A background image of a dense forest of evergreen trees, heavily shrouded in a thick, white fog or mist. The trees are dark green and their tops are visible against the lighter, hazy sky. The overall atmosphere is serene and somewhat mysterious.

# Local and global insight into the future of northern forest ecosystems

Ché Elkin

FRBC-Slocan Mixedwood Ecology and  
Management Chair

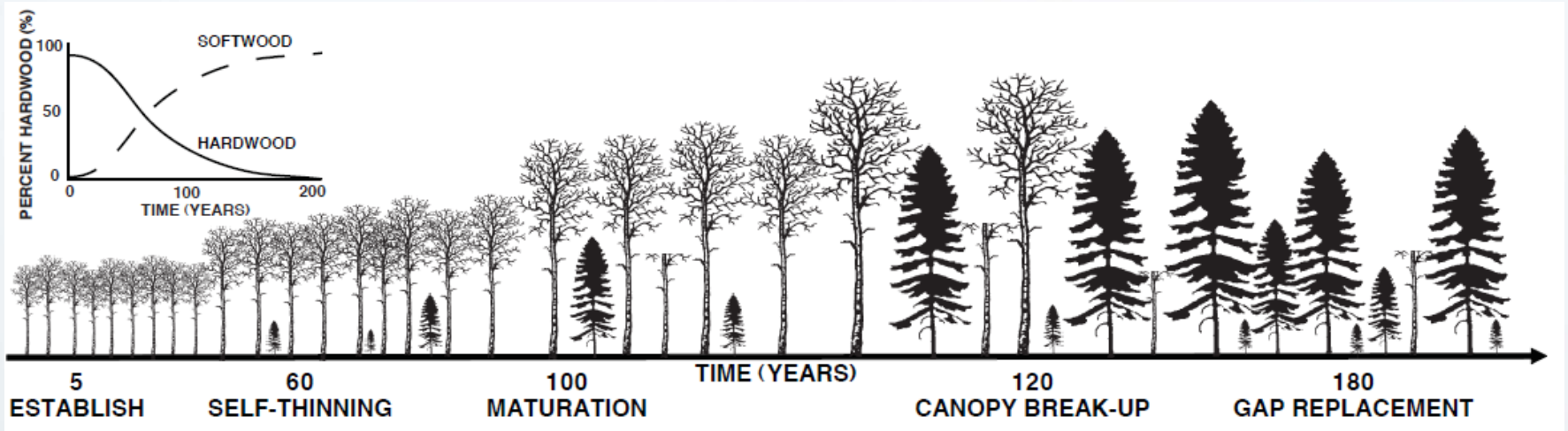
UNBC



BC Forest and Range, Fort Nelson FD

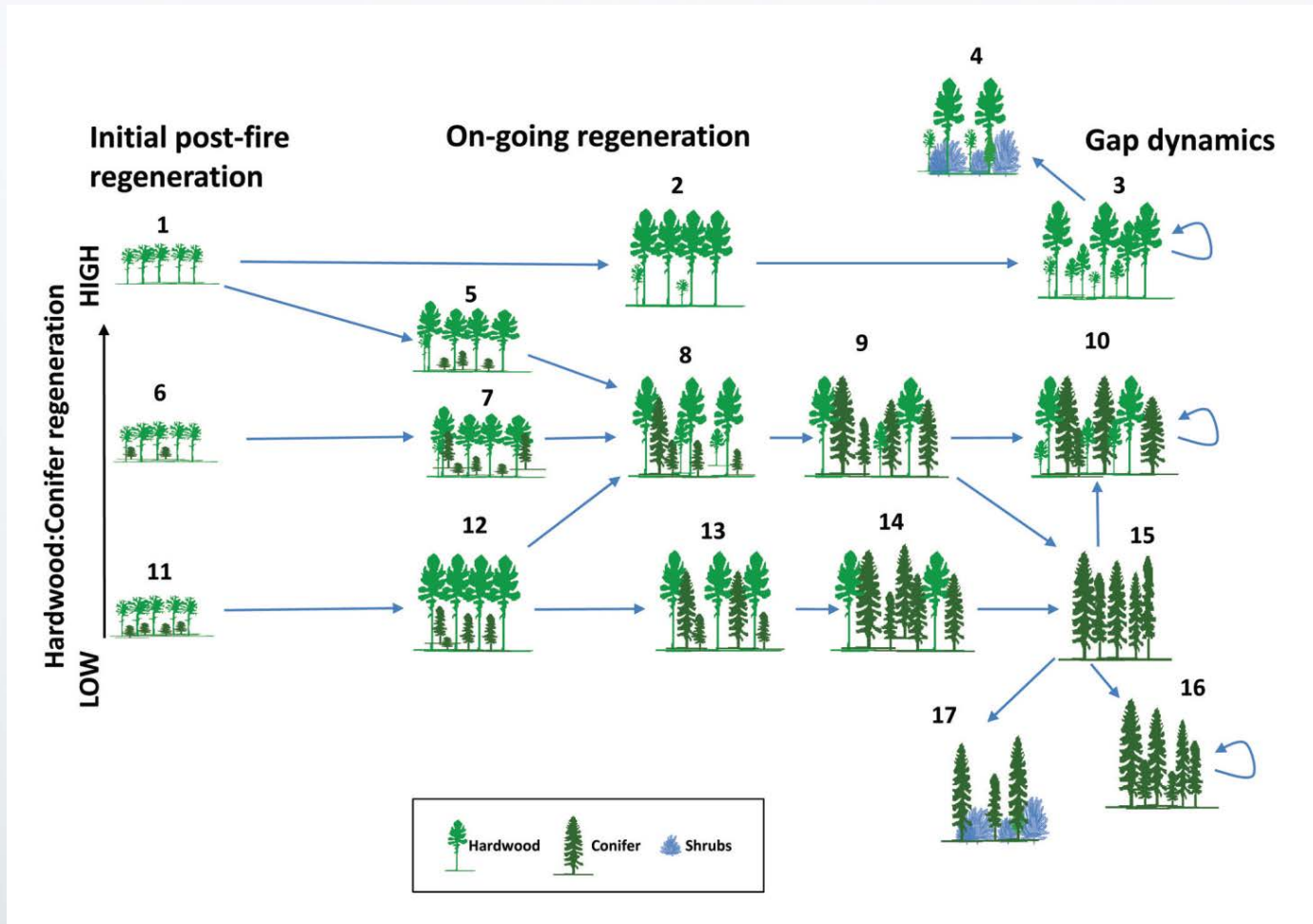


Levac, 2012



Fire, clearcut



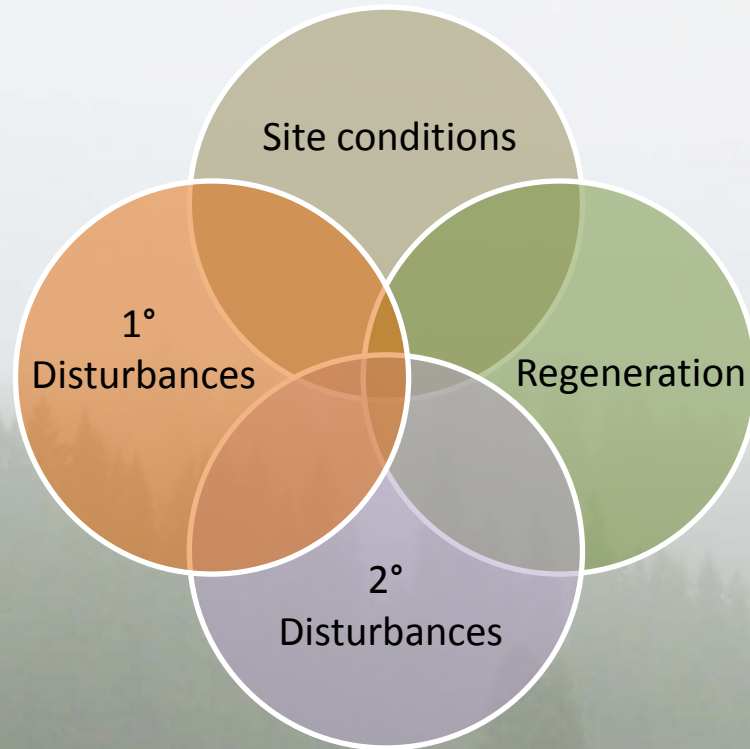


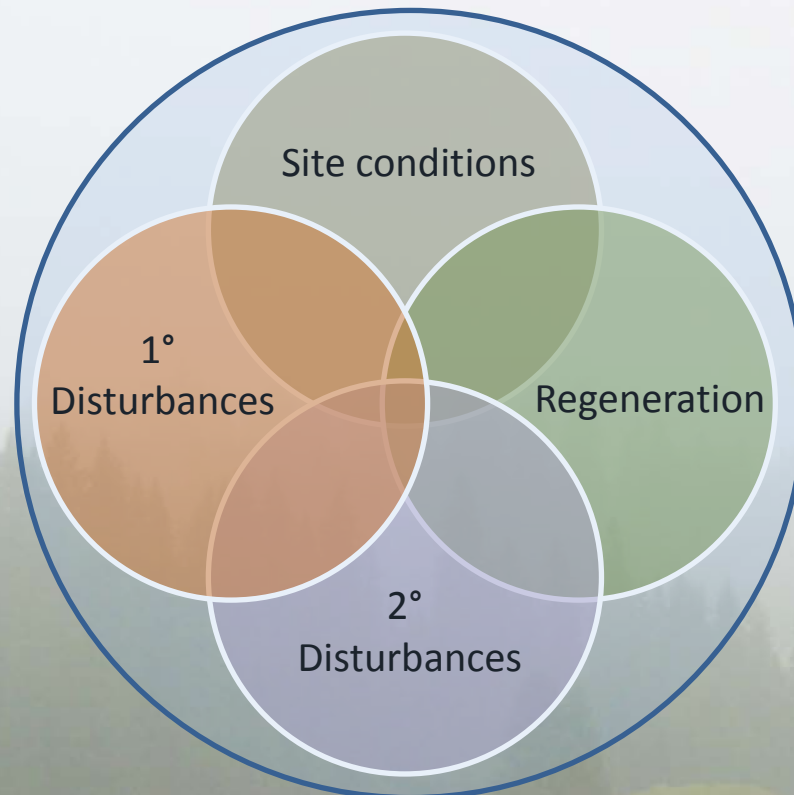
