

A robust approach to tree species selection for multifunctional forests

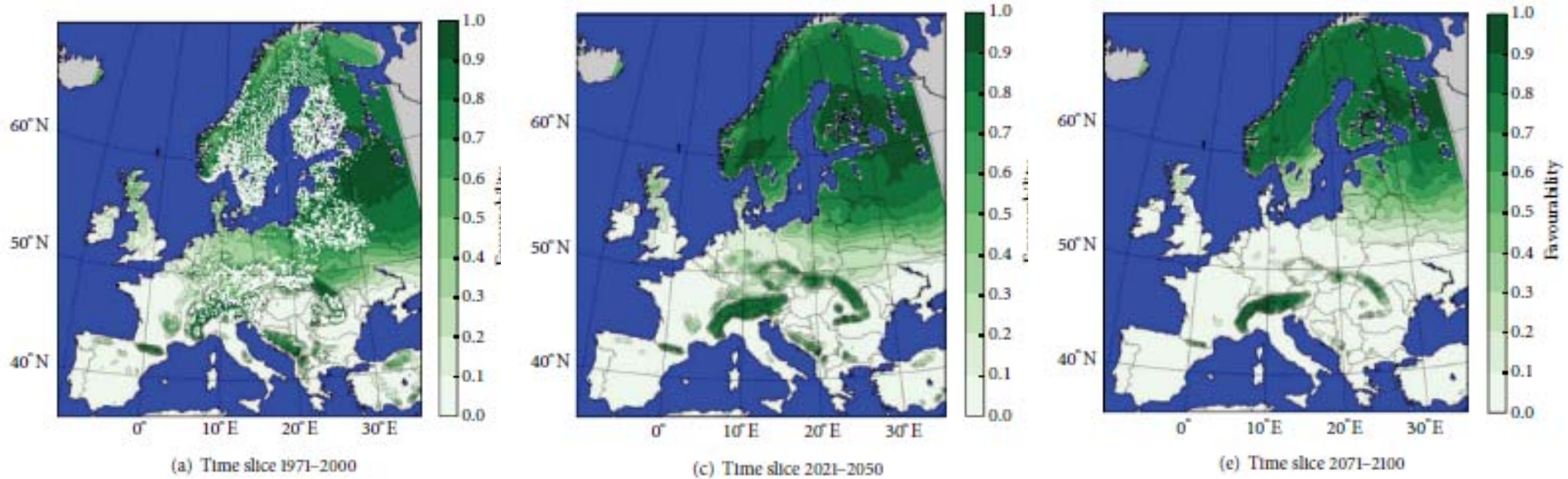
Stefan Friedrich

Seminar Waldbau, Ökosystemdynamik und Forstplanung

WS 2019/ 2020

Introduction

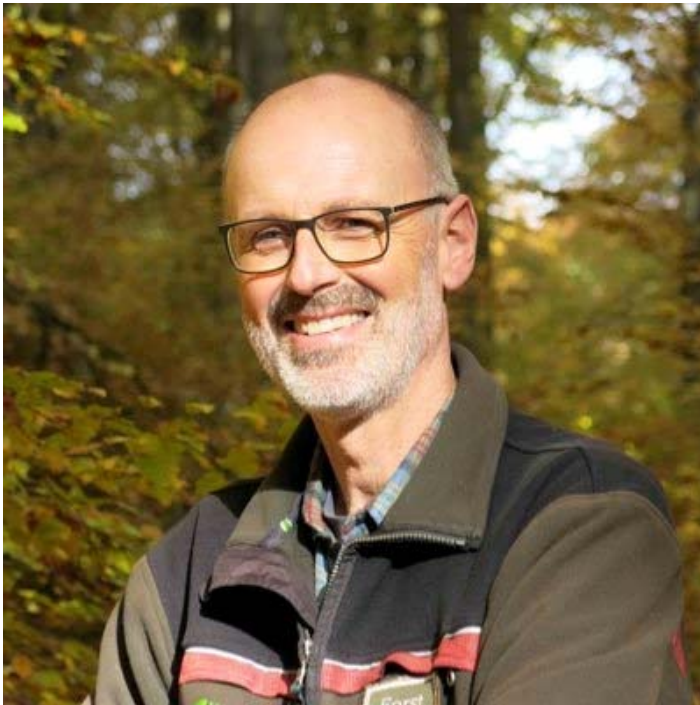
- Climate change → tree species selection



Falk, W.; Hempelmann, N. (2013): Species Favourability Shift in Europe due to Climate Change. A Case Study for *Fagus sylvatica* L. and *Picea abies* (L.) Karst. Based on an Ensemble of Climate Models 2013 (6), S. 1–18. DOI: 10.1155/2013/787250.

