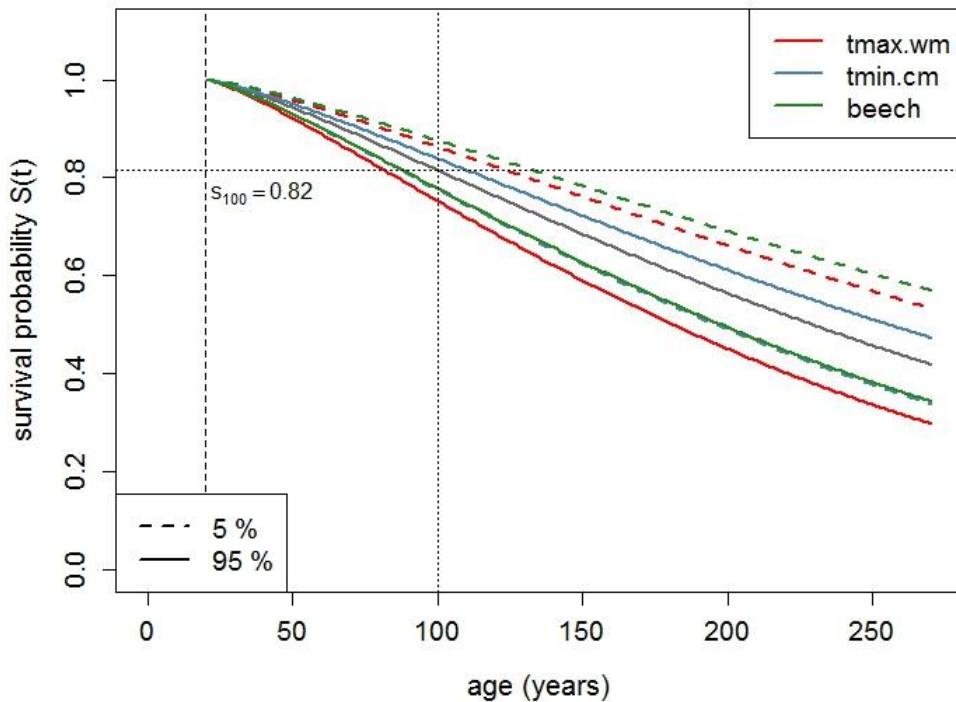
-> measure for risk: $1 - S_{100}$

Productivity and Mortality



Mortality – Results for beech

$S(t) \sim \text{proportion of beech} + \text{min. temperature coldest month} + \text{max. temperature warmest month}$