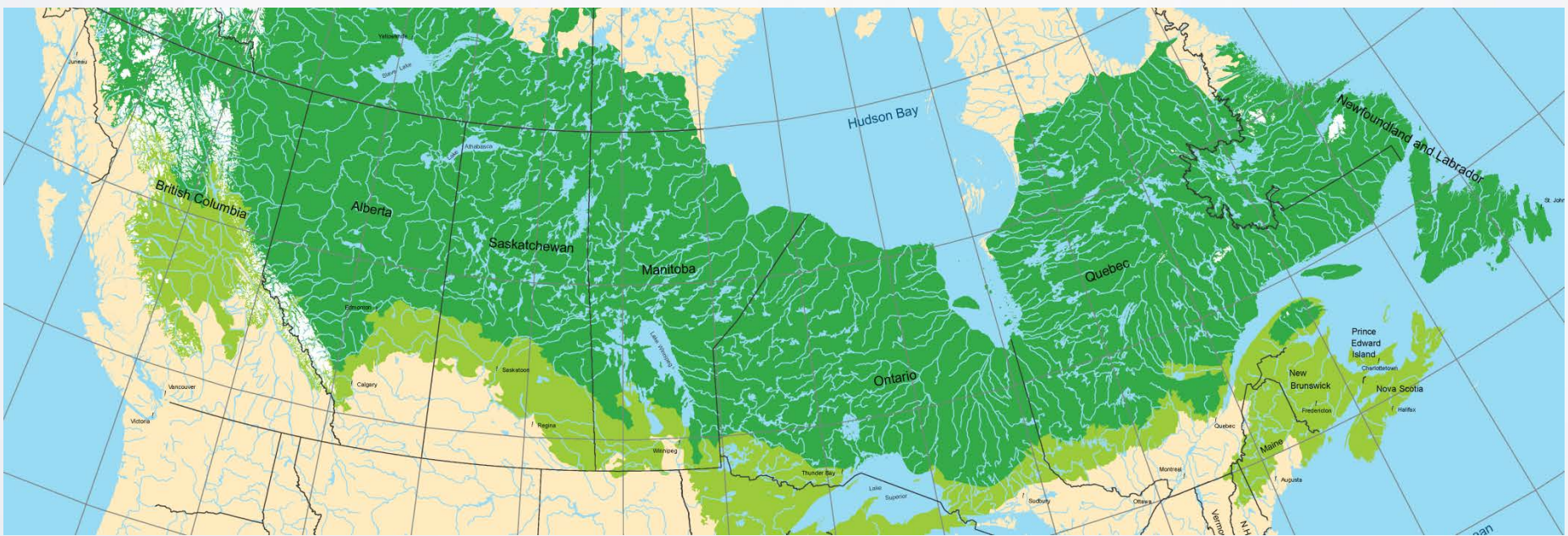
Bergeron et al. 2014. The Forestry Chronicle





Baldwin 2012 CBVM





Regional climate

Forest management





## **Sub-boreal, boreal mixed forests**

**How will climate change influence forest dynamics?**

**What impact will future changes have on forest ecosystem services?**

**Can adaptive management be used to maintain forests and forest ES?**

# Drivers of mixed forest dynamics



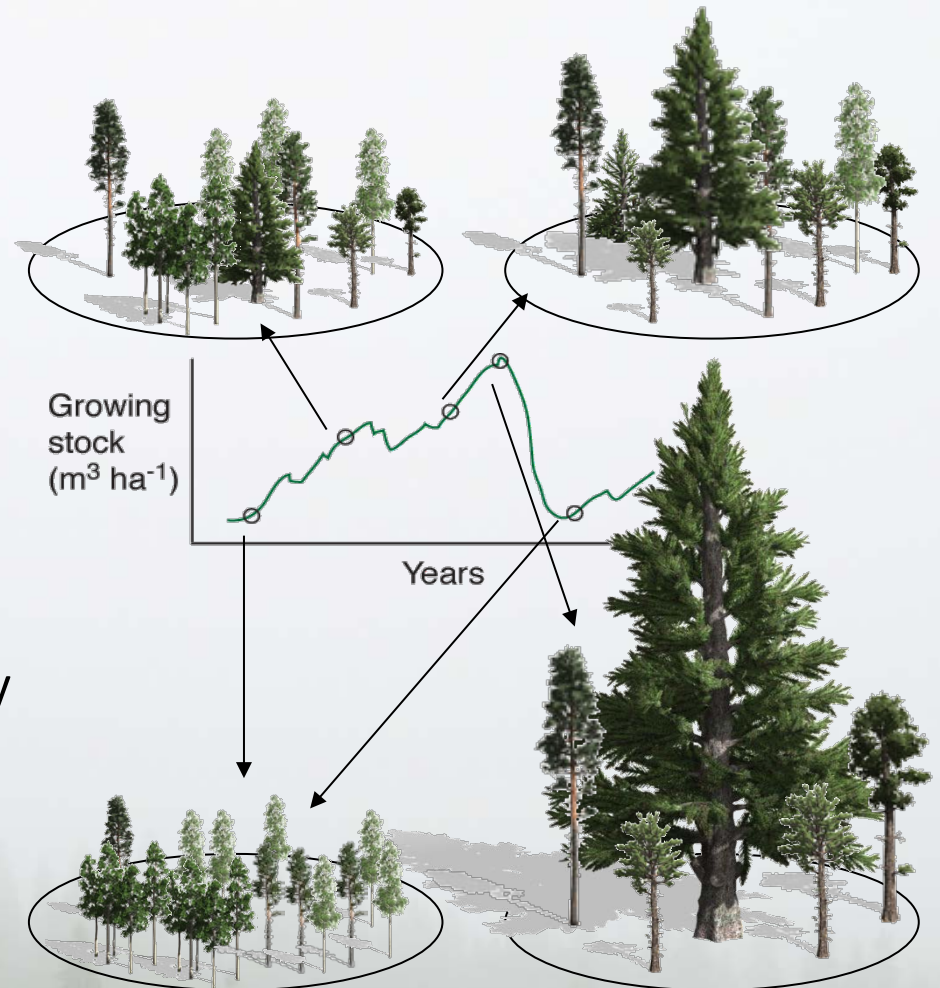
1. Drivers of forest dynamics
2. Climate impact
3. Forest disturbances
4. Forest ecosystem services
5. Adaptive management