Introduction

- Change → Decision makers' objectives



<https://twitter.com/peterwohlleben>



<https://www.bund-naturschutz.de/aktionen/volksbegehren-artenvielfalt.html>



<https://www.lbv.de/mitmachen/fuer-einsteiger/volksbegehren-artenvielfalt/>

Introduction

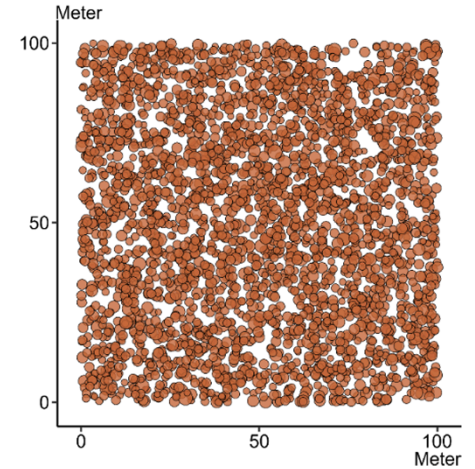
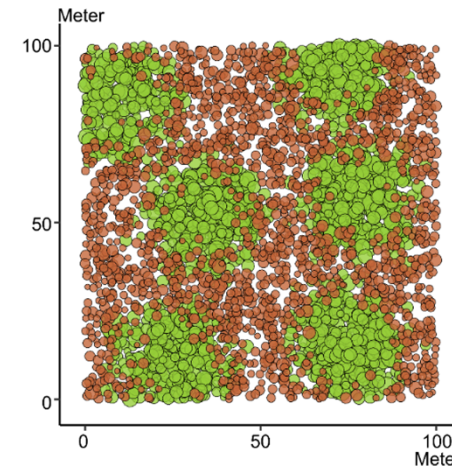
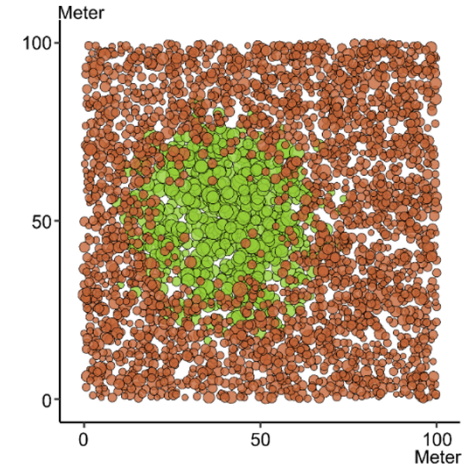
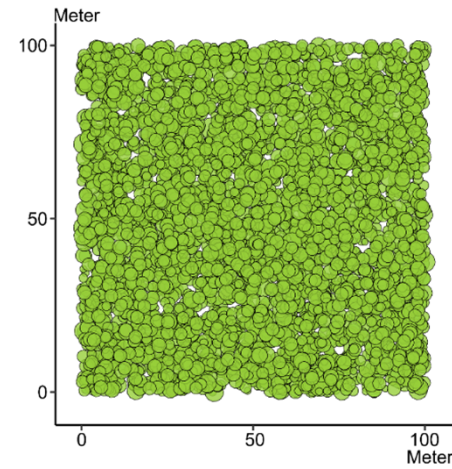
- Project: „Risk and return of pure and mixed stands of Norway spruce and European beech under climate change“ (Kuratorium für forstl. Forschung)
- Research questions:
 - How will climate change influence forest portfolios?
 - How will different objectives of decision makers influence forest portfolios?

