



Climate change, large-scale disturbances and adaptive forest management in Central Europe

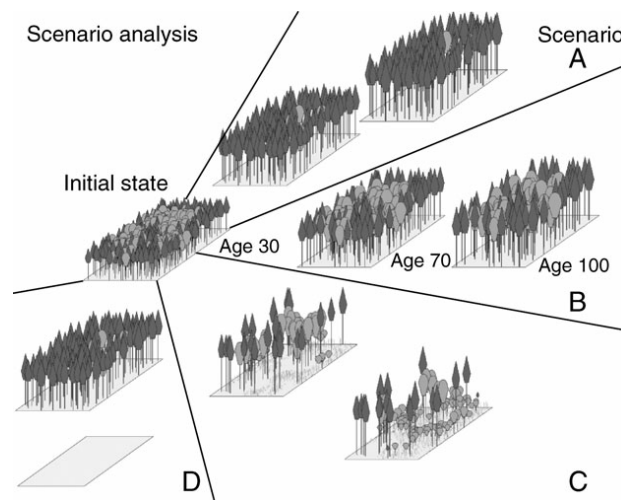
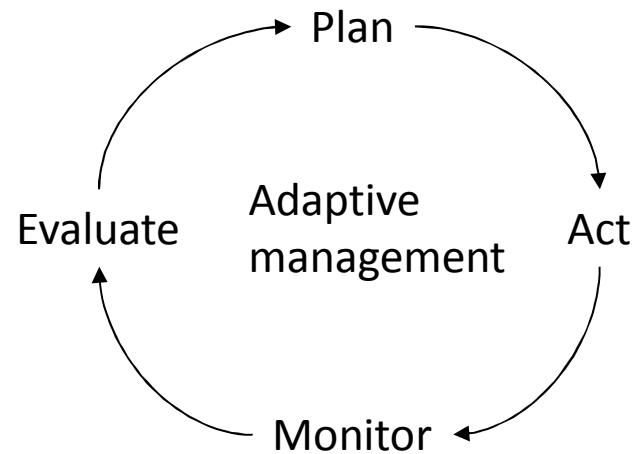
Christian Temperli

Forest Ecology, ETH Zürich



Introduction

Context

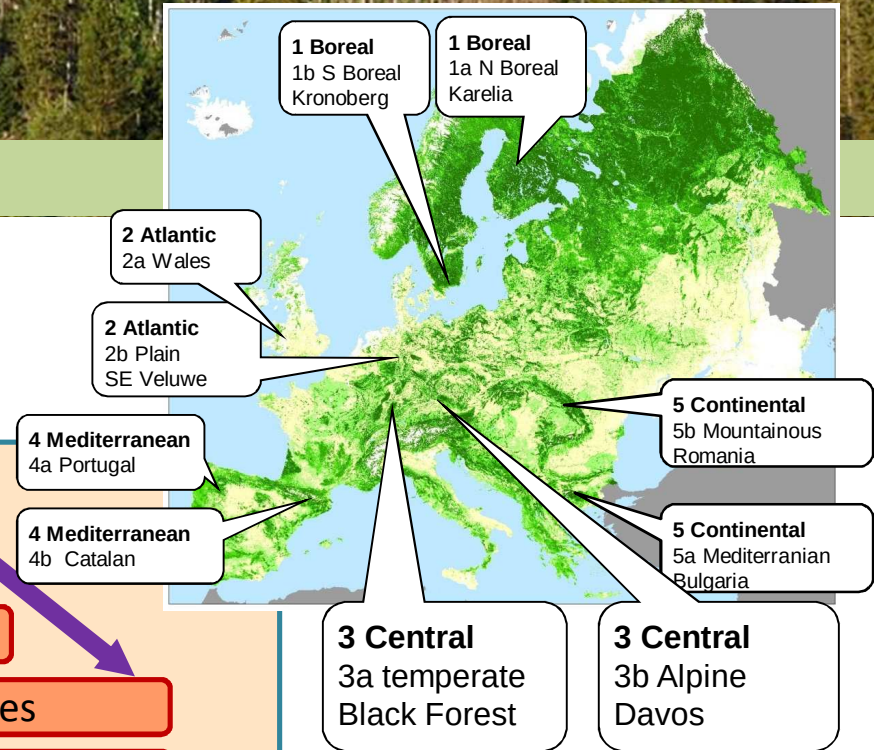
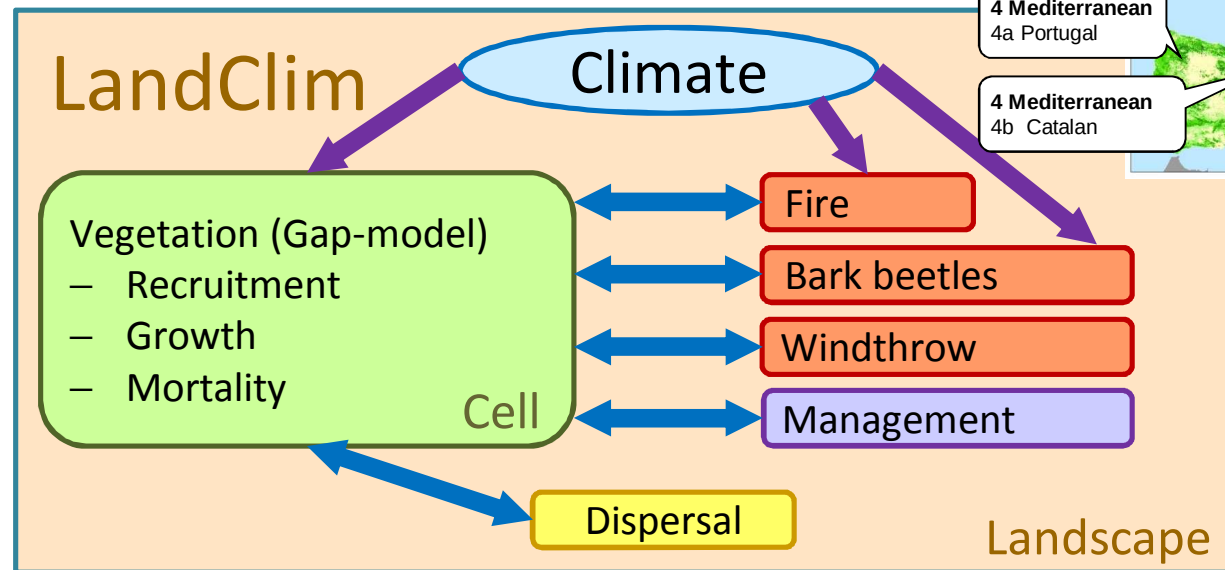


- Climate change vs. slow response of forests
- Forward-looking approach is needed
- Scientific basis:
 - *Systems knowledge*
 - *Target knowledge*
 - *Transformation knowledge*
- Scenario analysis with simulation models

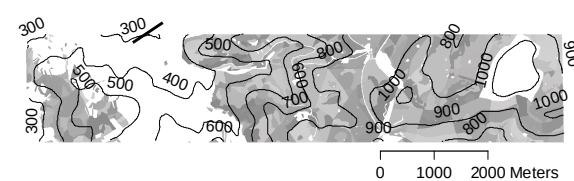
Walters 1986, Mc Graw Hill
Pretzsch et al. 2008, Annals of Botany

Introduction

LandClim model and case studies



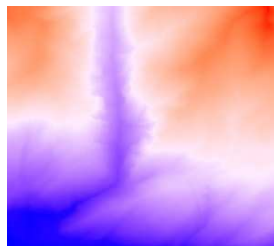
Black Forest



Davos



Schumacher et al. 2004, Ecol Model



Spatially explicit input

- Elevation
- Aspect
- Slope
- Soil AWC
- Monthly climate
- Browsing mask
- Management masks
- Initial forest state

Introduction

Challenges and aims

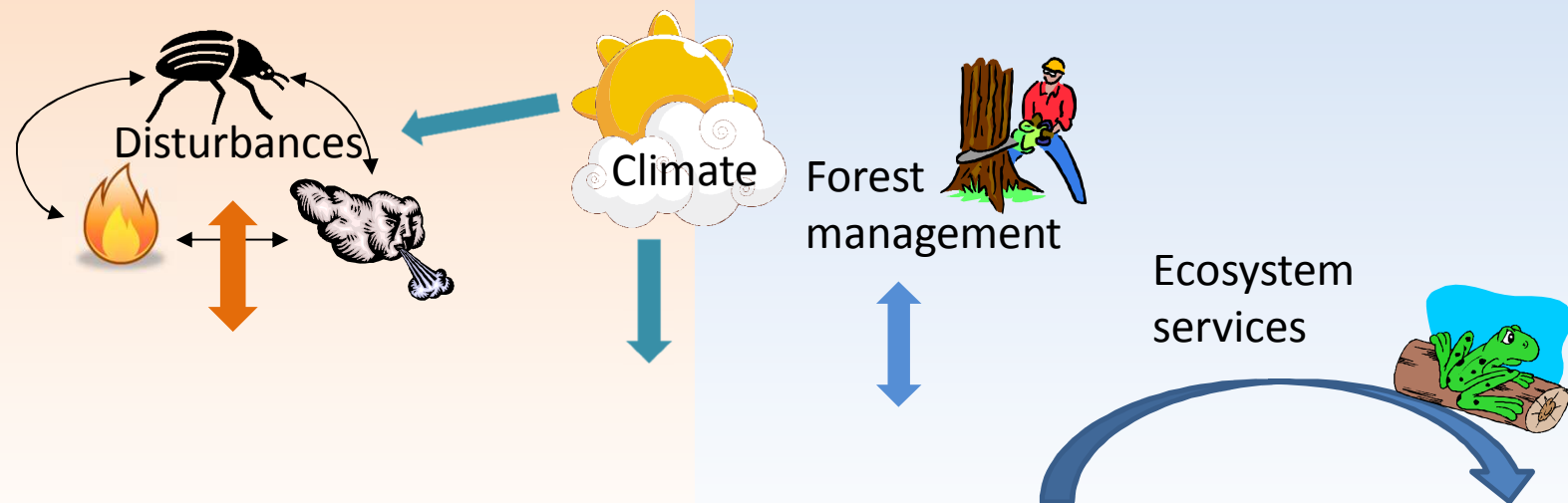


Climate change-disturbance interactions

- Shifts in direct and indirect interactions?
- long-term, landscape-scale interactions?