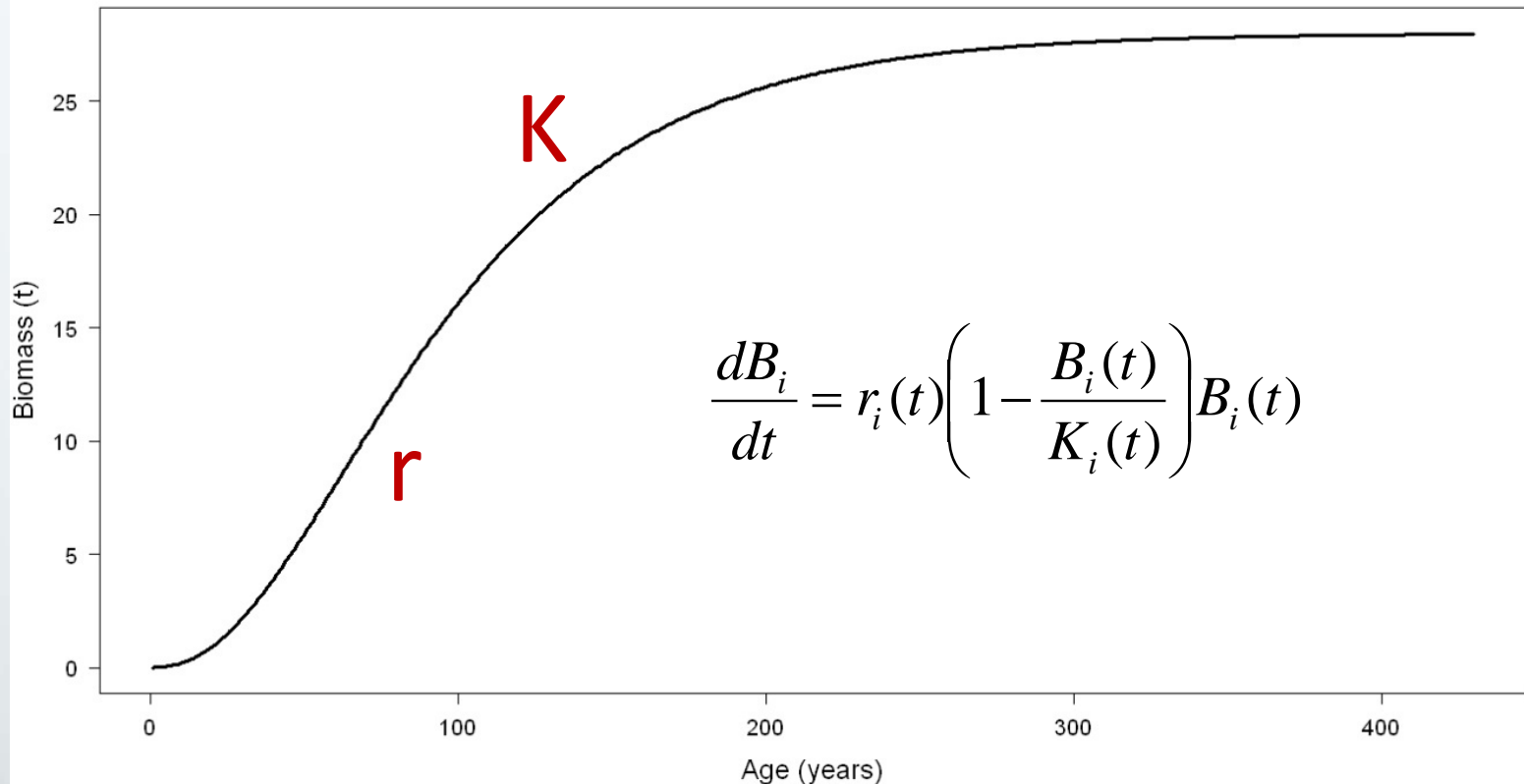
# Dynamic forest models



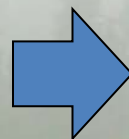
- Recruitment
- Growth
- Competition
- Mortality
- Light availability
- Moisture availability
- Temperature
- Nutrients



# Dynamic forest models



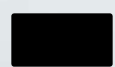
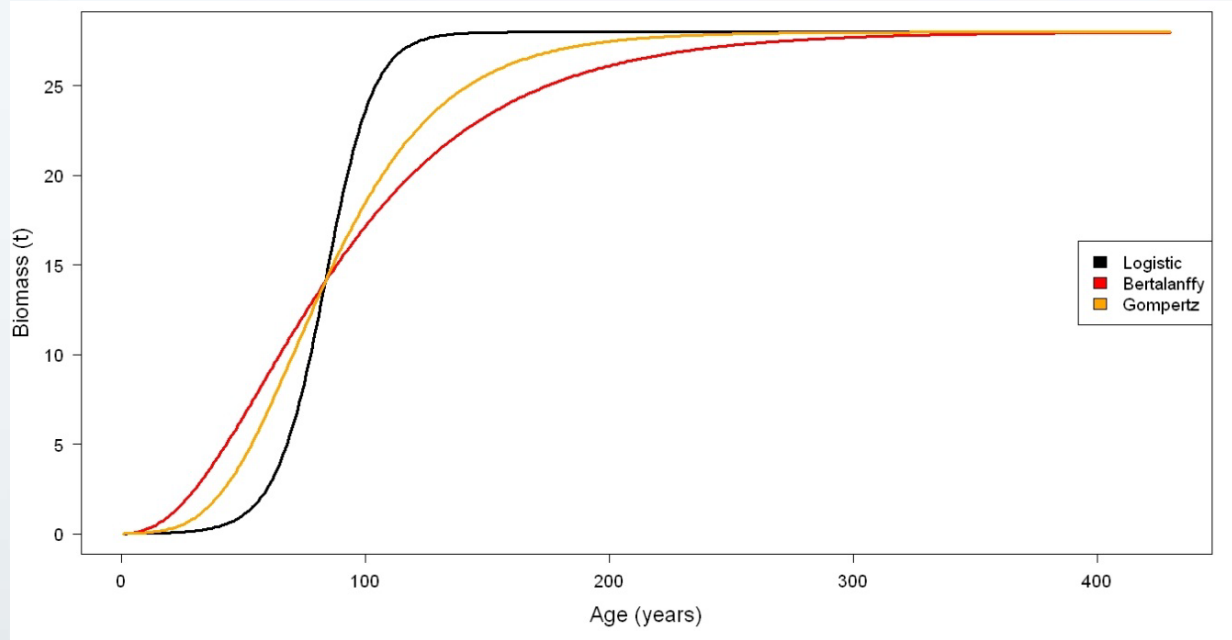
Light availability  
Moisture availability  
Temperature (degree days)  
Nutrients (nitrogen)



Growth rate ( $r$ )  
Max size ( $K$ )



# What is the appropriate form of the growth equation?



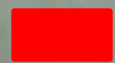
Logistic

$$\frac{dB_i}{dt} = r_i(t) \left( 1 - \frac{B_i(t)}{K_i(t)} \right) B_i(t)$$



Gompertz

$$\frac{dB_i}{dt} = 3 \cdot r_i(t) \cdot K_i(t)^{1/3} \cdot B_i(t)^{2/3} - B_i(t)$$



von Bertalanffy

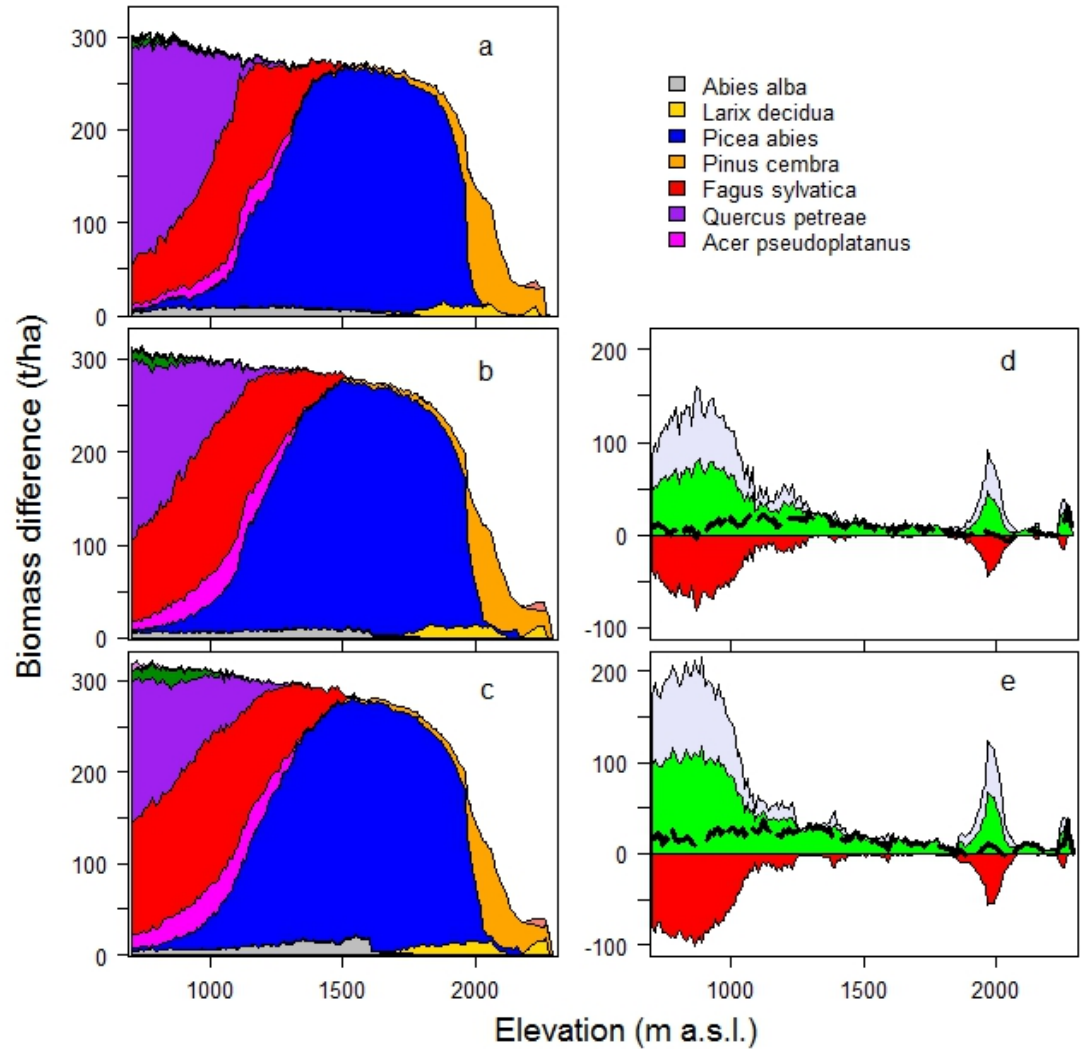
$$\frac{dB_i}{dt} = r_i(t) \cdot (\log(k) - \log[B_i(t)]) \cdot B_i(t)$$