Methods

- Simulation study with
- Compromise programming integrating
- Robust optimization

Simulation I –forest stands

- Growth simulation (SILVA 2.2)
- 5 Climatic regions



Simulation II – Ecosystem services

- Monte Carlo simulation → frequency distributions
- Stochastic effects → risks
- Indicators of ES
 - Financial return (annuity of soil expectation value) (Friedrich et al. 2019)
 - Carbon storage (following Härtl et al. 2017)
 - Stability of ecosystem (survival probability) (Brandl et al. 2020)

Optimization

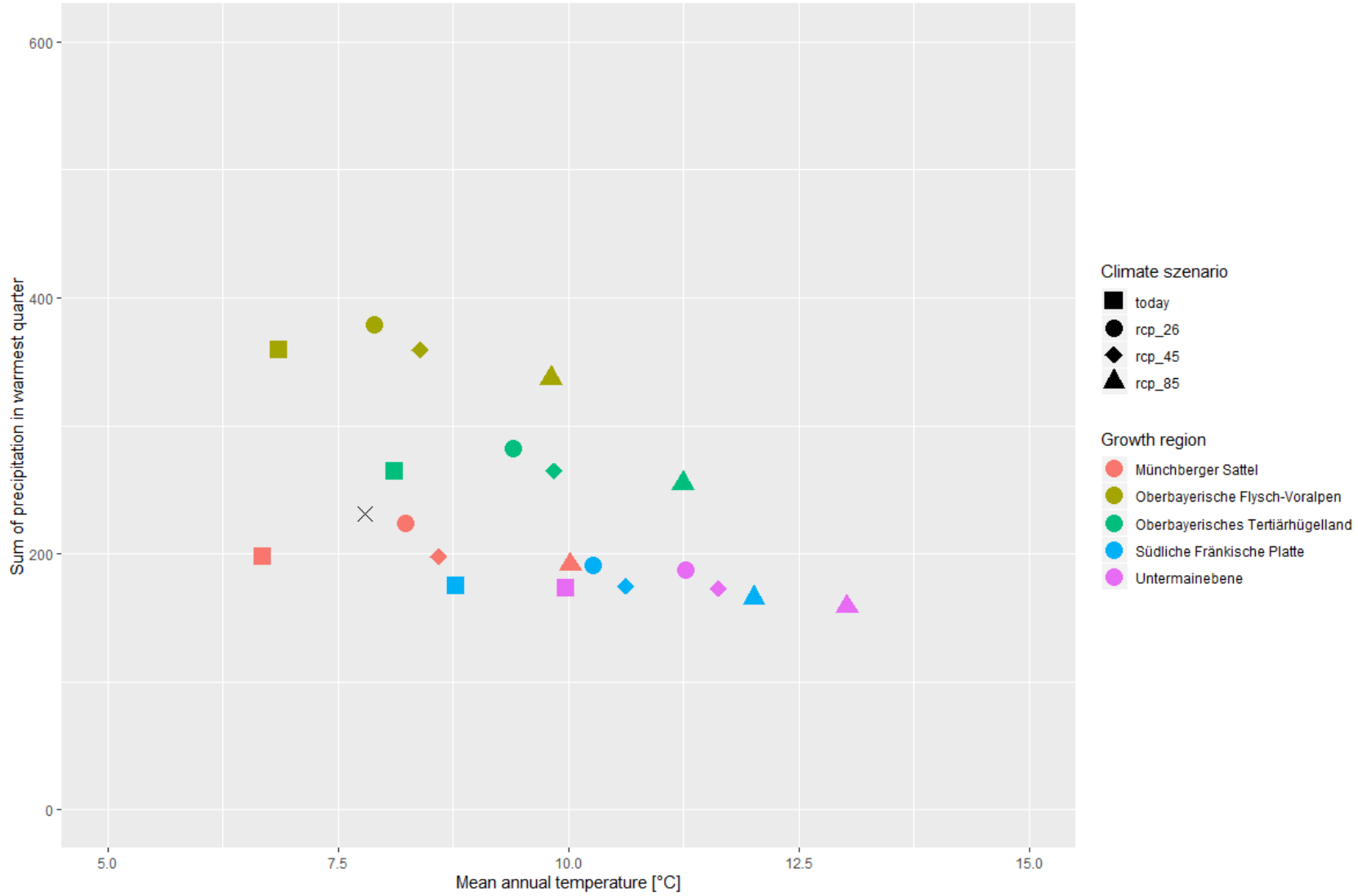
- Allocation of stand types → area of forest enterprise
- Robust Optimization
 - Implication: Input values deviate
 - Solutions for worst case scenarios
- Compromise programming
 - Finding a balanced solution between different objectives
 - Maximizing the minimum performance simultaneously