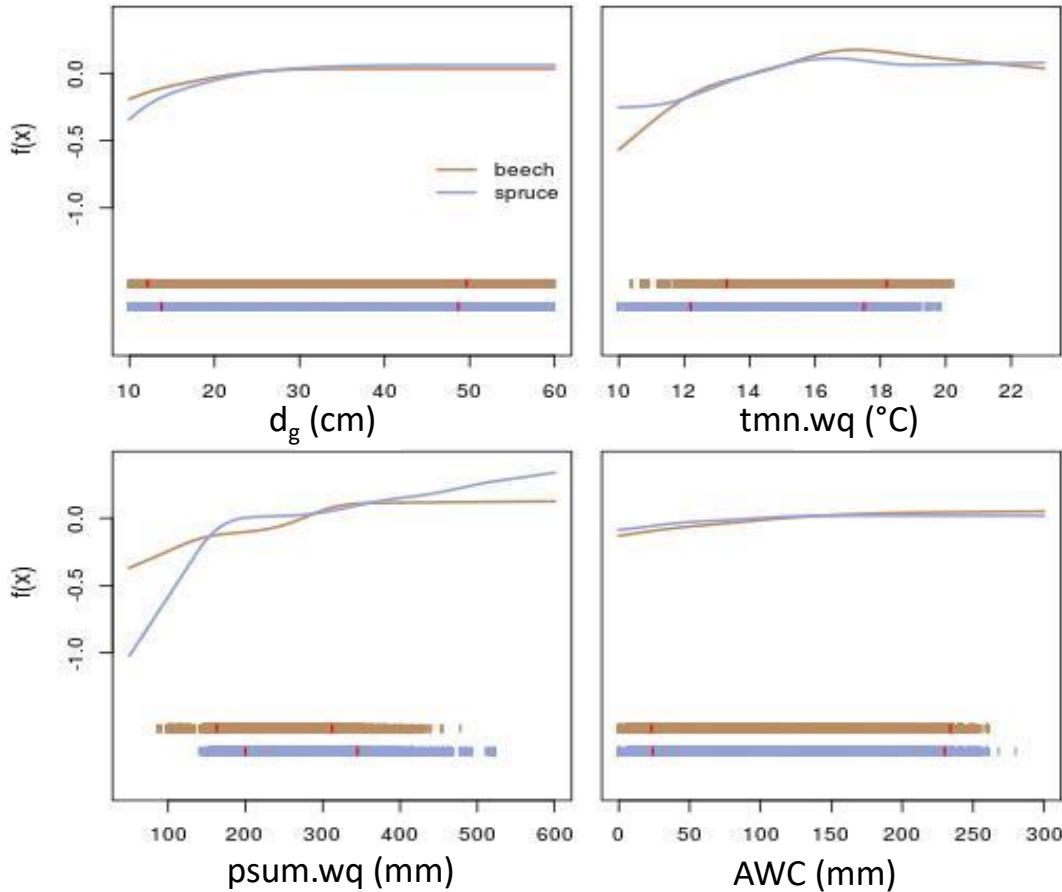


Productivity – Data and Method

- Height-Diameter model
- Height $\sim f(dbh, d_g, tmn.wq, psum.wq, AWC)$
- Based on three sets of inventory data
 - German NFI
 - French NFI
 - BioSoil
- Climate from WorldClim dataset