# What is the appropriate form of the growth equation?

Logistic

Gompertz

von Bertalanffy

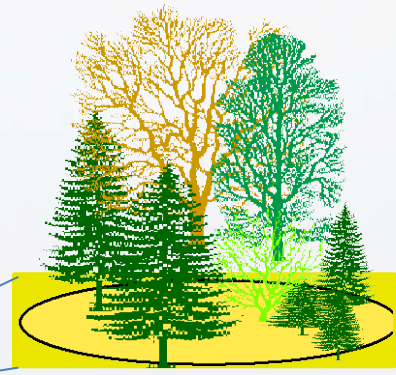
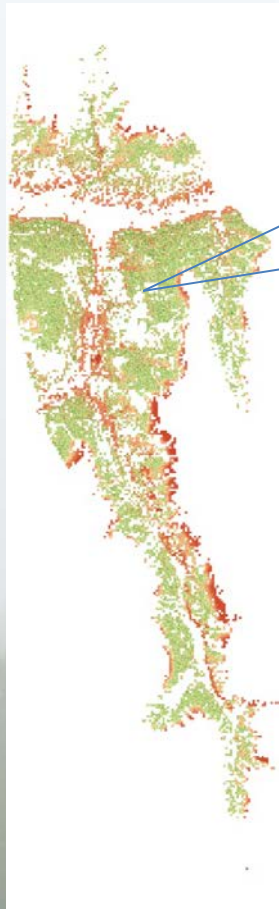
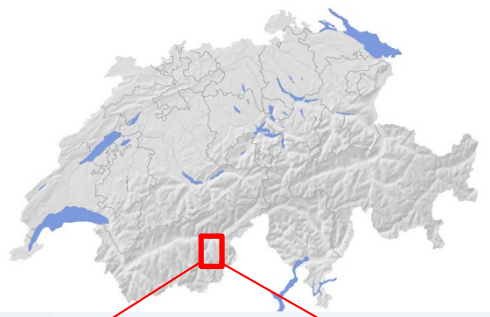




# Climate impacts on forest

1. Drivers of forest dynamics
2. **Climate impact**
3. Landscape disturbances
4. Forest ecosystem services
5. Adaptive management

# Assessing the current and future state of forest ecosystem services



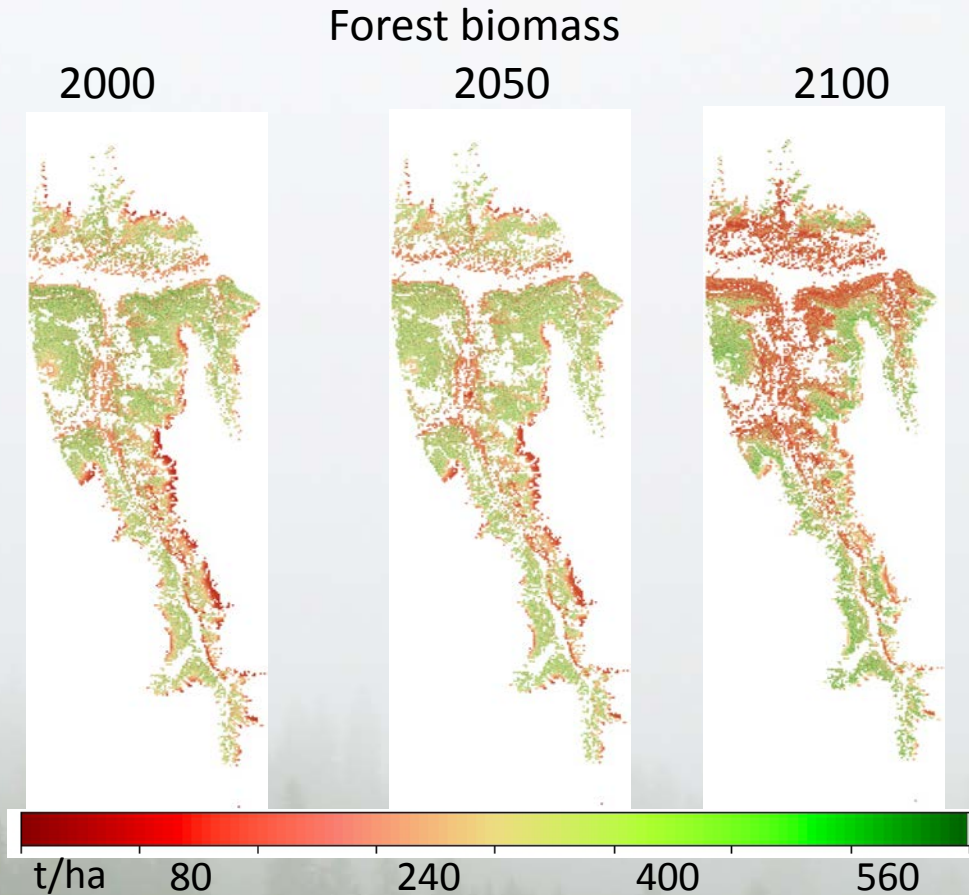
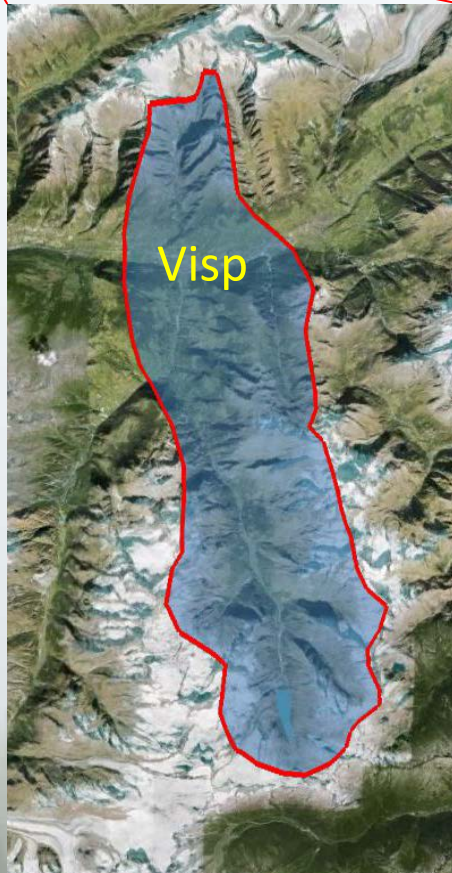
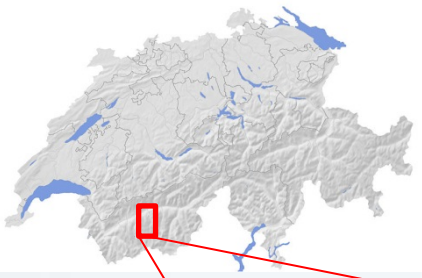
25 m

Species	Cohort	Biomass (tones/ha)	Stem #
<i>Picea abies</i>	1960	3.474	4
<i>Picea abies</i>	1995	0.011	12
<i>Pinus cembra</i>	1994	0.010	11
<i>Abies alba</i>	1982	0.020	2
<i>Abies alba</i>	1983	0.018	1

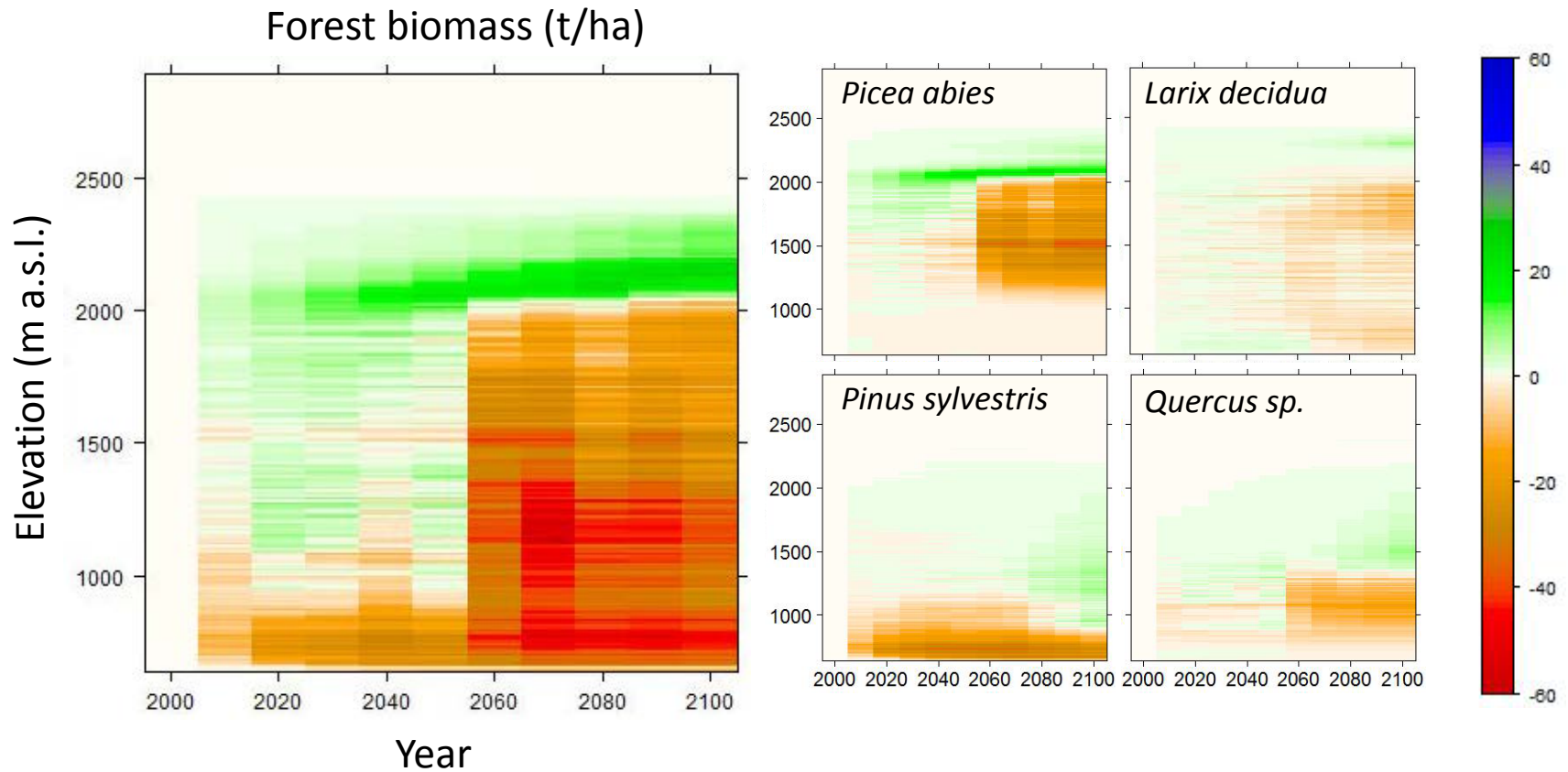
Forest ecosystem services



# Climate impacts on forest dynamics



# Climate impact on forest composition





- Spain (Iberian Mtn.)
  - Slovenia (Dinaric Mtn.)
  - Slovakia (Carpathian Mtn.)
  - Bulgaria (Rhodope Mtn.)
- 
- Climate thresholds