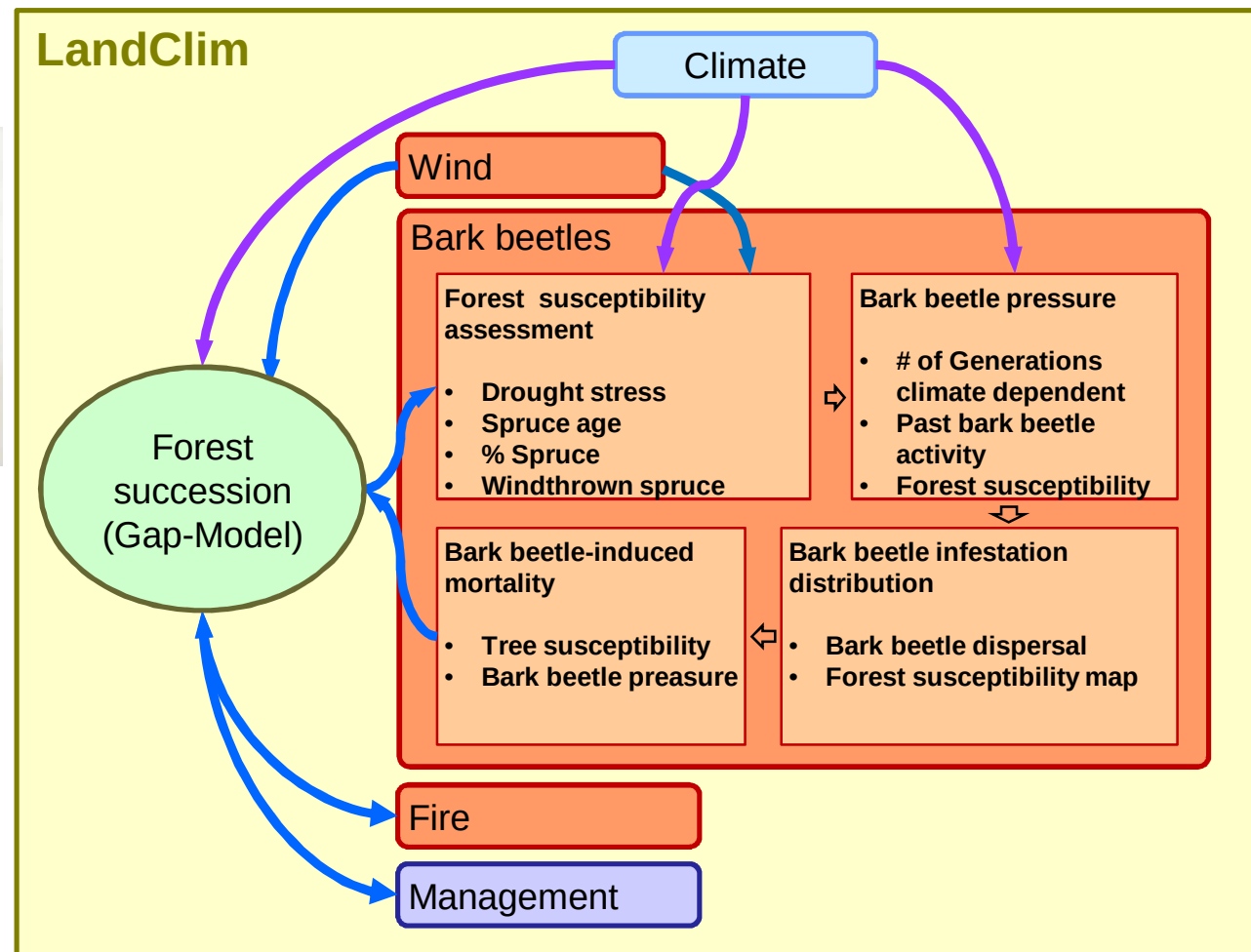
Management impacts on Ecosystem services (ES)

- Management-climate interactions?
- Trade-offs and synergies between ES?



Climate change-bark beetle interactions

Methods

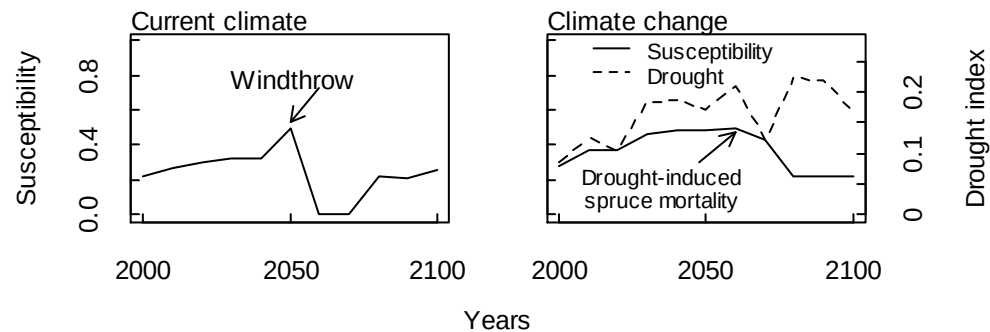


Baier et al. 2007, For Ecol Manage
Netherer and Nopp-Mayr 2005, For Ecol Manage

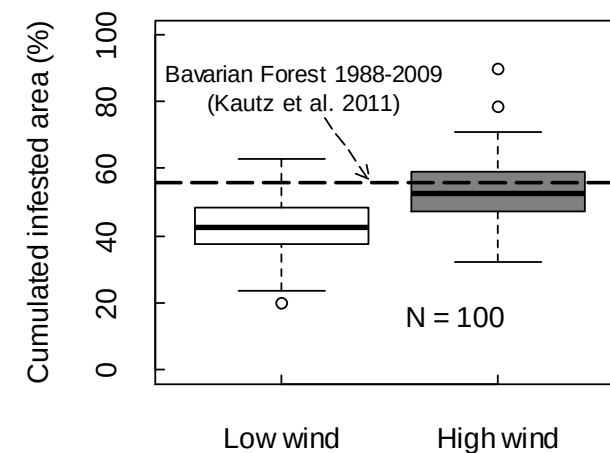
Climate change-bark beetle interactions

Model verification/validation

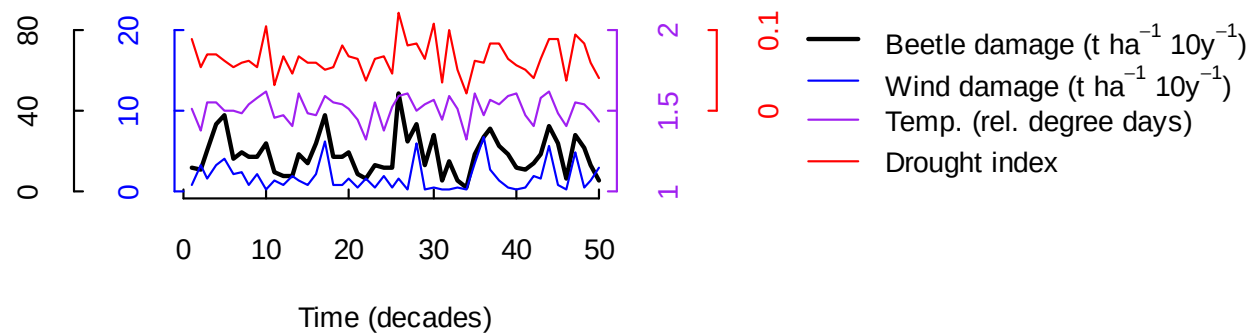
Patch scale:



Validation:

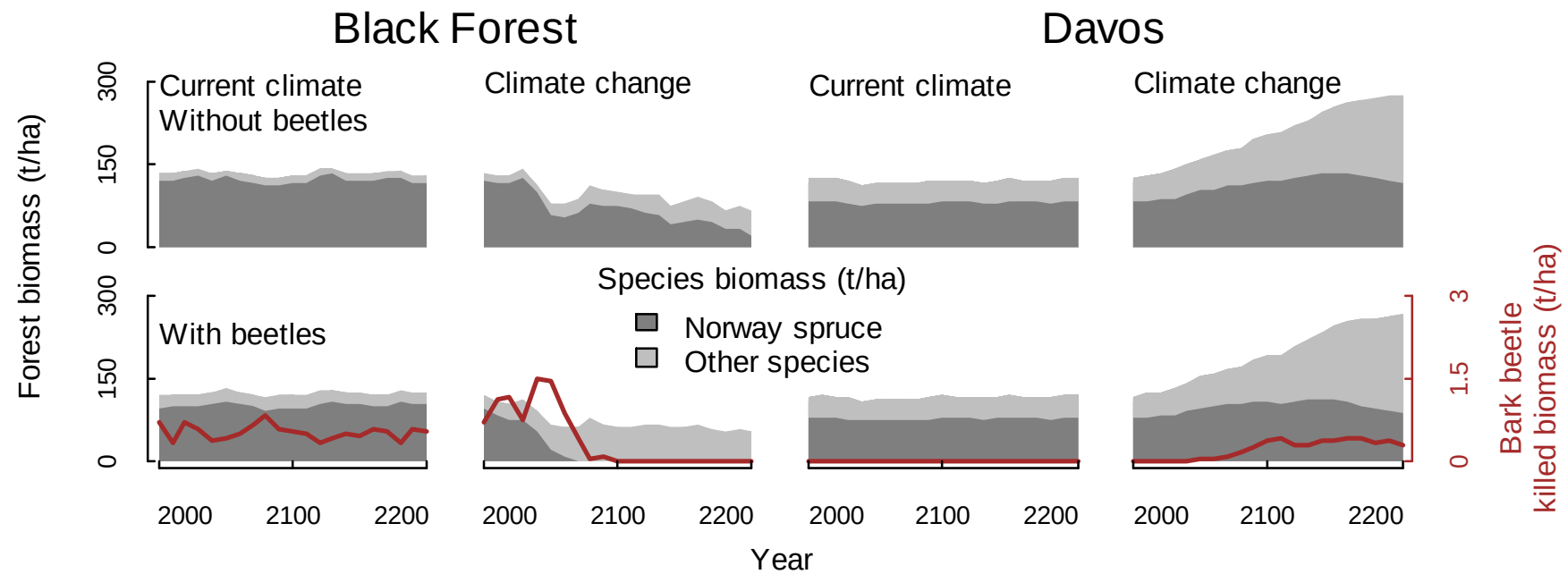


Landscape scale:



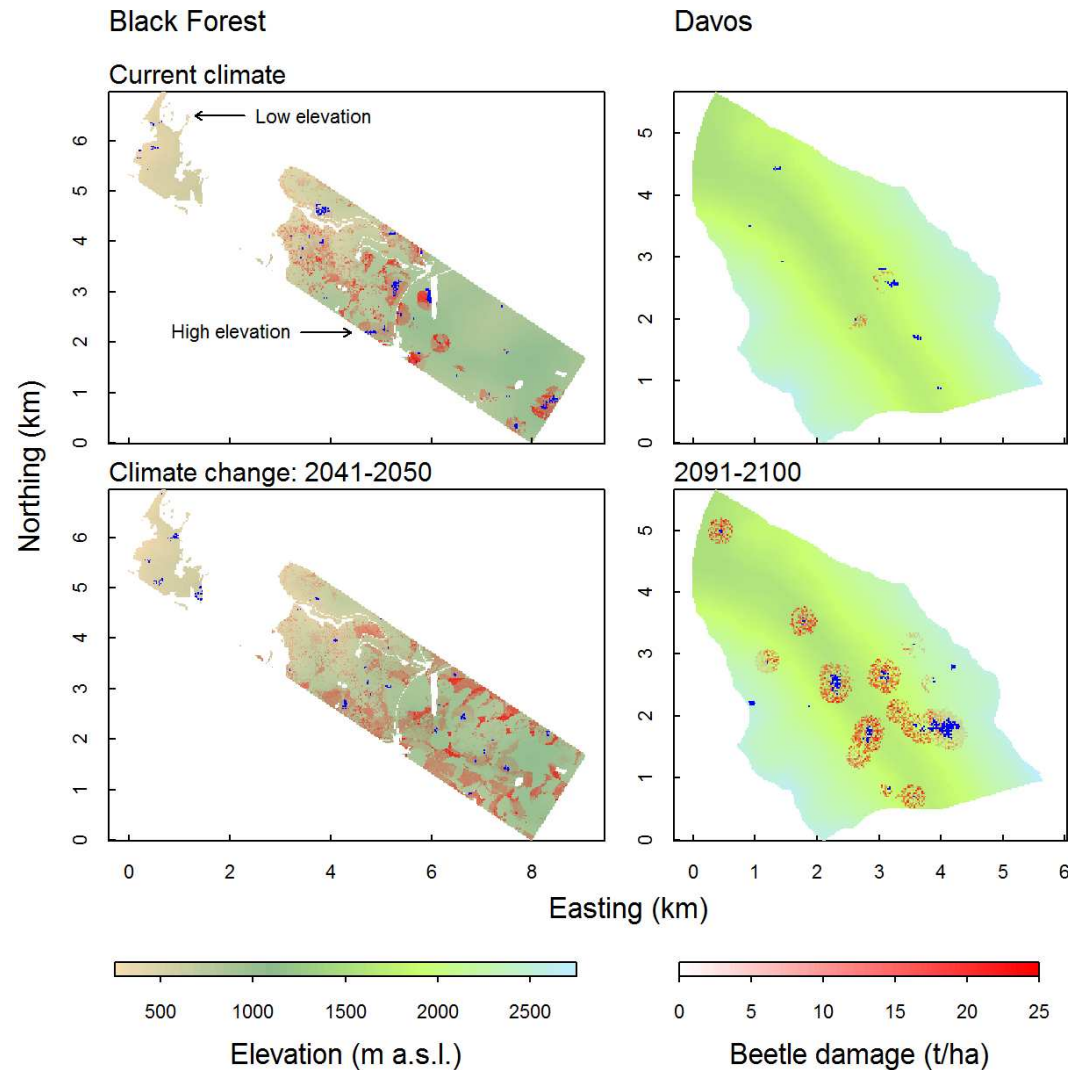
Climate change-bark beetle interactions

Model application



Climate change-bark beetle interactions

Model application



Climate change-bark beetle interactions



Conclusions

- In the long term climate change may shift the importance of individual driving factors.
- Interactions between bark beetles, drought, and windthrow may shift in sign (+ or -) depending on forest state and the intensity of drought.

In press as:

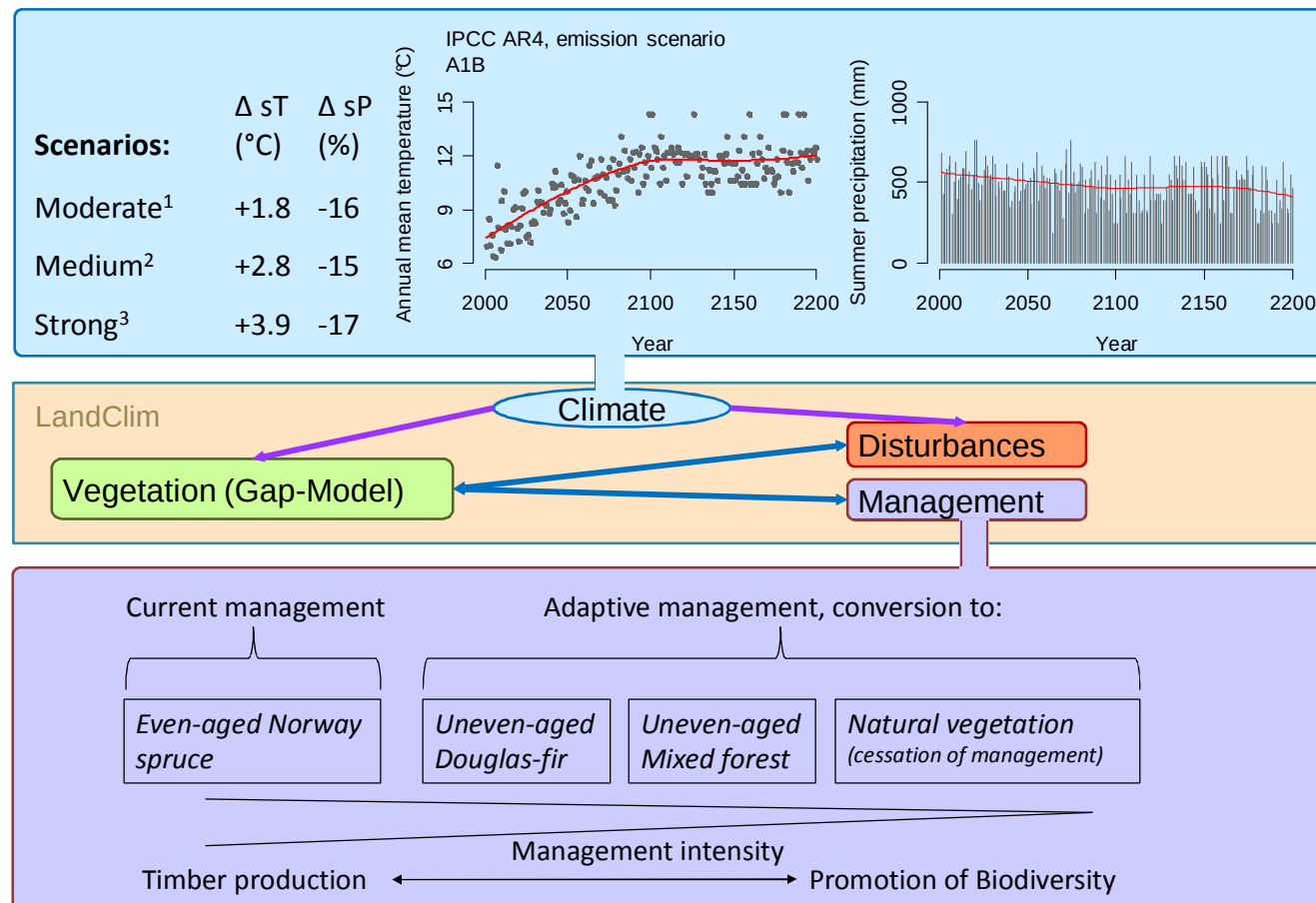
Temperli, C., H. Bugmann, and C. Elkin,

Cross-scale interactions among bark beetles, climate change and wind disturbances: a landscape modeling approach,

Ecological Monographs

Climate-adaptive ecosystem management

Methods



Spiecker et al. 2004, Brill

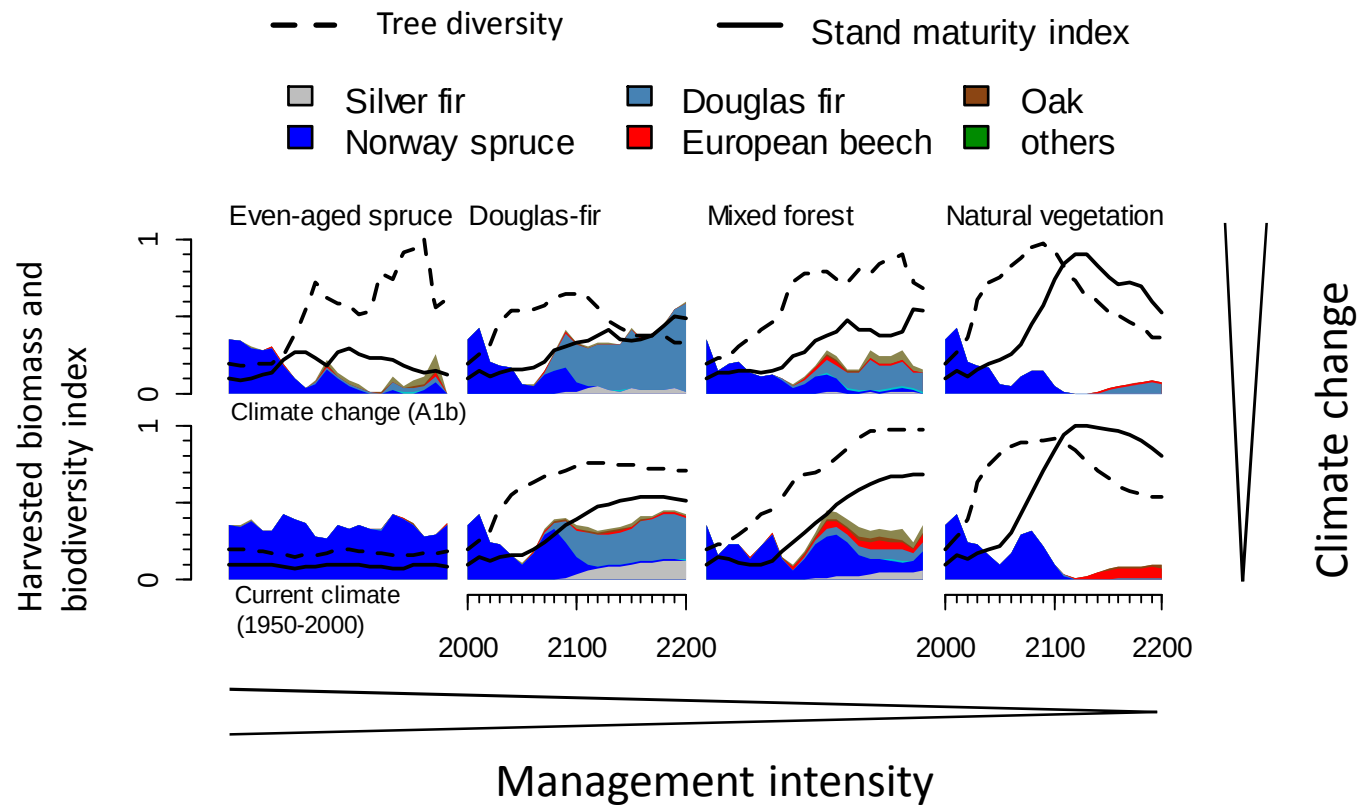
Duncker et al. 2007, EFORWOOD

Ministerium Ländlicher Raum Baden-Württemberg 1999, Richtlinien Landesweiter Waldentwicklungstypen