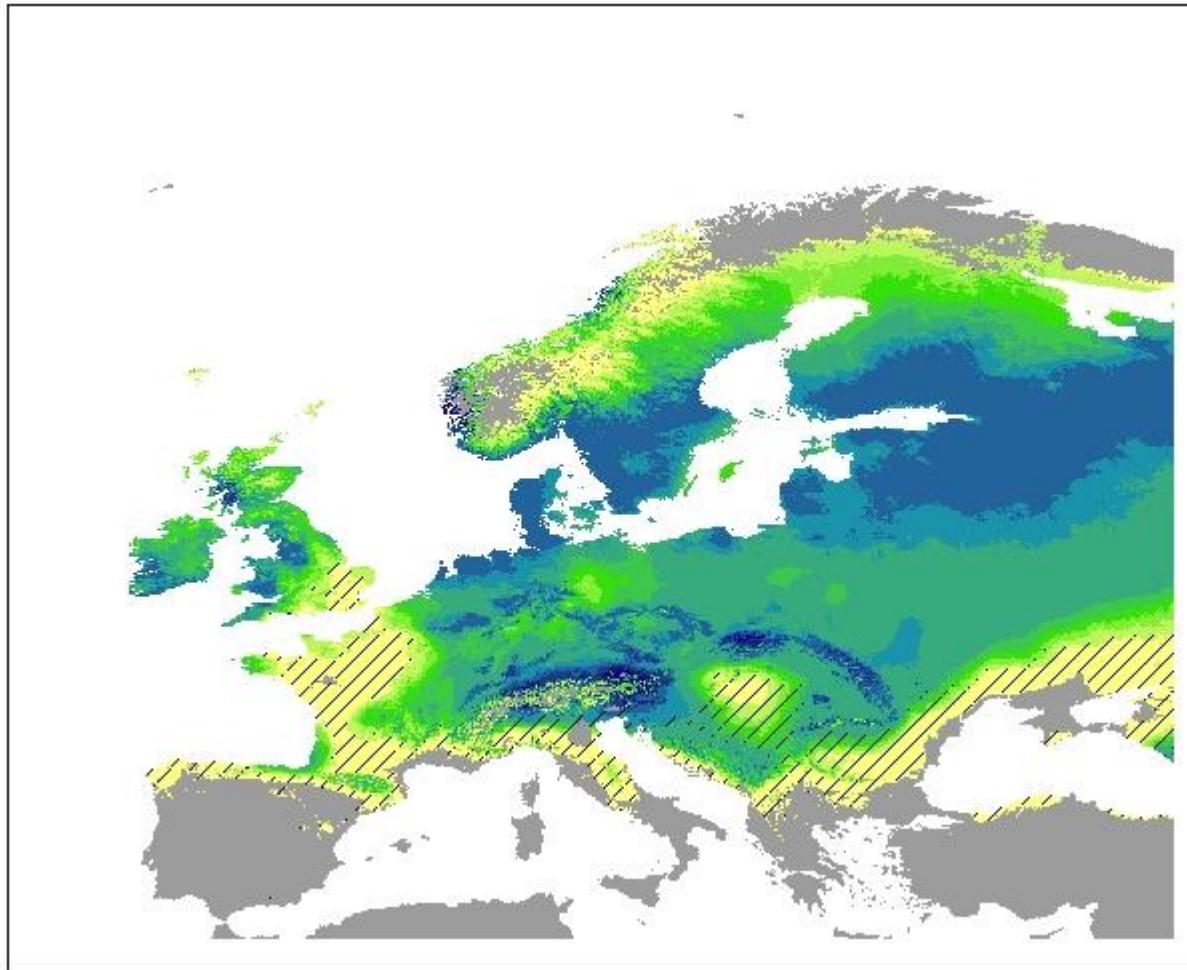
Productivity – Results

Height $\sim f(\text{dbh}, d_g, \text{tmn.wq}, \text{psum.wq}, \text{AWC})$

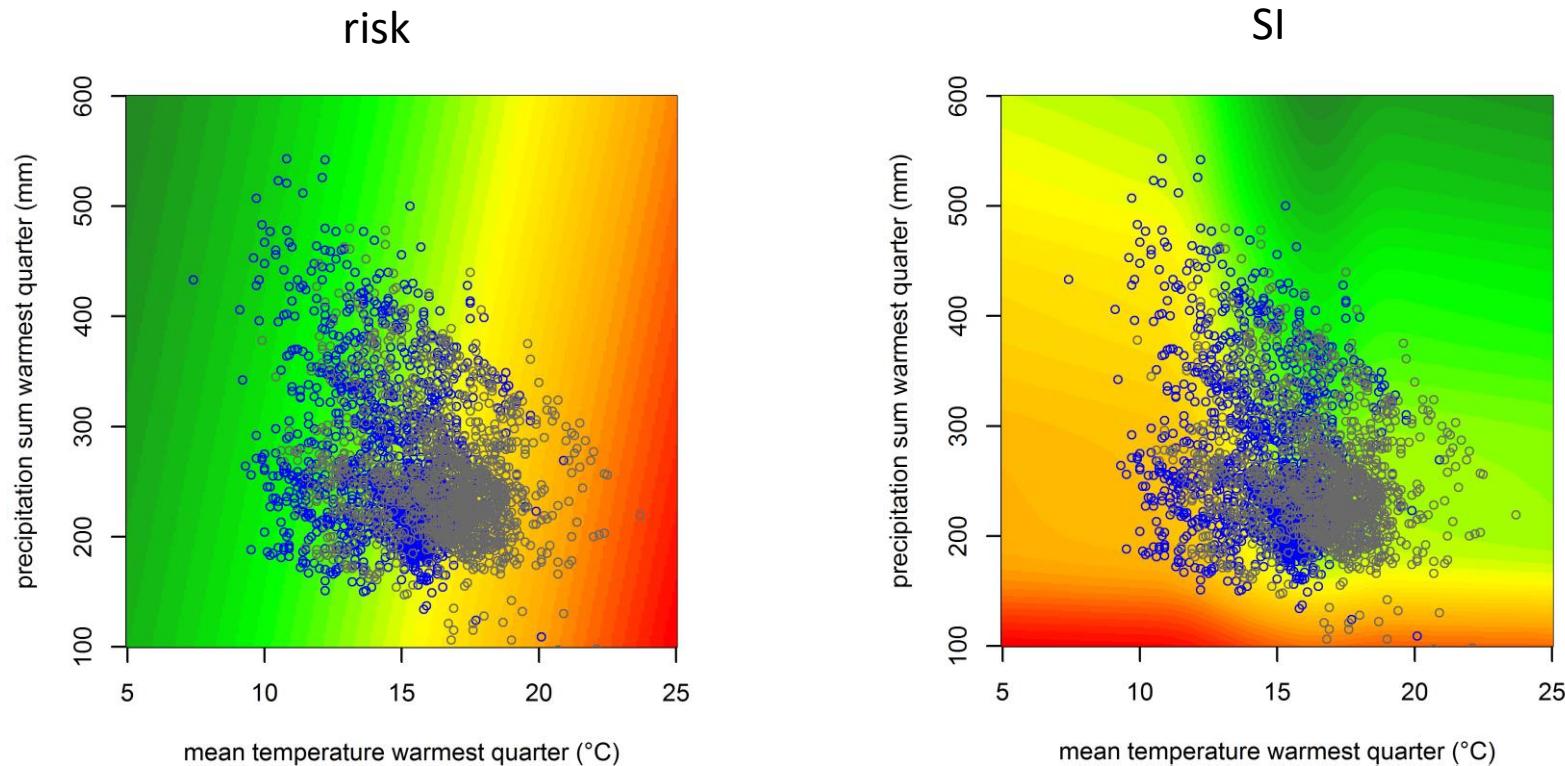


-> measure for productivity:
SI (site index)