Ben-Tal A, Nemirovski A (1999) Robust solutions of uncertain linear programs. *Operations Research Letters* 25:1–13

Bertsimas D, Brown DB, Caramanis C (2011) Theory and Applications of Robust Optimization. *SIAM Rev.* 53:464–501

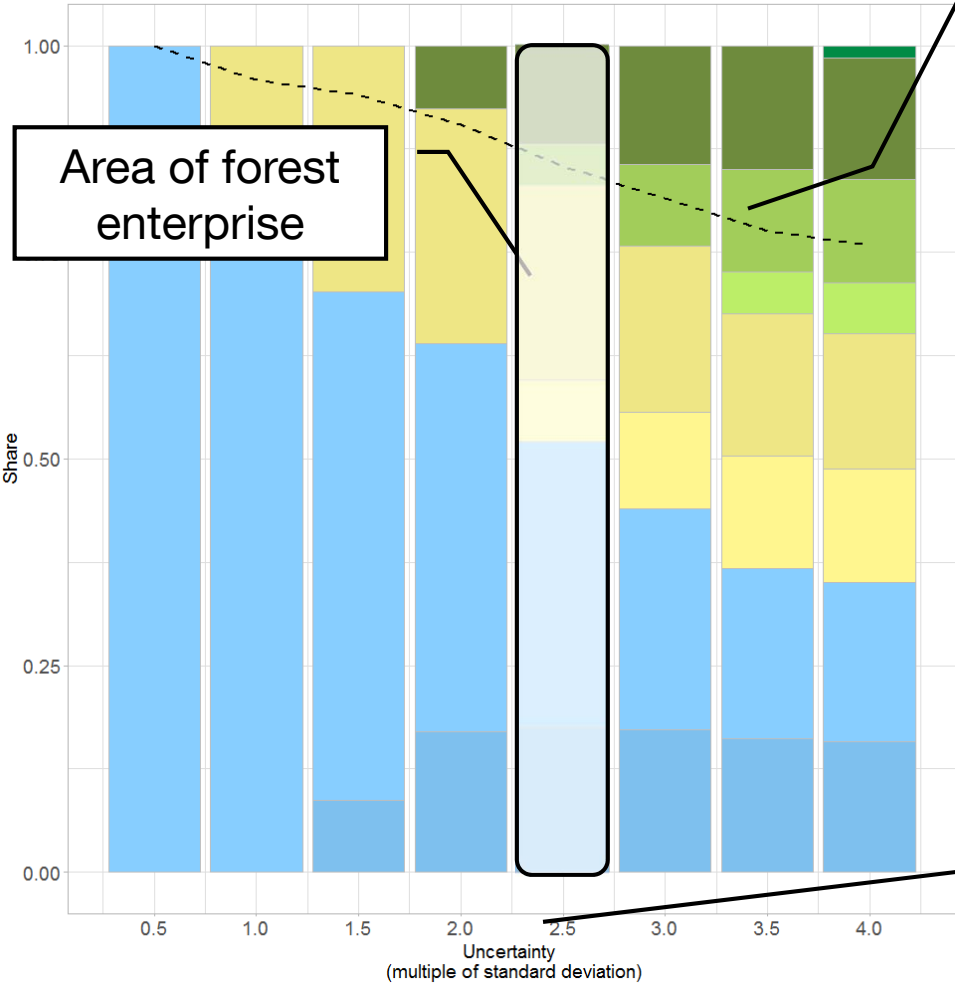
Knoke T., Paul C., Rammig A. *et al.* (2020) Accounting for multiple ecosystem services in a simulation of land-use decisions: Does it reduce tropical deforestation? *Global change biology*

Climatic conditions in the growth regions



Results – portfolios of stand types

moderately warm-moderately high precipitation - Financial objective - Interest rate 2.0



Area of forest enterprise

Share of spruce (%)