# Landscape forest disturbances

1. Drivers of forest dynamics
2. Climate impact
3. Forest disturbances
4. Forest ecosystem services
5. Adaptive management

Fire



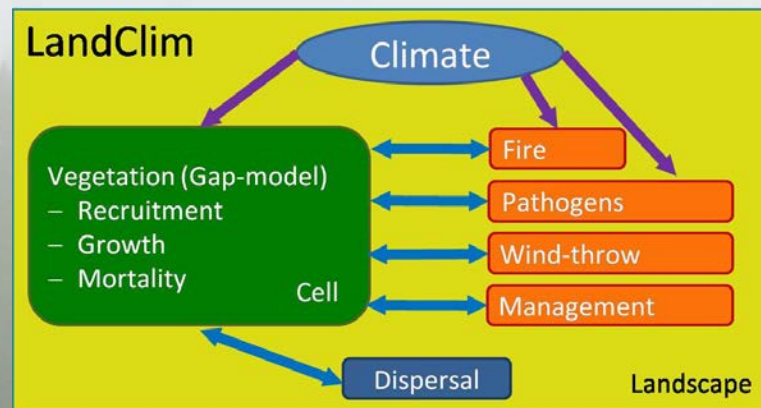
Disease



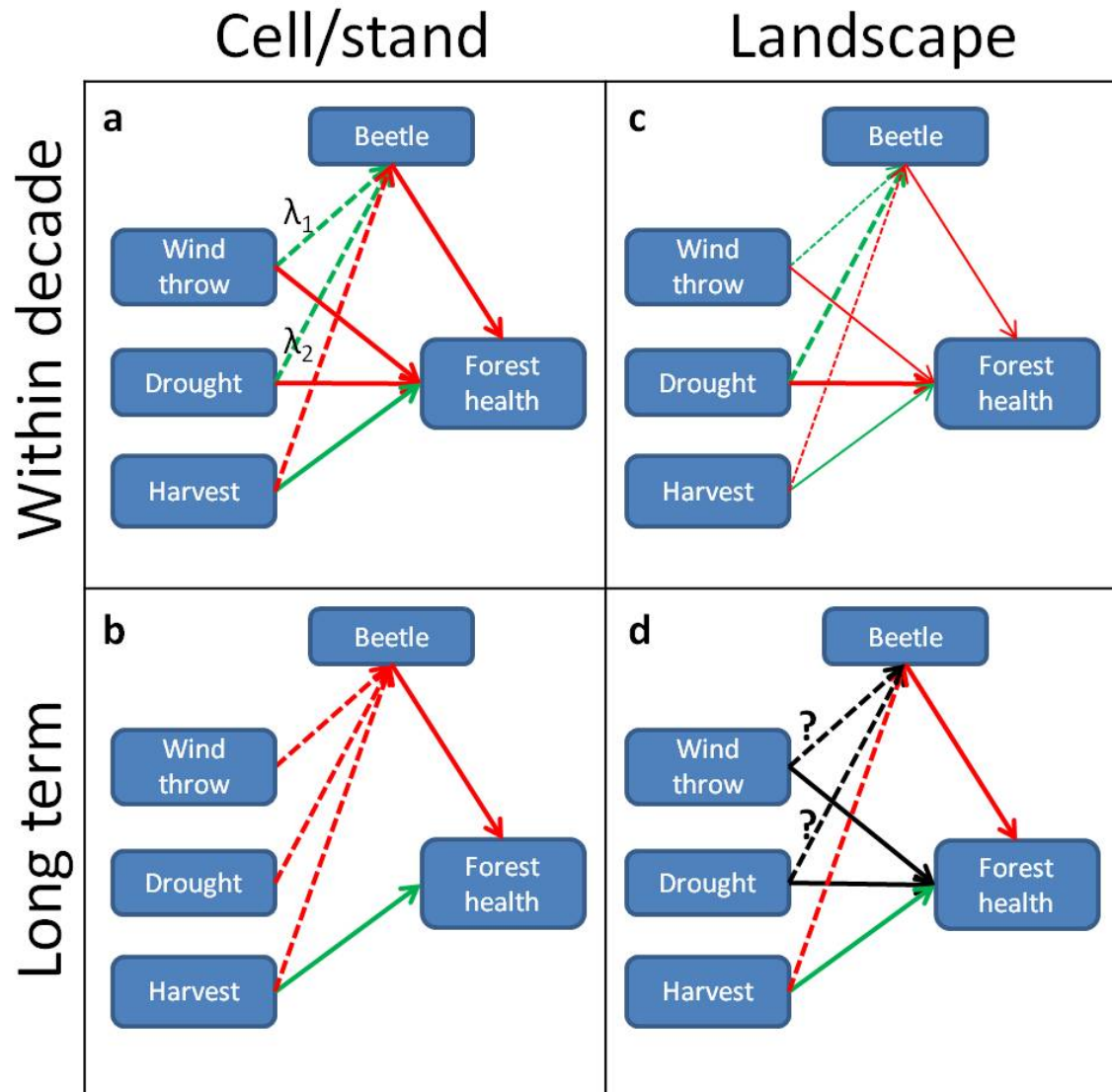
Wind, snow  
breakage



Harvest