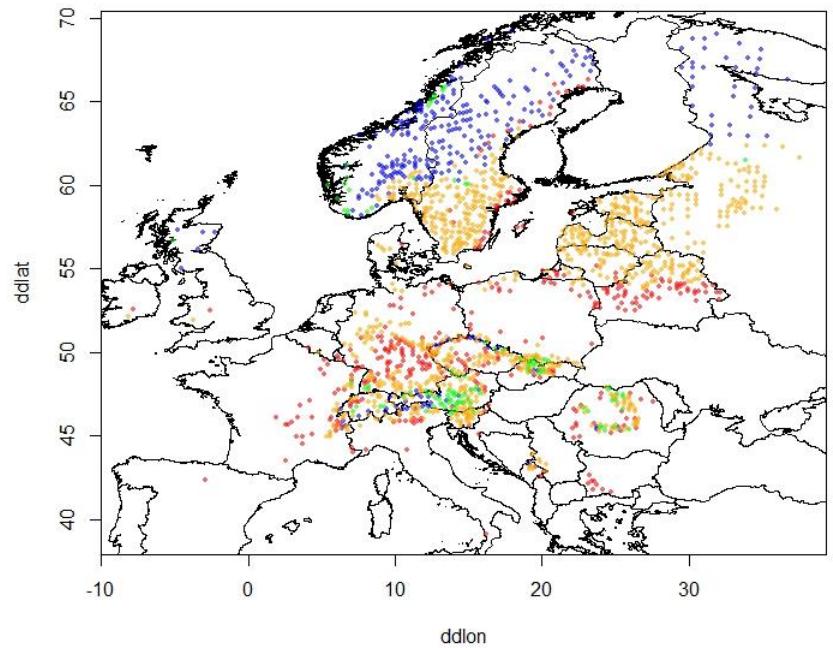
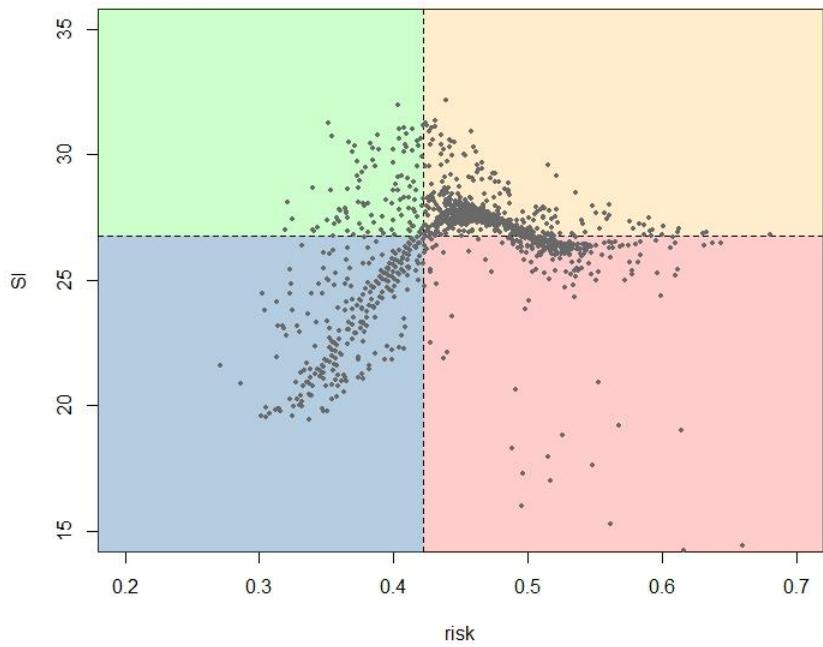
Productivity and Mortality