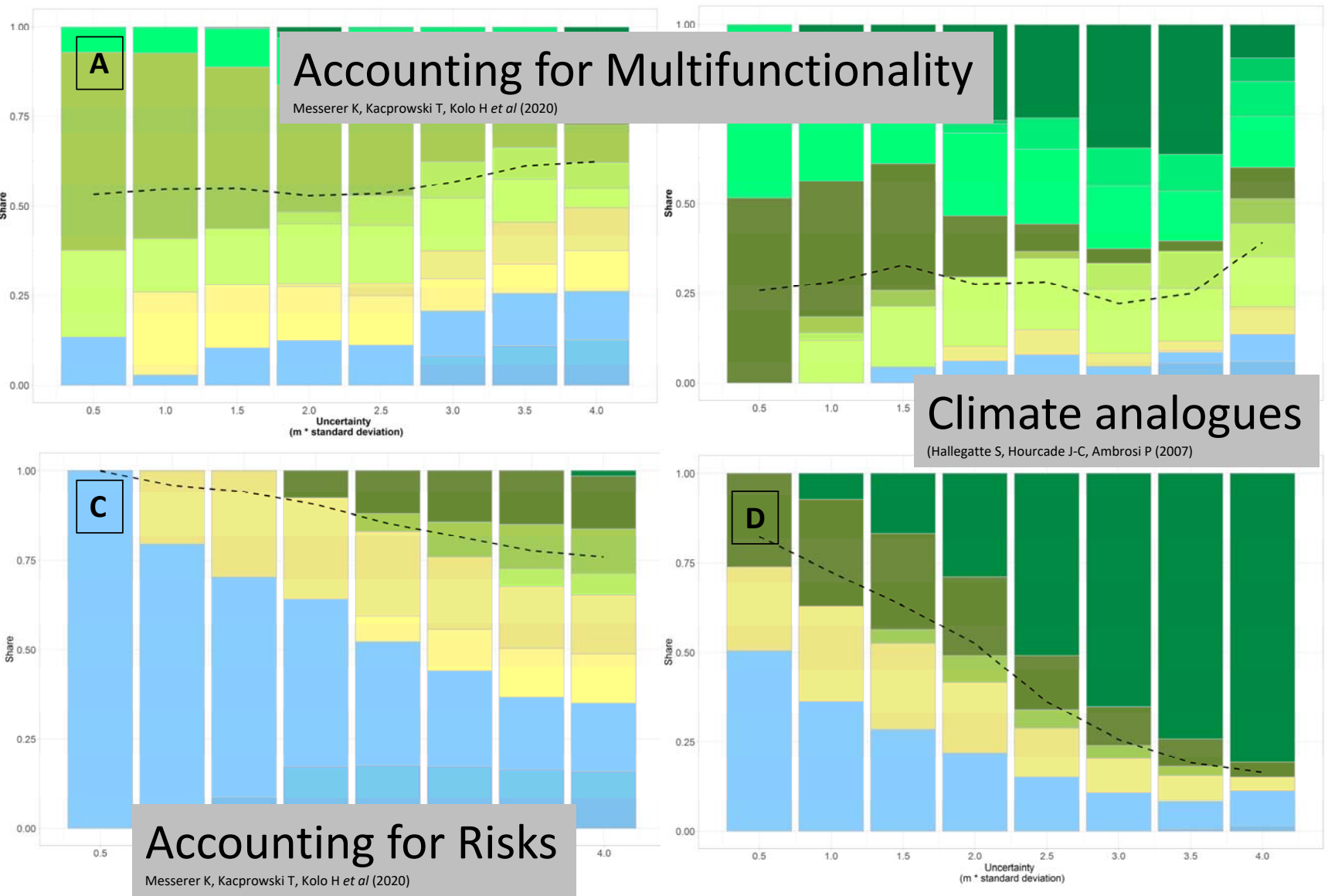
Legend: stand types

- blue = sp 100
- dark green = be 100
- sand = sp 80, be 20
- olive = sp 50, be 50

- Beech_pure_short rota
- Beech_pure_short rota
- Beech_pure_long rotat
- Beech_pure_long rotat
- Beech-Spruce_0.5_sho
- Beech-Spruce_0.5_short rotation_unthinned
- Beech-Spruce_0.5_long rotation_thinned
- Beech-Spruce_0.5_long rotation_unthinned
- Spruce-Beech_0.8_short rotation_thinned
- Spruce-Beech_0.8_long rotation_thinned
- Spruce_pure_short rotation_thinned
- Spruce_pure_long rotation_thinned