Climate-adaptive ecosystem management

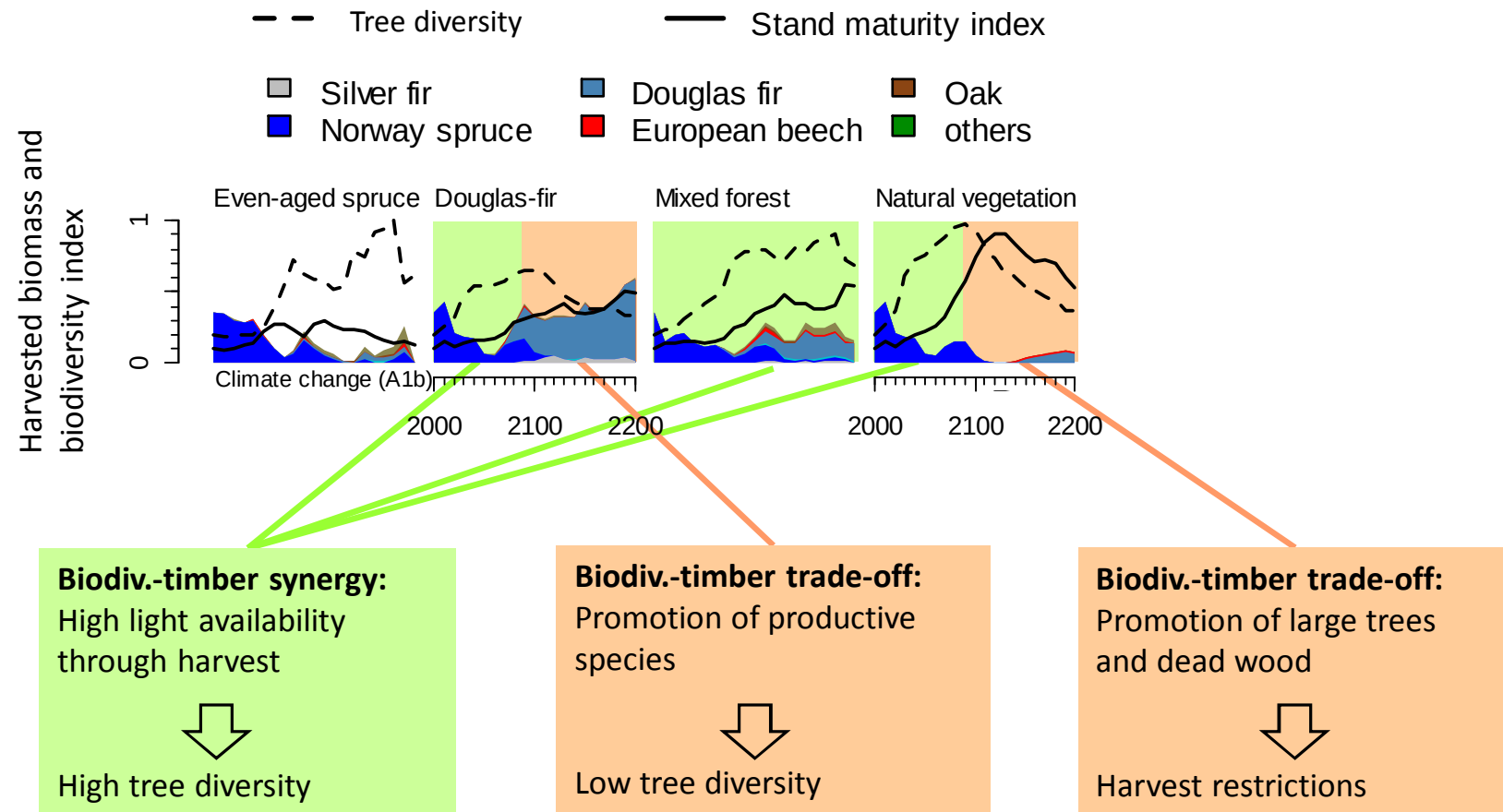
Results

Ecosystem services in the Black Forest



Climate-adaptive ecosystem management

Results



Climate-adaptive ecosystem management



Conclusions

- Forest and ES dynamics during conversion are highly dependent on:
 - past management (historic promotion of spruce)
 - specific implementation of adaptive management.
- Adaptive management needs to consider trade-offs,
- ... but, can also lead to 'win-win' situations between resource and conservation objectives.

Published as:

Temperli, C., H. Bugmann, and C. Elkin,

Adaptive management for competing forest goods and services under climate change,

Ecological Applications

Synthesis



Contribution to system, target and transformation knowledge

- Systems knowledge
 - Insights on interactions and feedbacks in forest dynamics that are not eminent from individual ecological relationships.
- Target knowledge
 - Future forest states and disturbance regimes
 - Trade-offs and synergies in ES
- Transformation knowledge
 - Shifts in ES and thus trade-offs over time.
 - Shifts in the importance of factors that drive beetle disturbance
 - starting points for adaptive management

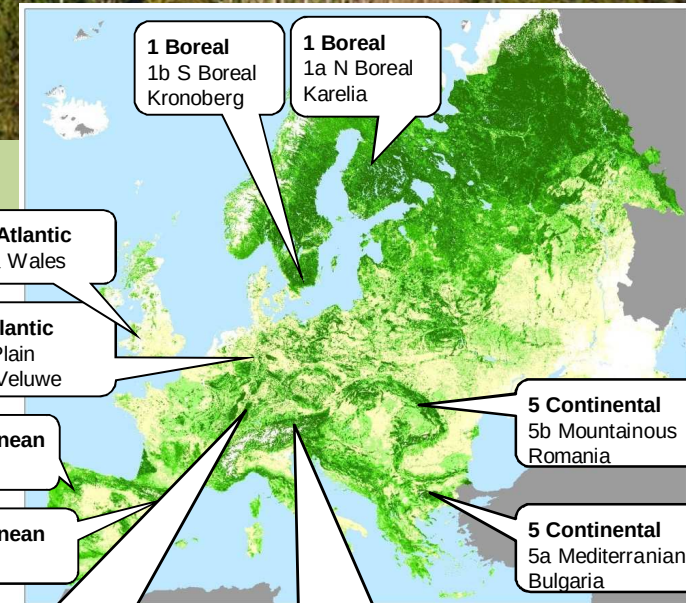
Thanks



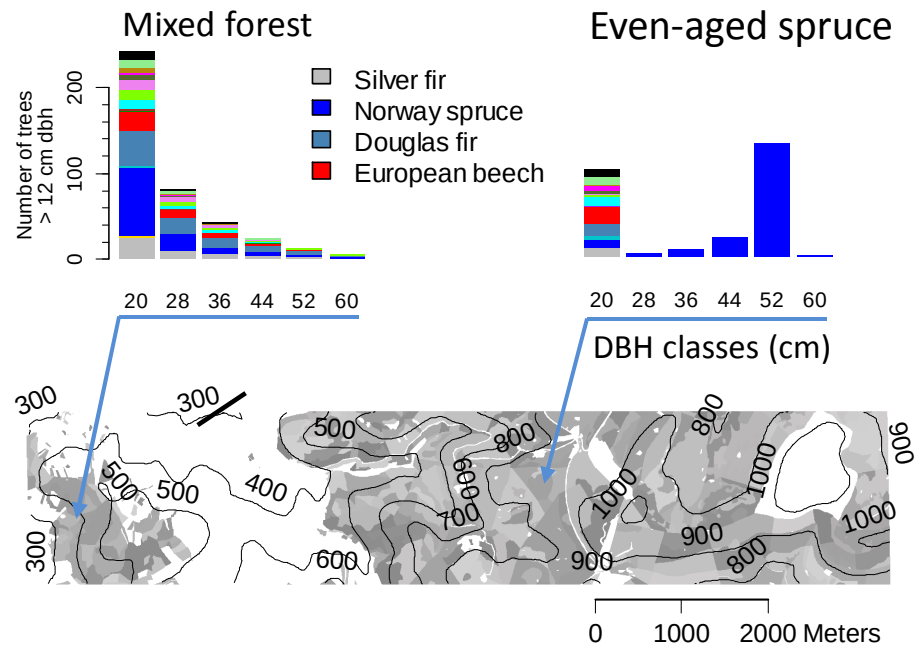
Appendix

MOTIVE case studies

MOdels for adapTIVE forest management



3 Central 3a temperate Black Forest



3 Central 3b Alpine



Dischma valley (Davos)

Appendix



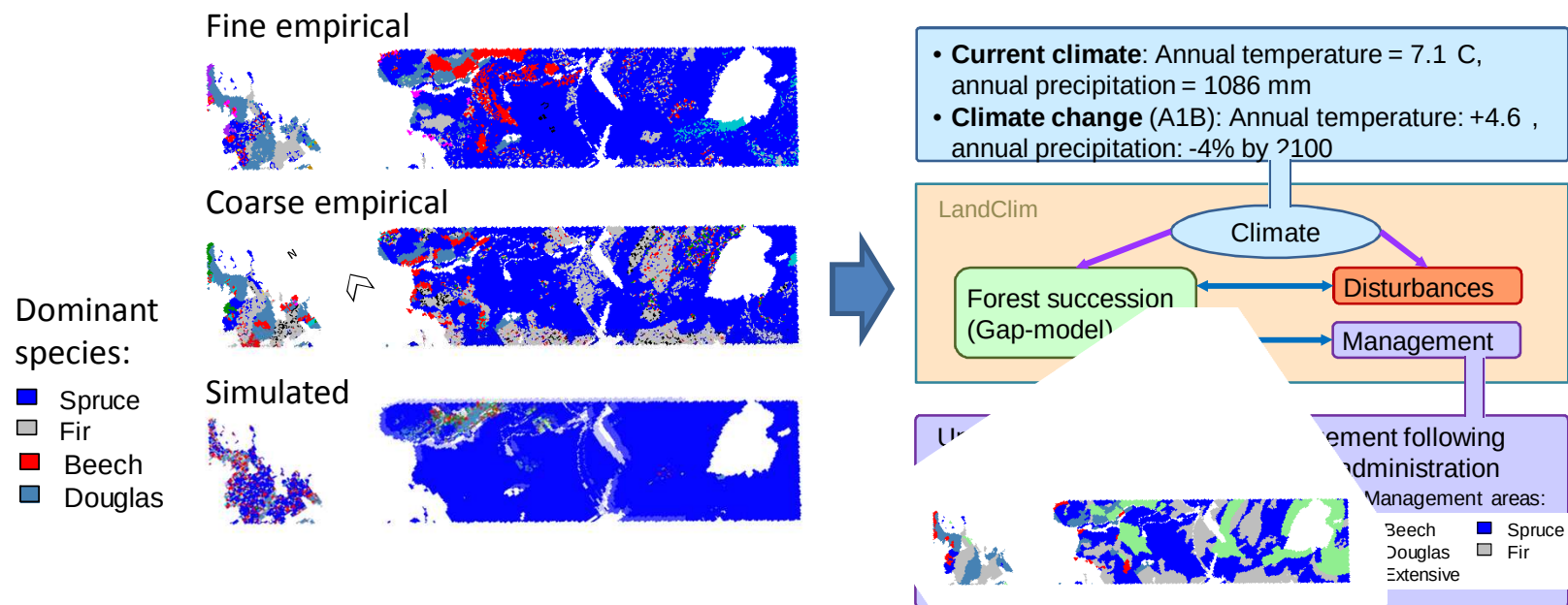
Research recommendations

- Initialization data (Remote sensing, LIDAR)
 - Bark beetle-wind interaction
 - Other pathogens on other species → General pathogen model?
 - Model application to test beetle management strategies
-