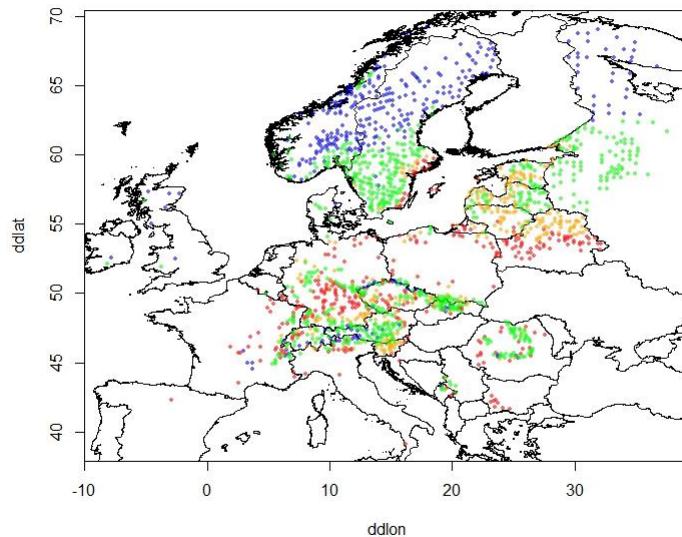
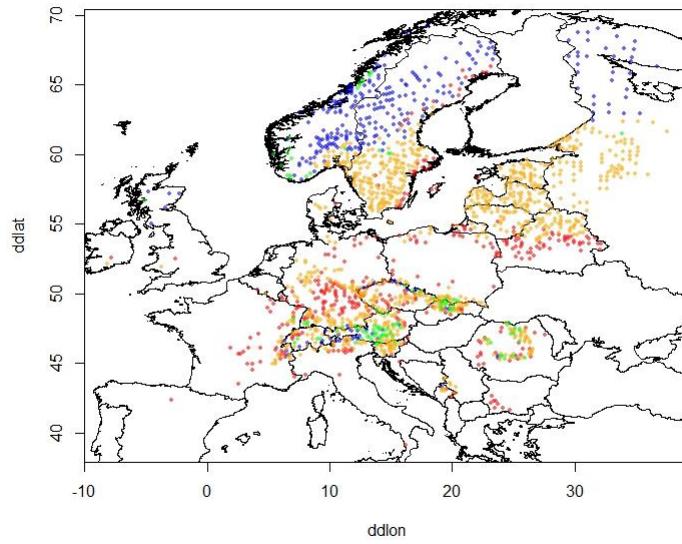
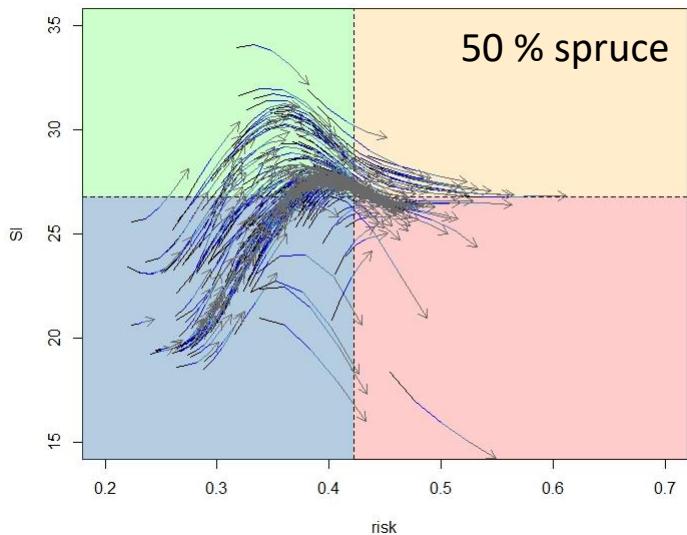
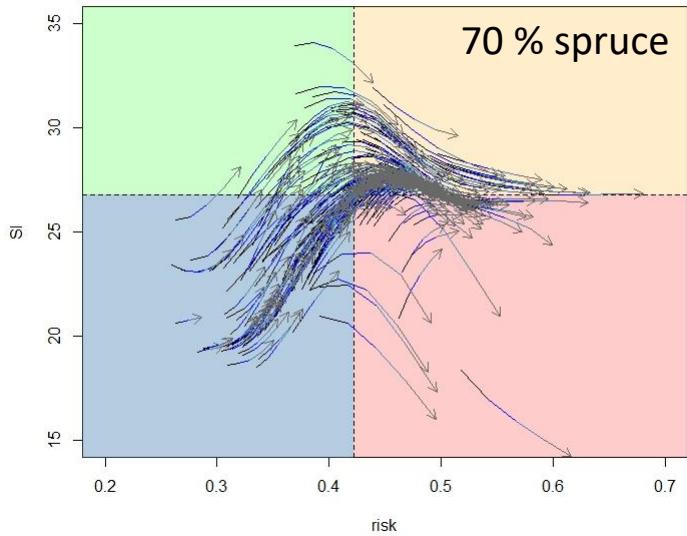
Productivity and Mortality



Productivity and Mortality



Productivity and Mortality





Conclusion and outlook

- mortality risk increases linearly with rising summer temperatures
- forest adaptation: species mixture and rotation period
- survival curves are used in economic assessments
- summer temperature only enhances growth until threshold value is reached, precipitation has a positive effect on growth
- development of sites under changing climate can be visualized by trajectories in a productivity-mortality-graph
- Improve the underlying models
 - Survival analysis: complement/substitute predisposing factors by inciting factors
- Data: age, cause of removal, time series

Literature

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