Multiple of standard deviation (uncertainty factor)

Financial objective → Multifunctional forestry



Climate change

Results

- Cost of climate change
- Premium for multifunctionality
- Uncertainty factor $m = 3$

| Climatic region | | Financial objective | Multifunctional objective |
|-----------------------|---|---------------------|---------------------------|
| Cool – high precipit. | Annuity [Euro ha ⁻¹ a ⁻¹] | 250 | 186 |
| Warm – low precipit. | Annuity [Euro ha ⁻¹ a ⁻¹] | 63 | 51 |

Conclusions & Discussion

Conclusions

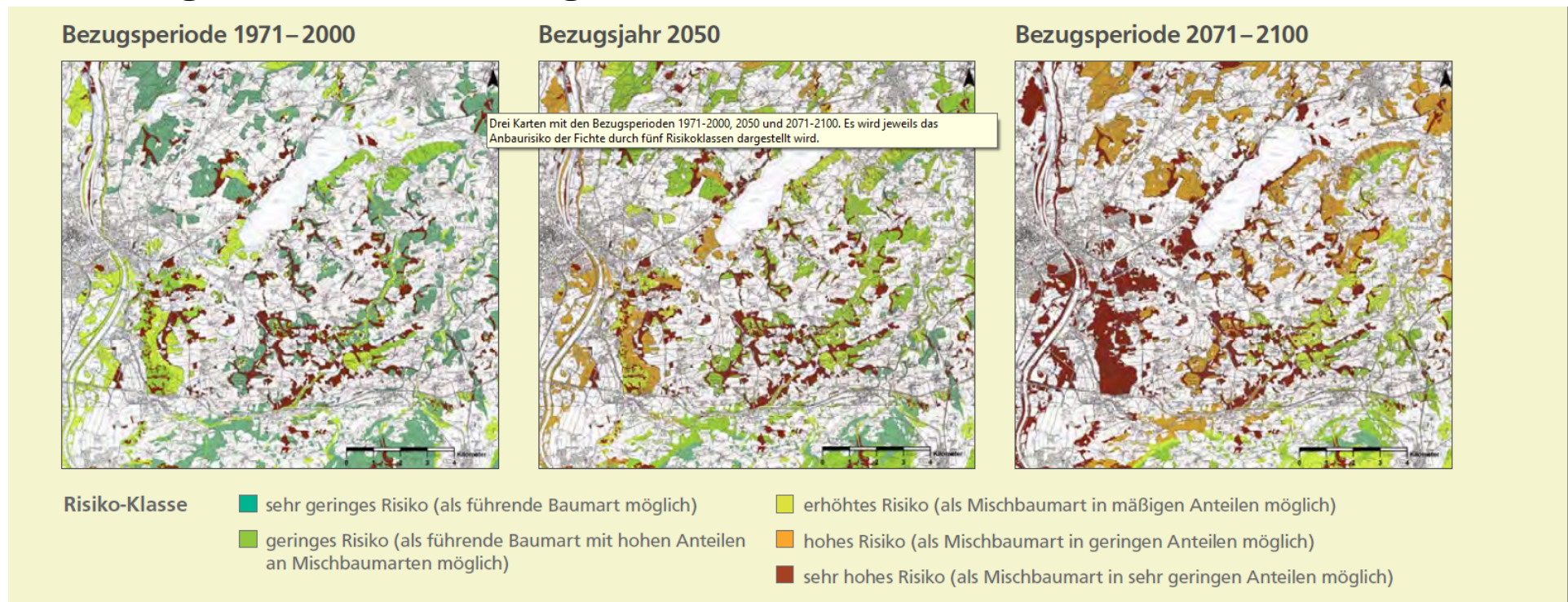
- Mixing forests stand types can reduce risks and provide multiple ES.
- Objectives → different strategies to mitigate risks
- Premiums for risk management and multifunctionality

Discussion

- Limitation to spruce and beech
- Static approach → forest enterprise composition

Outlook

- Linking models of ecological niches with economic models



Thank you.
Questions, please.