Model sensitivity to initialization

Methods

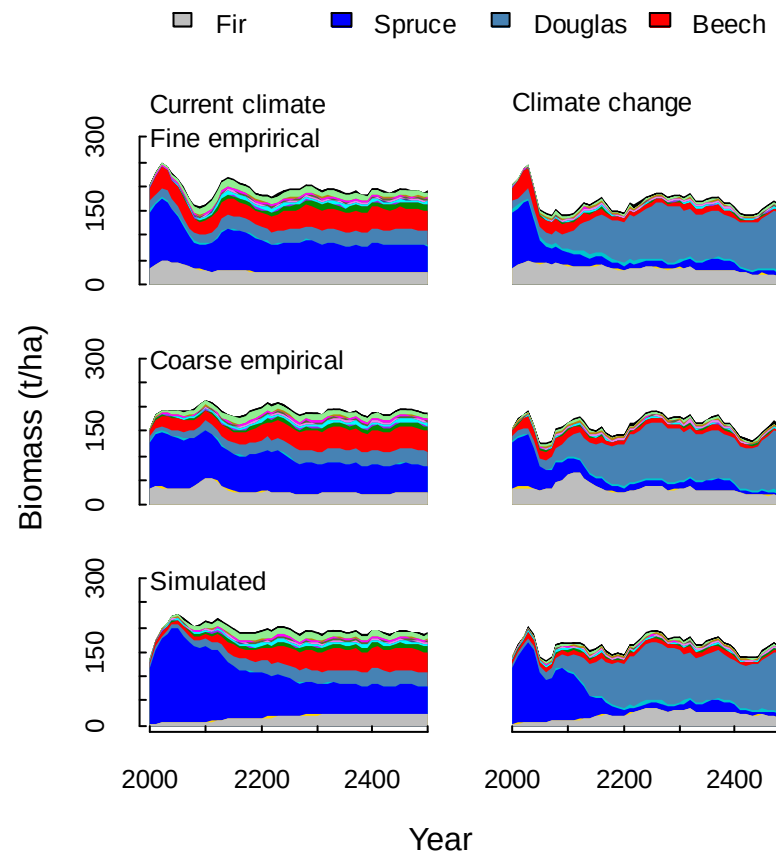
- Uncertainty in current forest state represented by:
 - Fine empirical data: Inventory by forest corporations (200 m grid)
 - Coarse empirical data: German national forest inventory (2 km grid)
 - Simulation derived initialization based on past management



Ministerium Ländlicher Raum Baden-Württemberg 1999, Richtlinien Landesweiter Waldentwicklungstypen

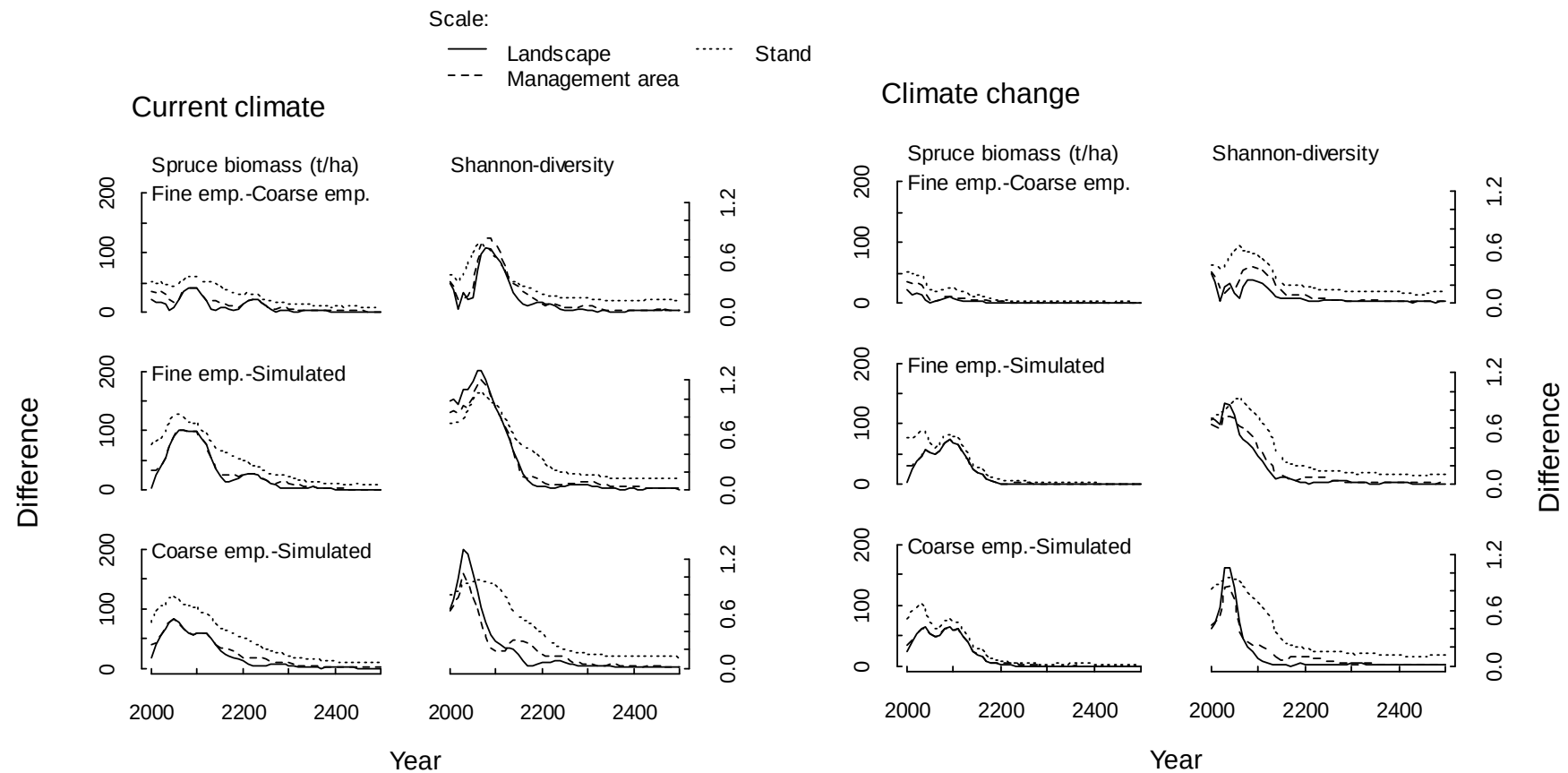
Model sensitivity to initialisation

Results



Model sensitivity to initialization

Results



Model sensitivity to initialization



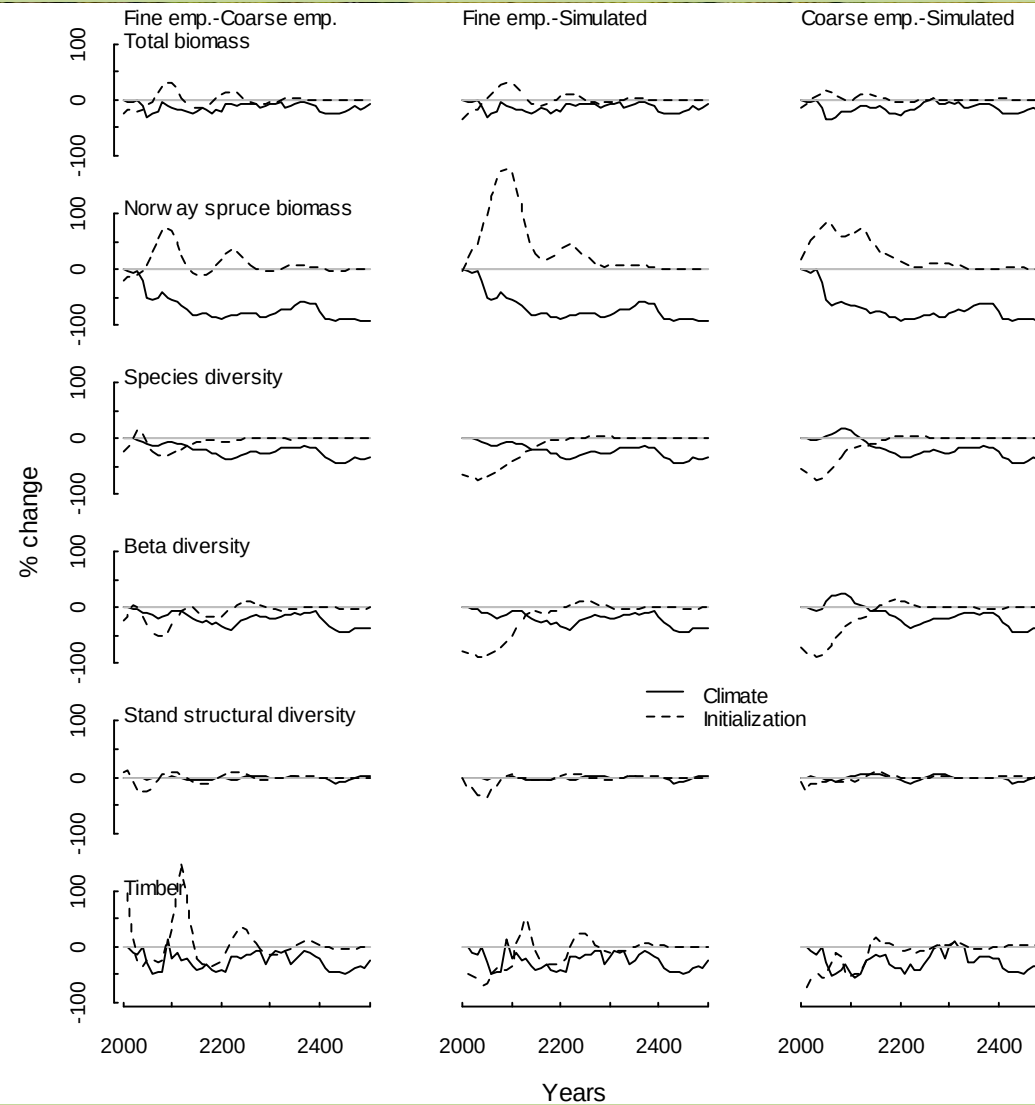
Conclusions

- Importance of legacies of past management and disturbance for ES projections
 - over small spatial scales and short time frames
 - when the impact of external drivers (e.g., climate change and management) is weak
- Calls for accurate initialization data and transparent assumptions and procedures for initialization.
- Landscape models are most useful to reveal ecological mechanisms. They cannot be used to project the fate of individual trees.