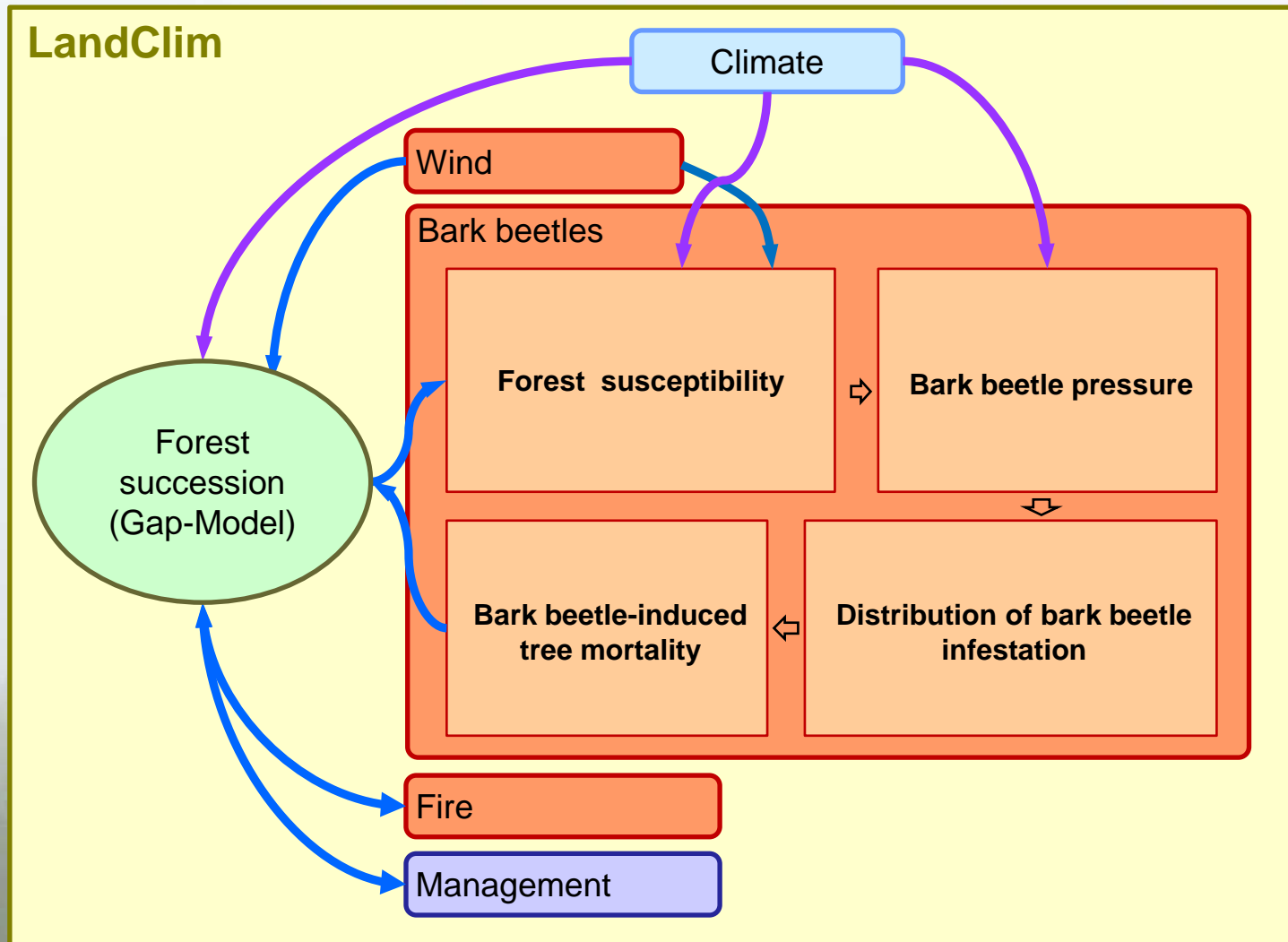


# Bark beetle interactions with drought and wind disturbance

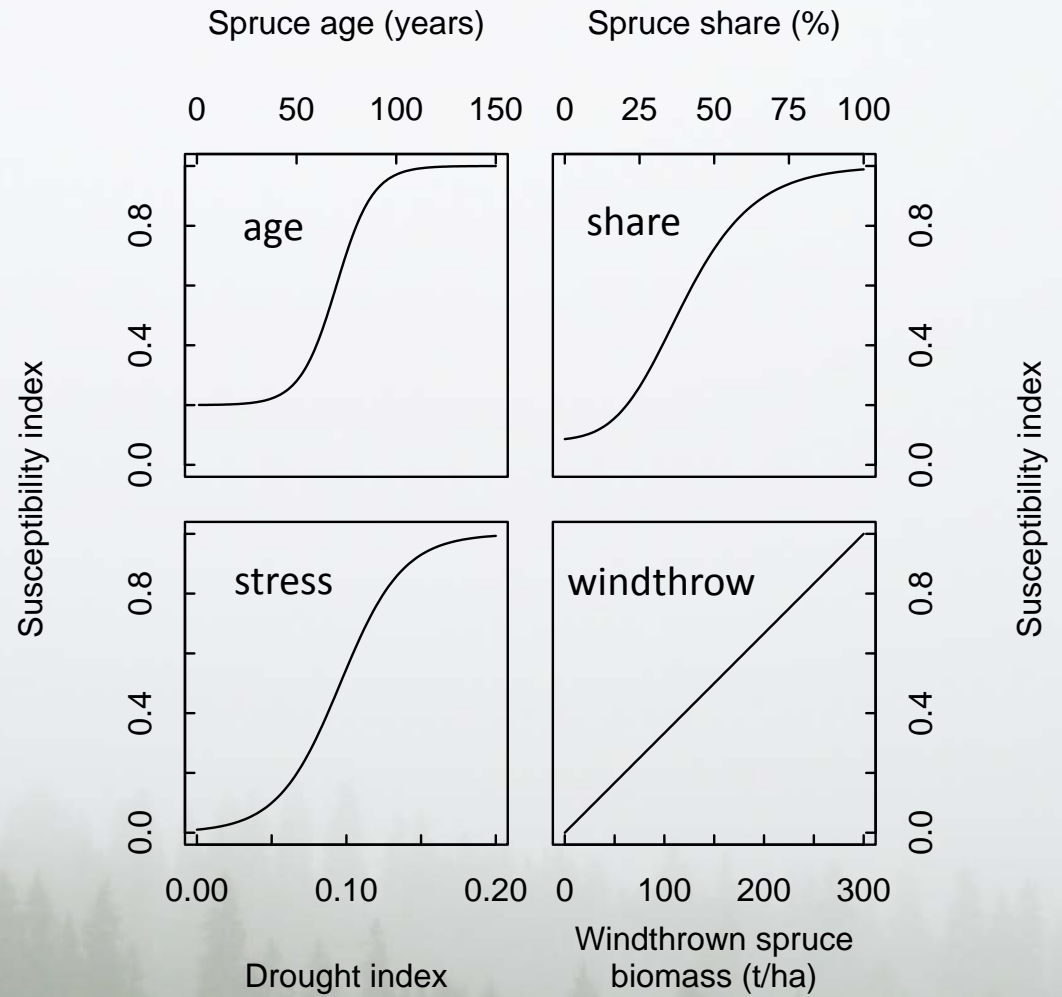




# Dynamic beetle/forest model



# Forest susceptibility

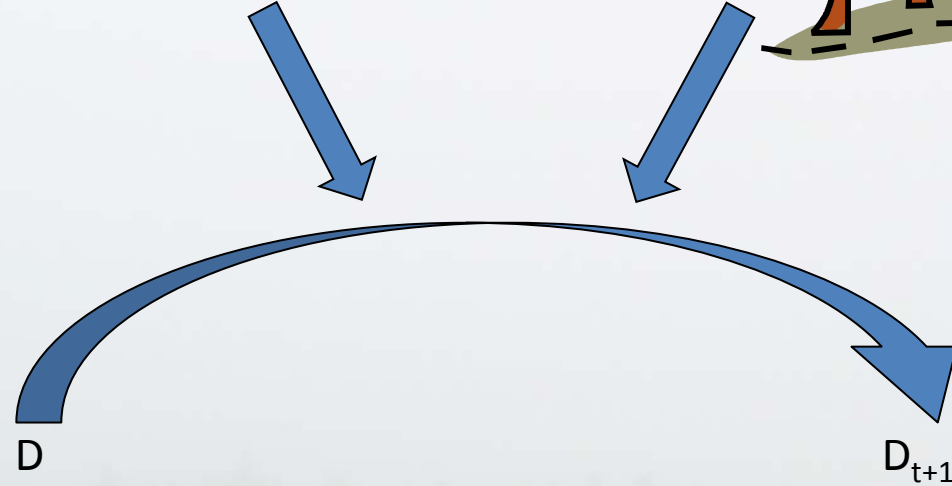


# Beetle pressure

Temperature  
(PHENIPS,  
Baier et al. 2007)