Appendix



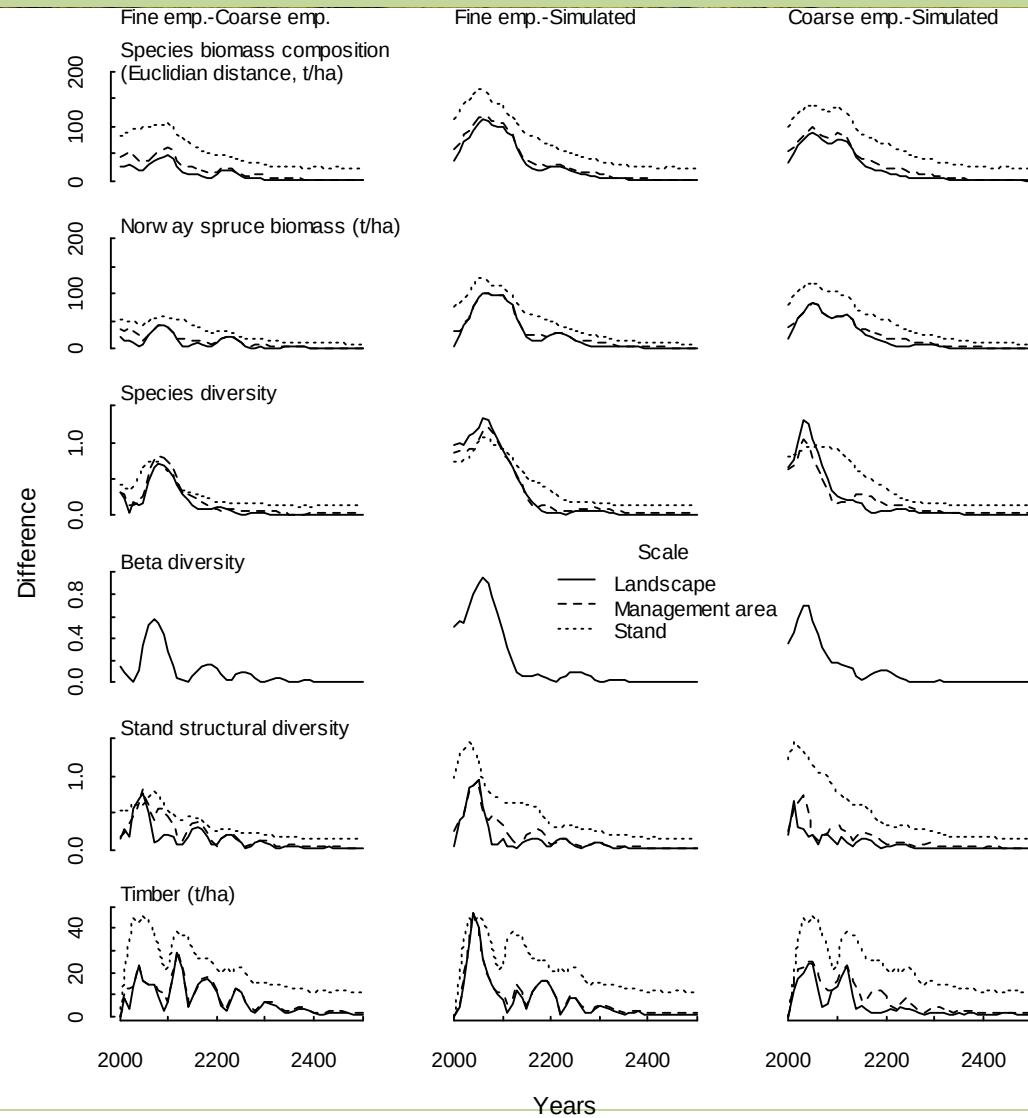
Relative importance of climate change and initialization



Appendix



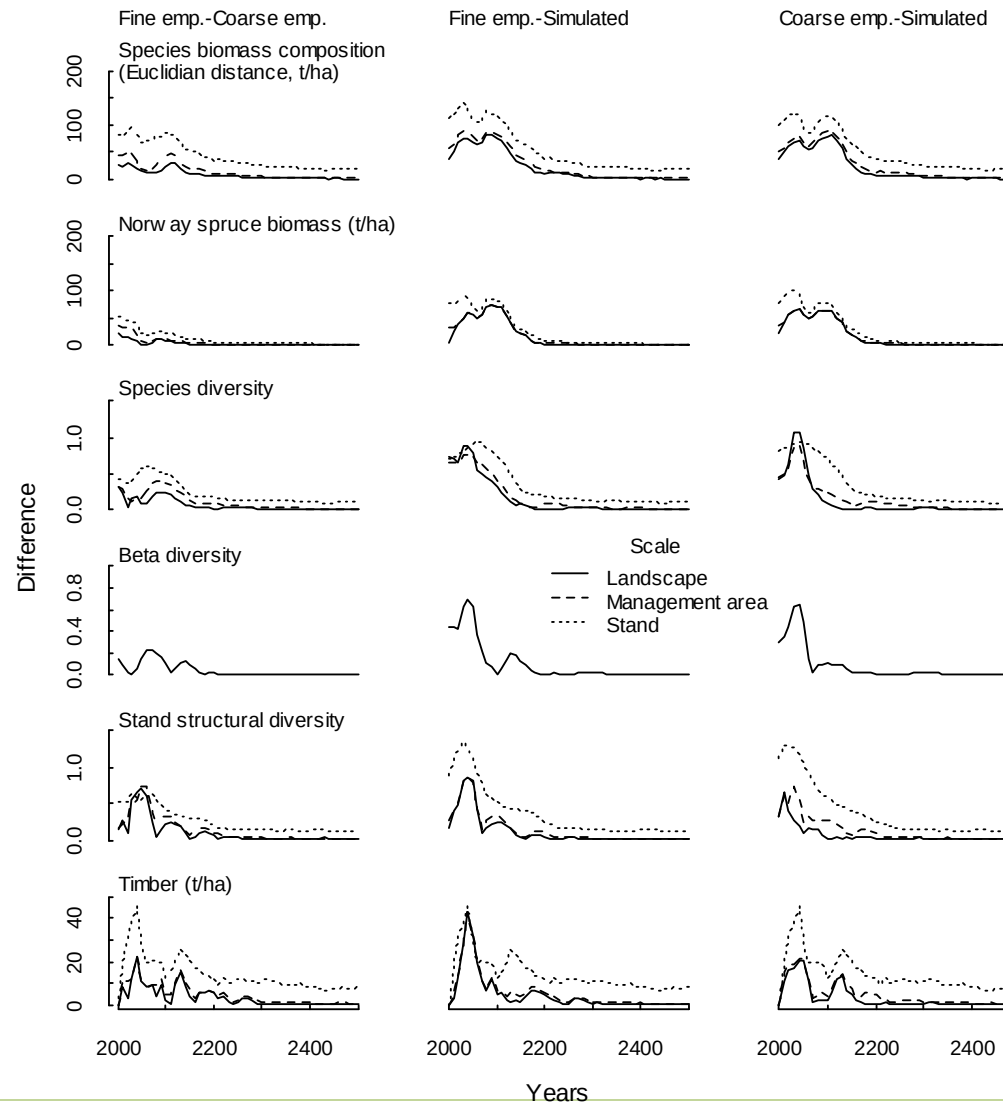
Initialization effect on ES under current climate



Appendix



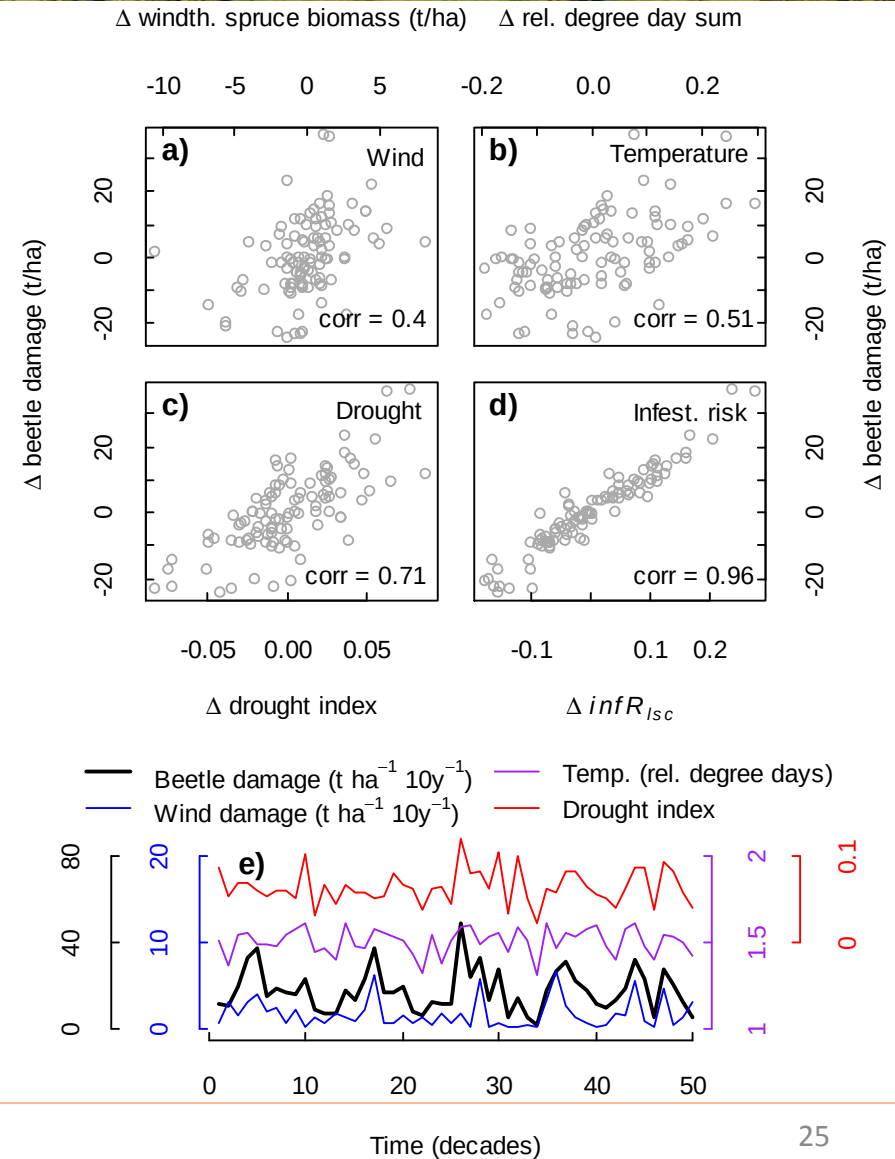
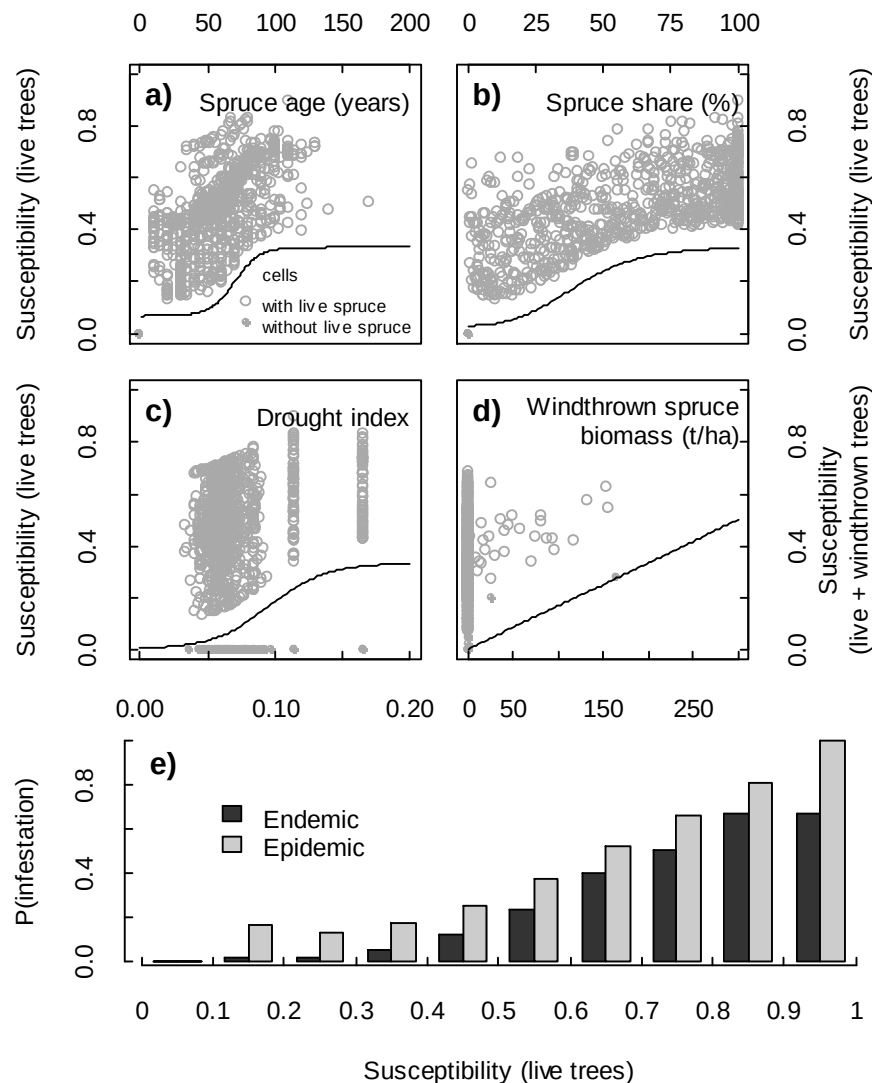
Initialization effect on ES under climate change



Appendix



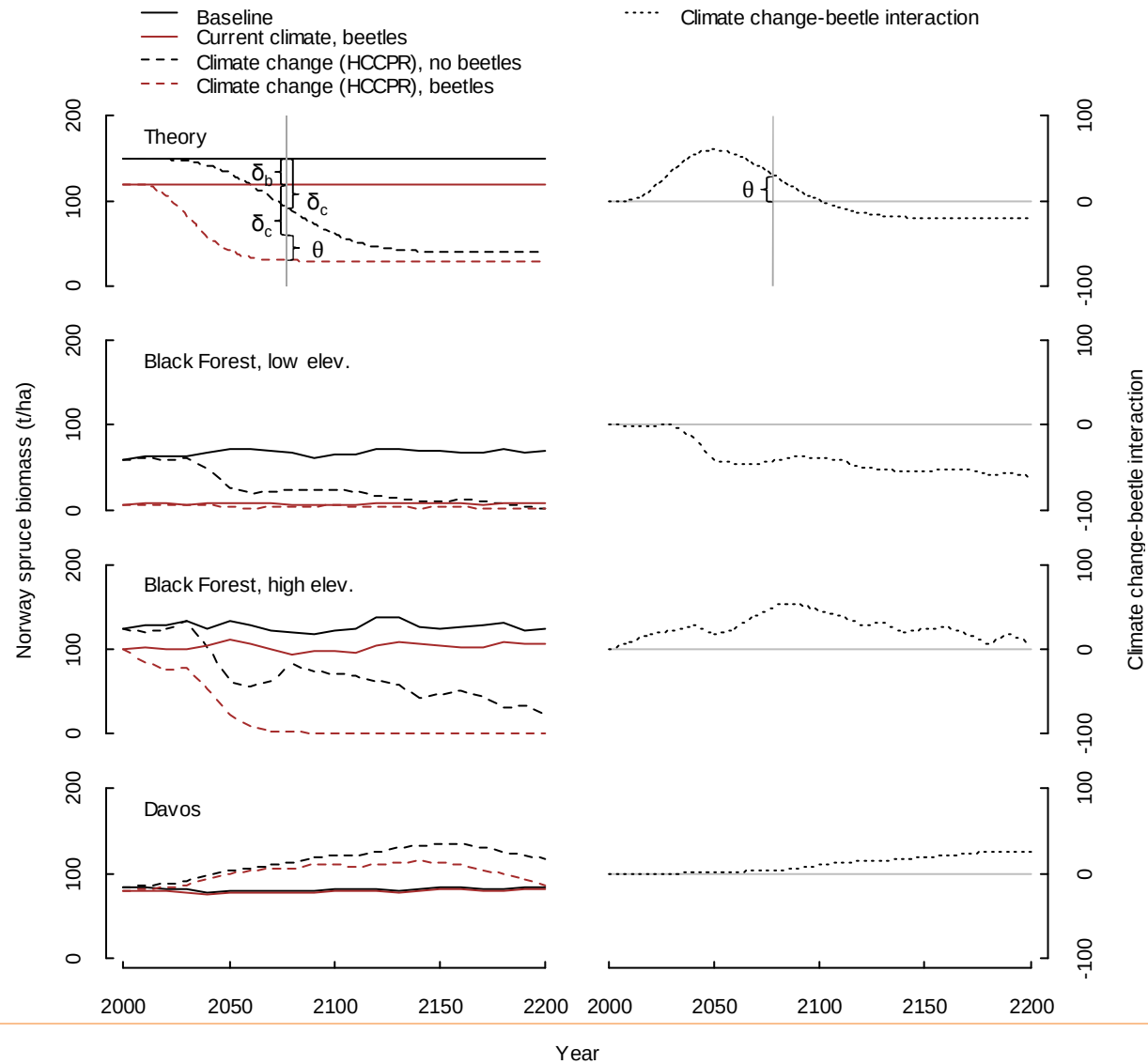
Verification of short-term beetle model behavior