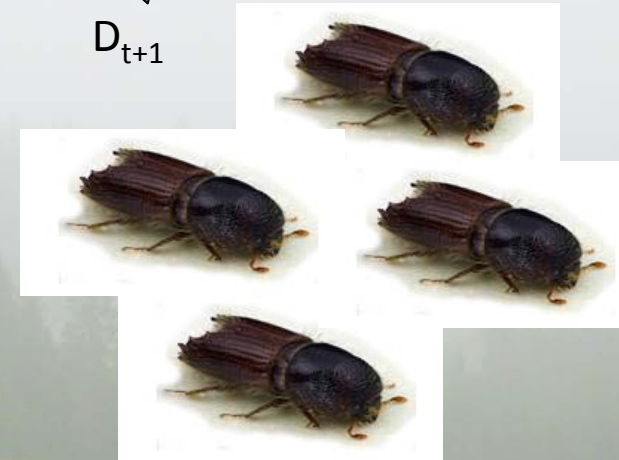
Forest  
susceptibility



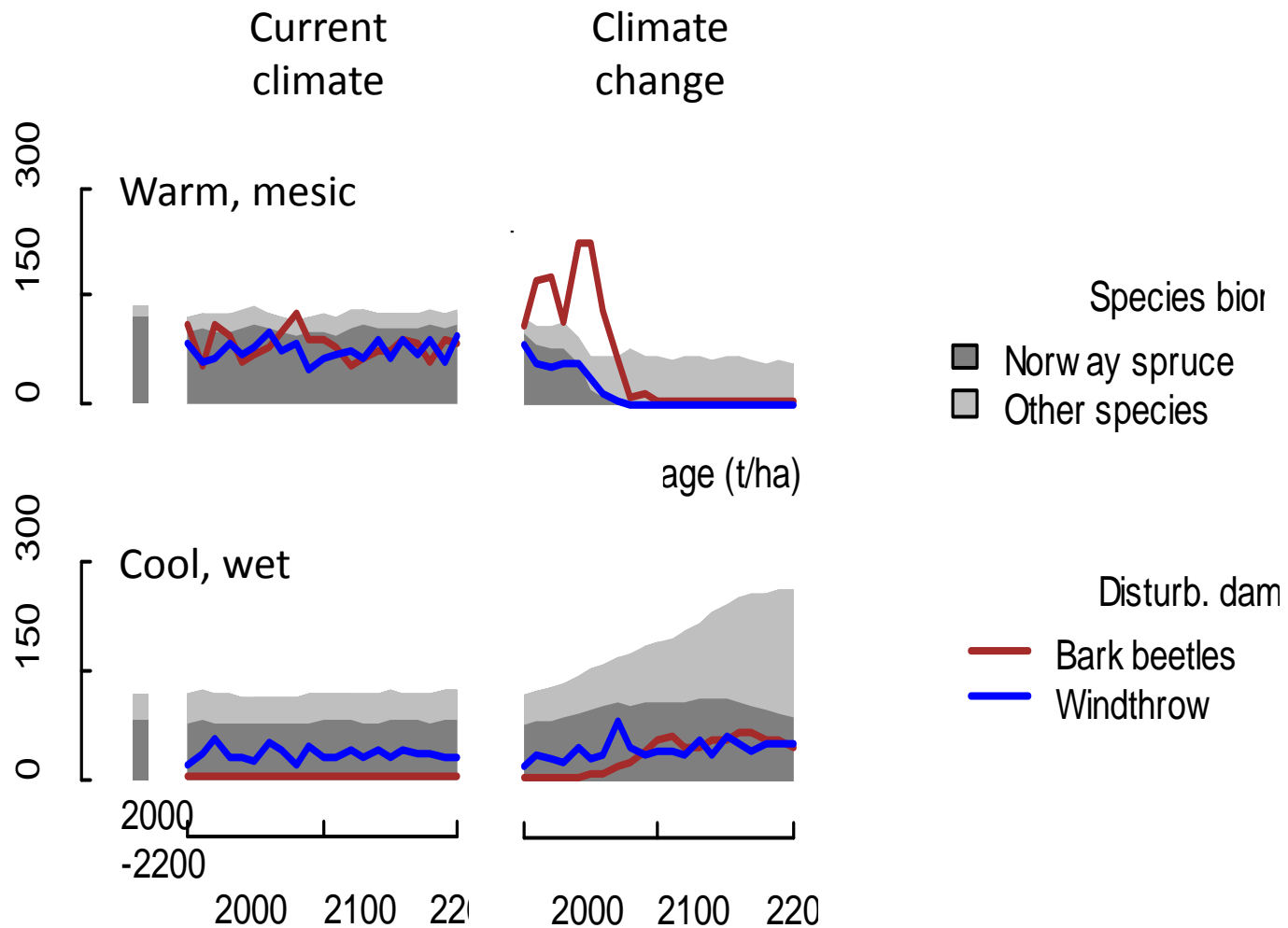
Beetle  
pressure



Beetle-killed biomass





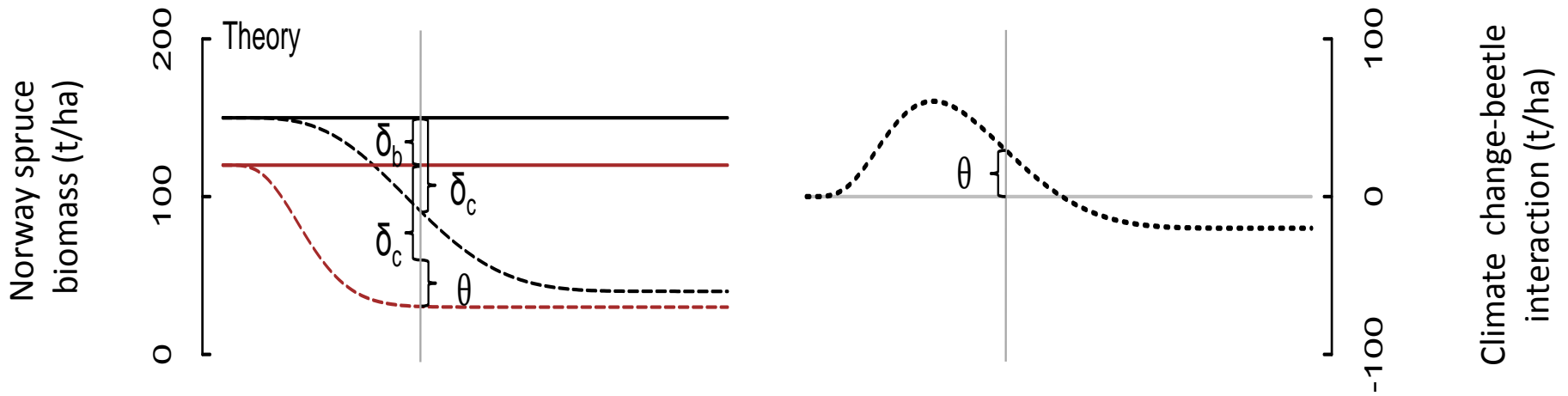


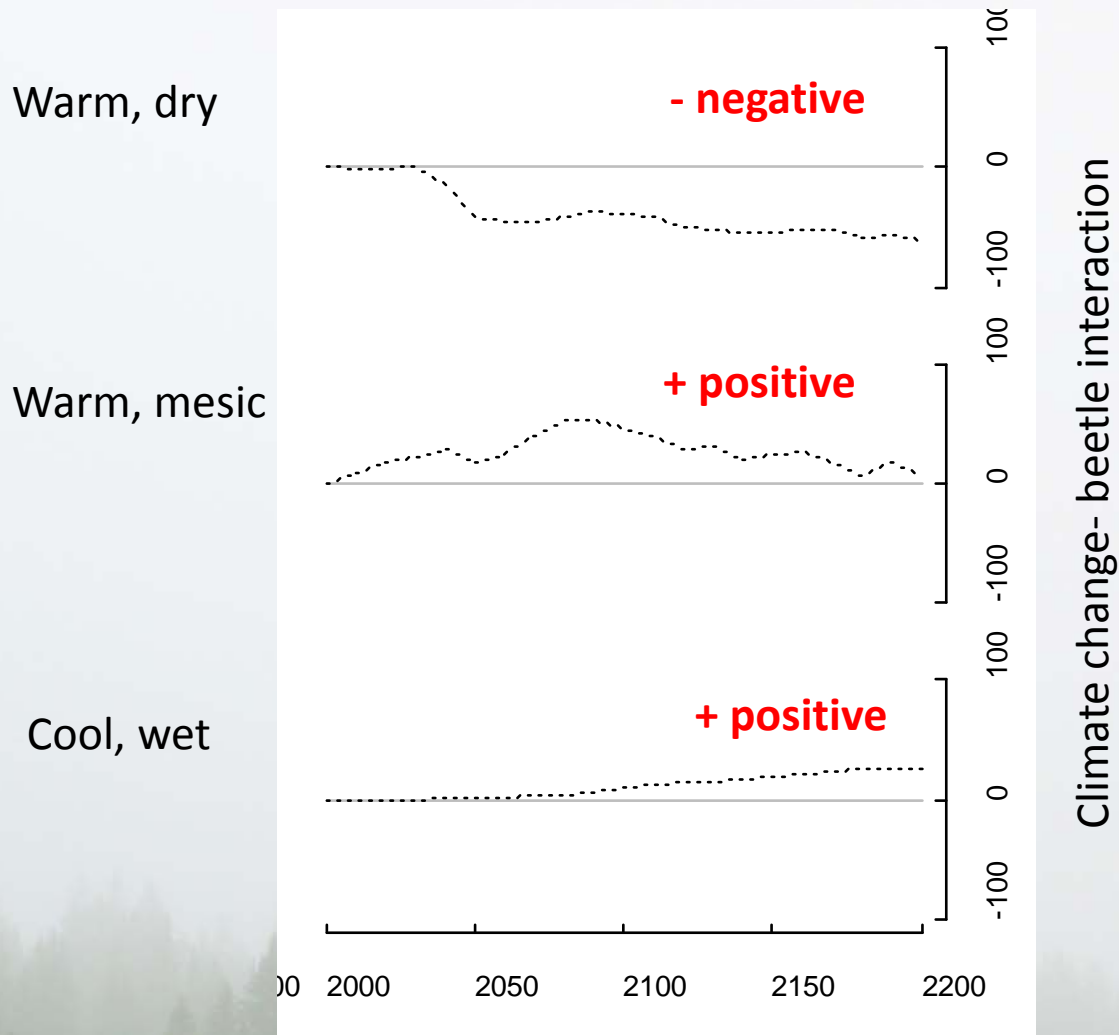
Temperli et al. 2013. Ecological Monographs

# Forest interactions

- Baseline
- Current climate, beetles
- - - Climate change (HCCPR), no beetles
- - - Climate change (HCCPR), beetles

..... Climate change-beetle interaction (t/ha)