Appendix



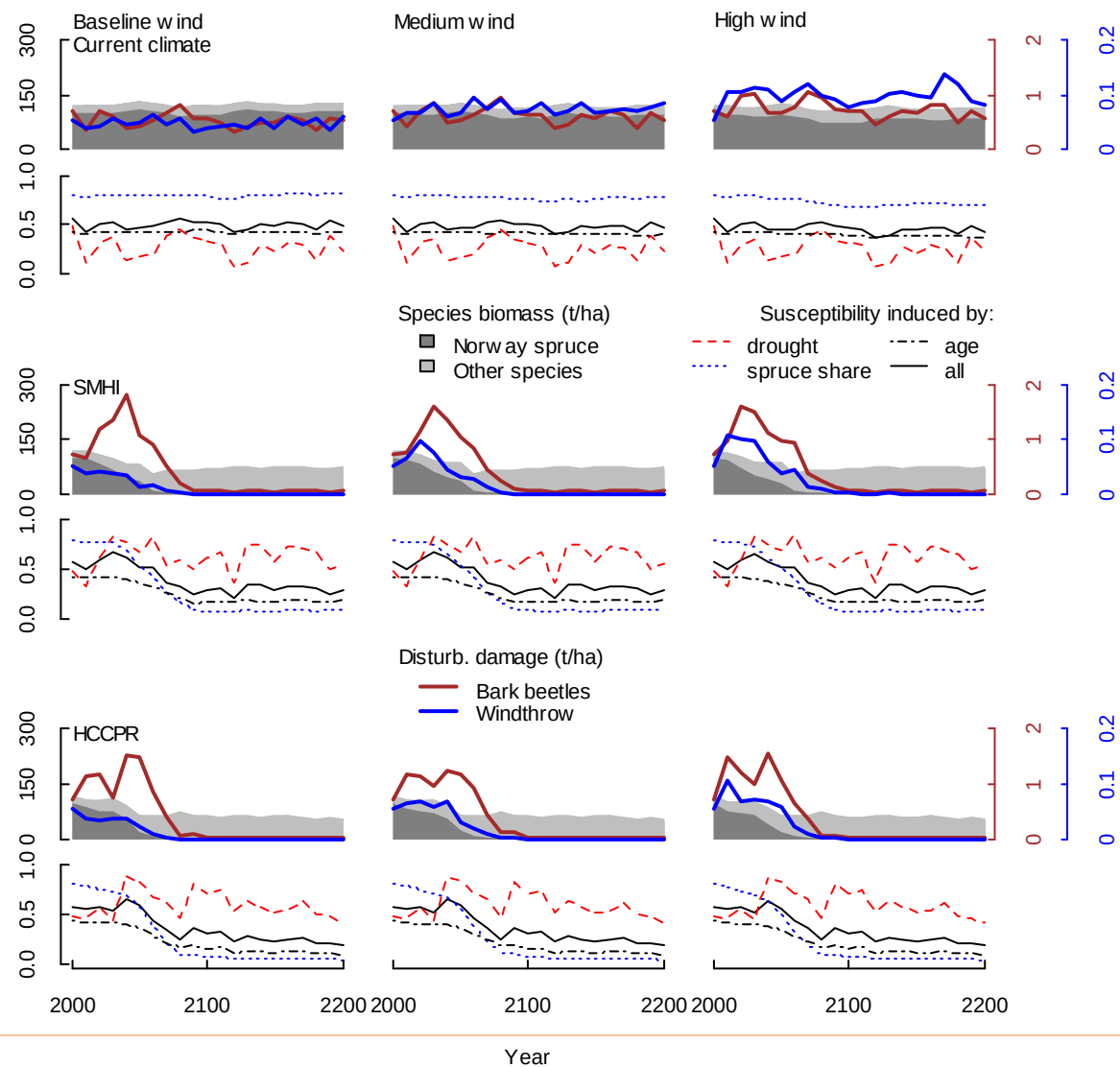
Climate change-beetle interactions



Appendix



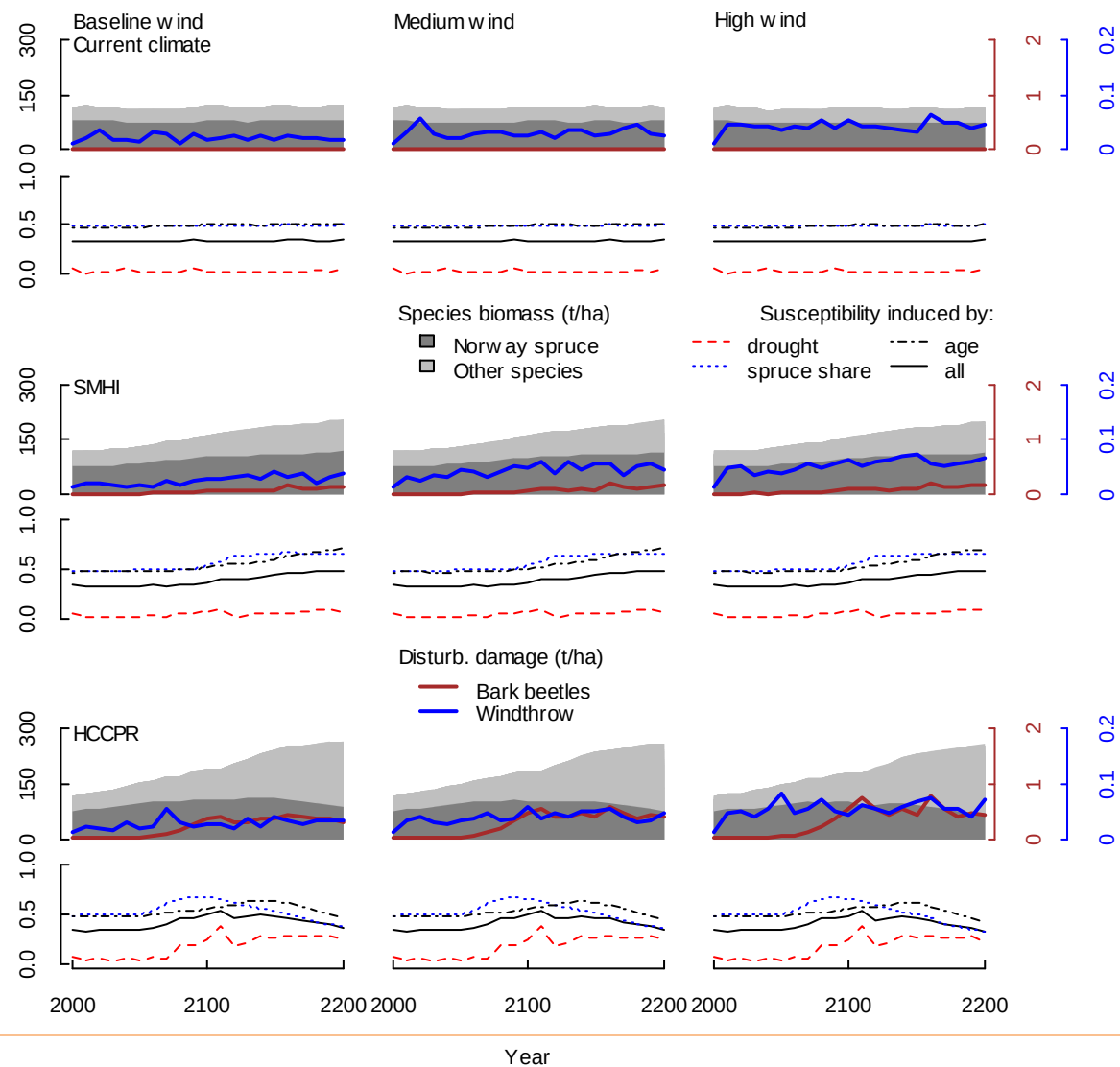
Full set of beetle simulation results for high-elevation Black Forest



Appendix



Full set of beetle simulation results for Davos



Appendix



Beetle equations (examples)

Age induced beetle susceptibility:

$$\text{—————} \quad (\text{A.4})$$

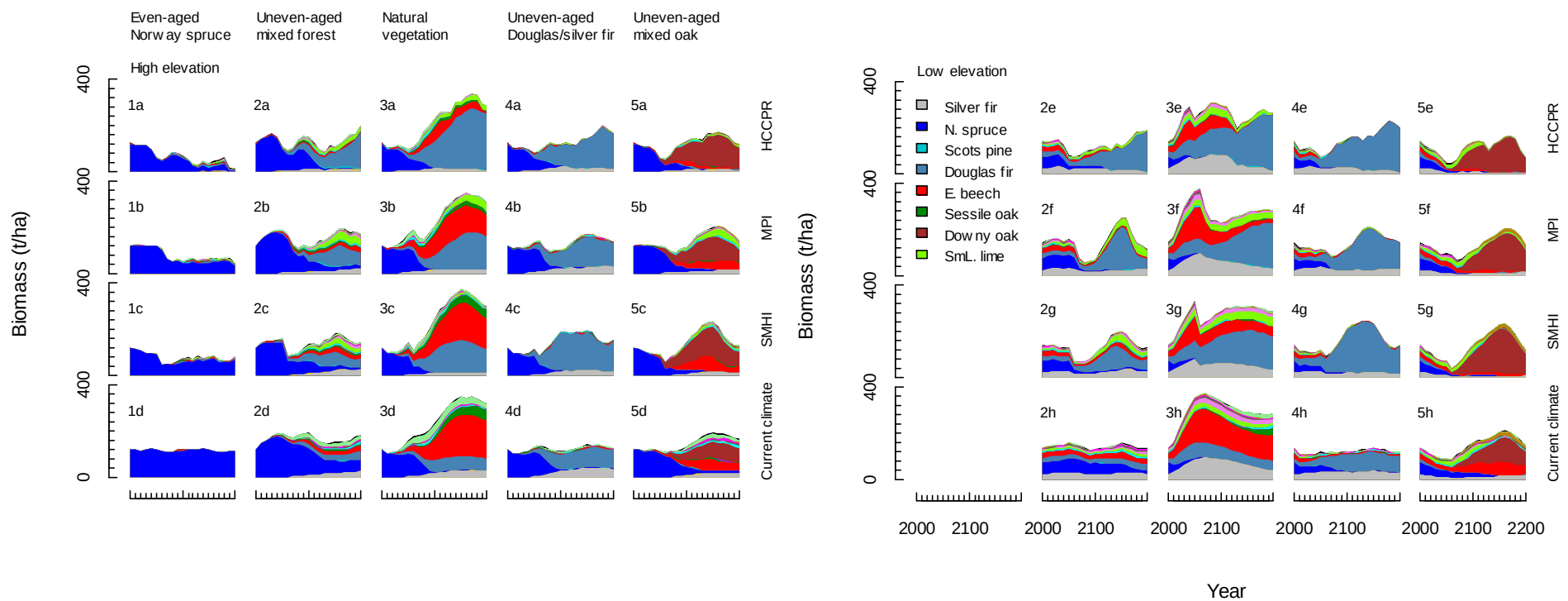
Beetle Hazard:

$$\text{—————} \quad (\text{A.10})$$

Appendix



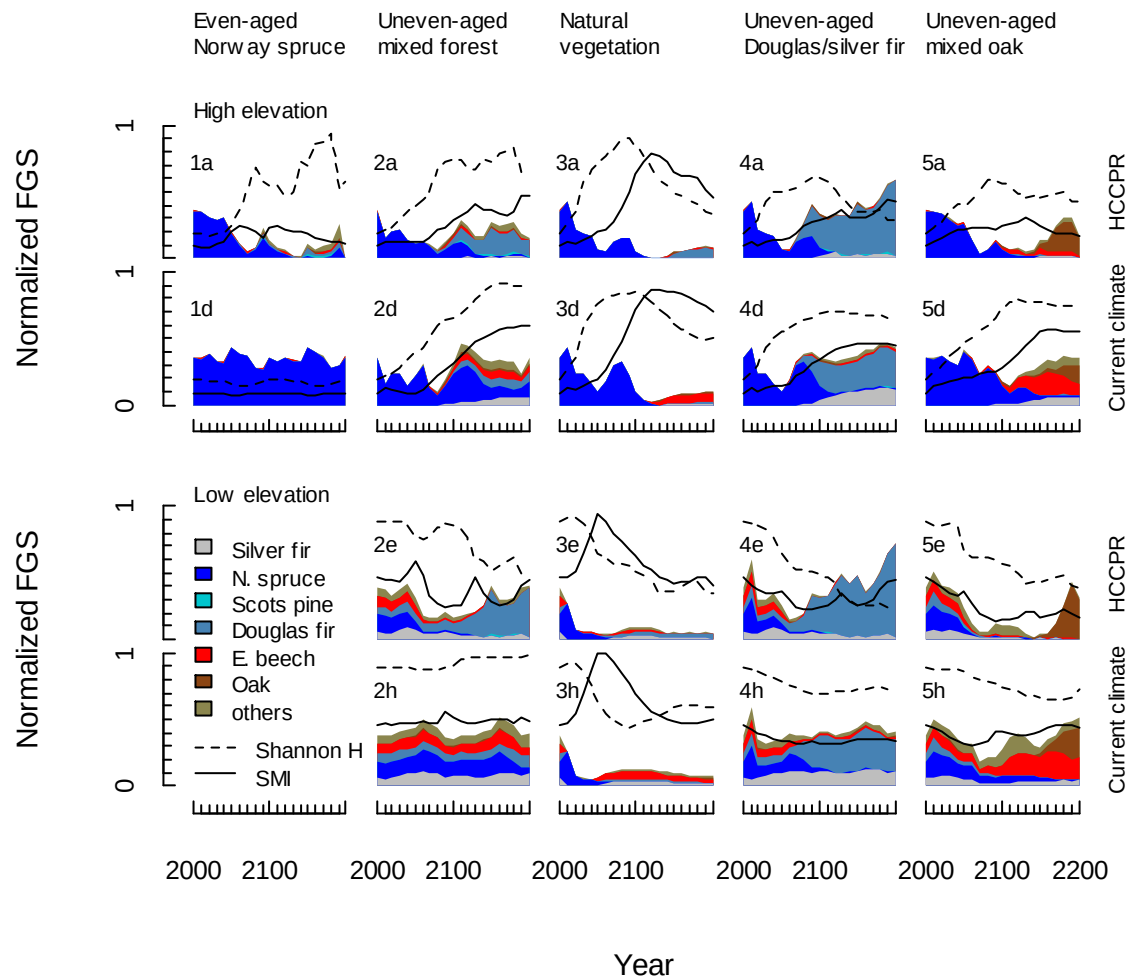
Species biomass development under climate change and adapt. management



Appendix



ES development under climate change and adapt. management



Appendix

ES trade-offs