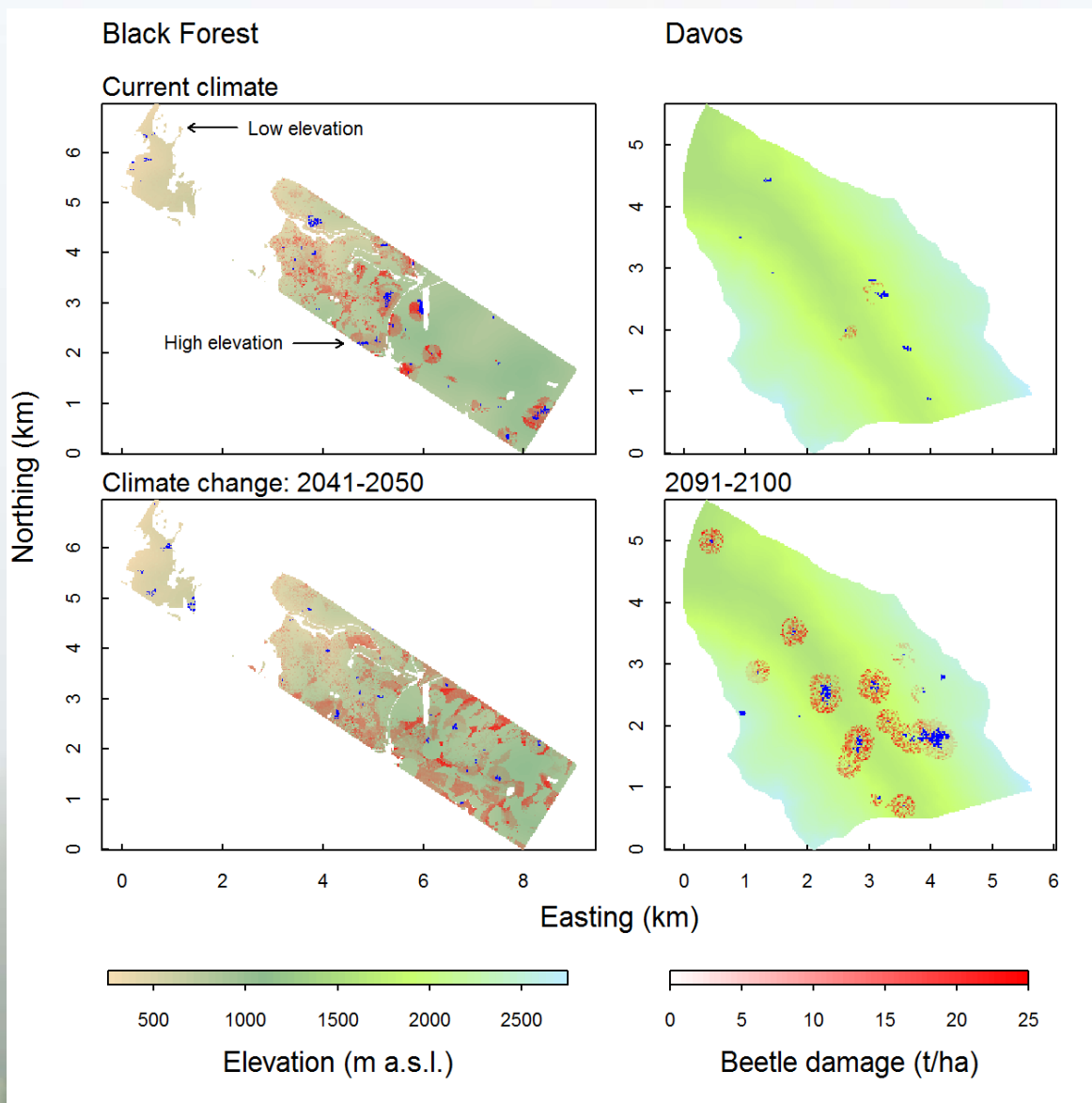




Temperli et al. 2013. Ecological Monographs



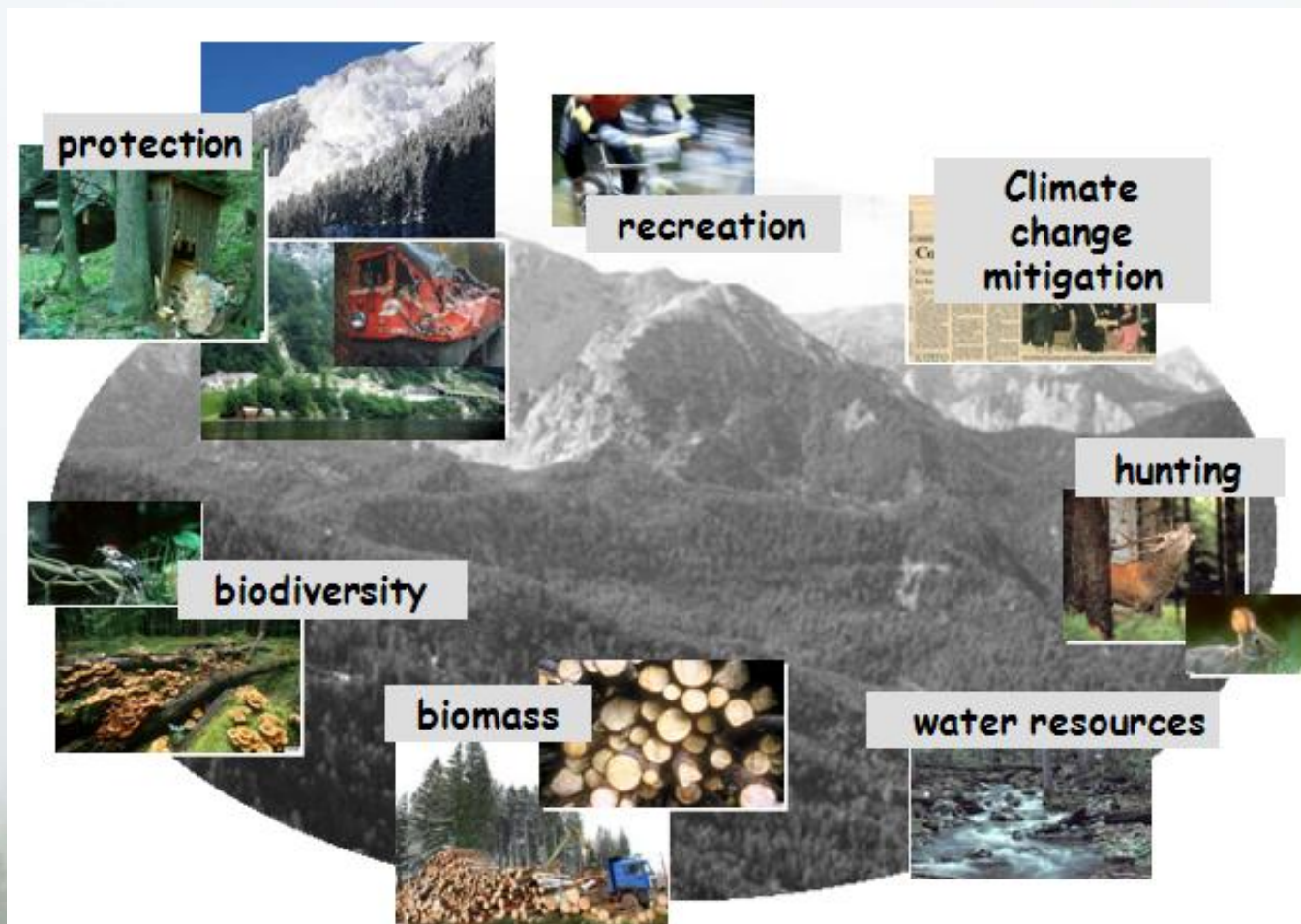
# Infestation triggers



# Forest ecosystem services

1. Drivers of forest dynamics
2. Climate impact
3. Landscape disturbances
4. **Forest ecosystem services**
5. Adaptive management

# Climate impacts on forest ecosystem services



Forest multifunctionality

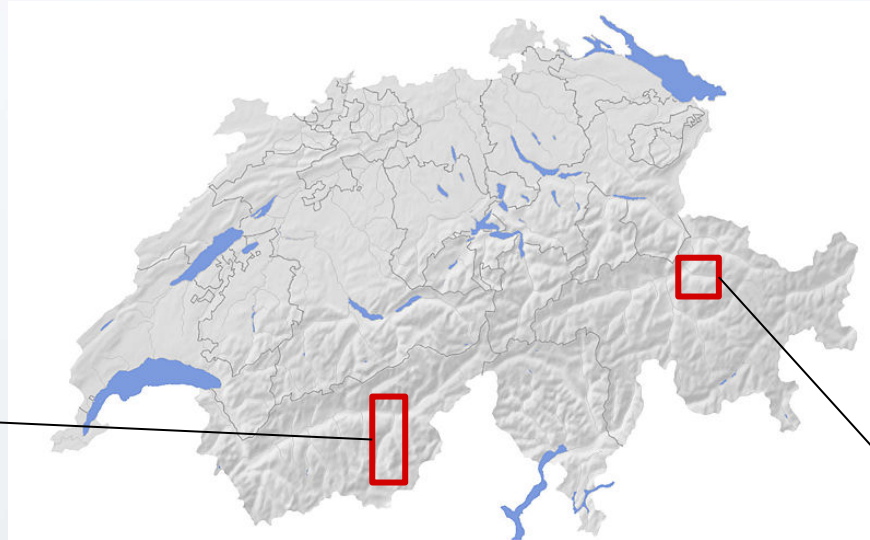
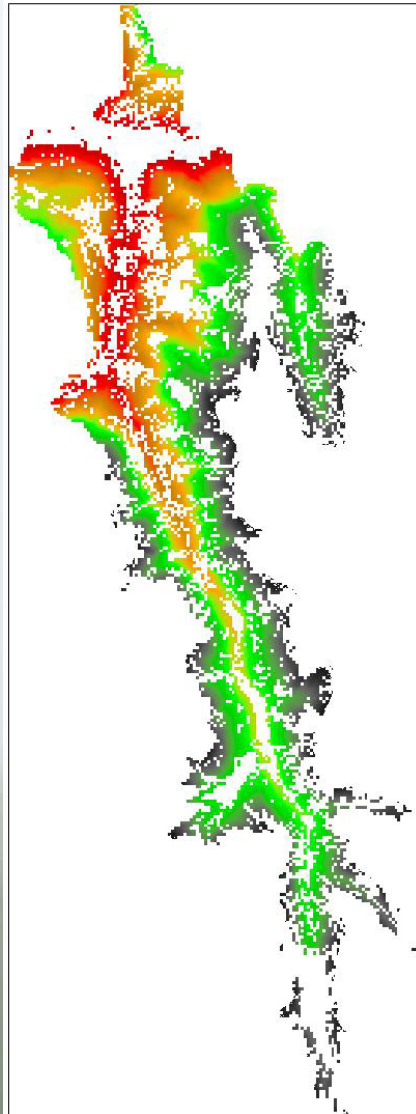


# Forest ecosystem services

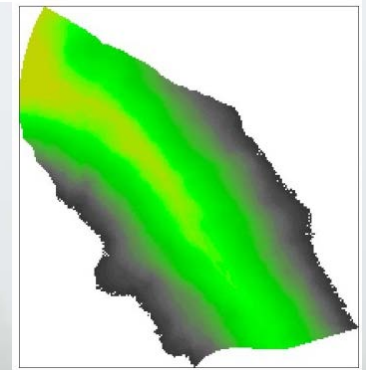
- Which forest ES are at risk?
- Where are these ES at risk?
- When will ES provision be impacted?

# Climate sensitivity?

Saas Valley



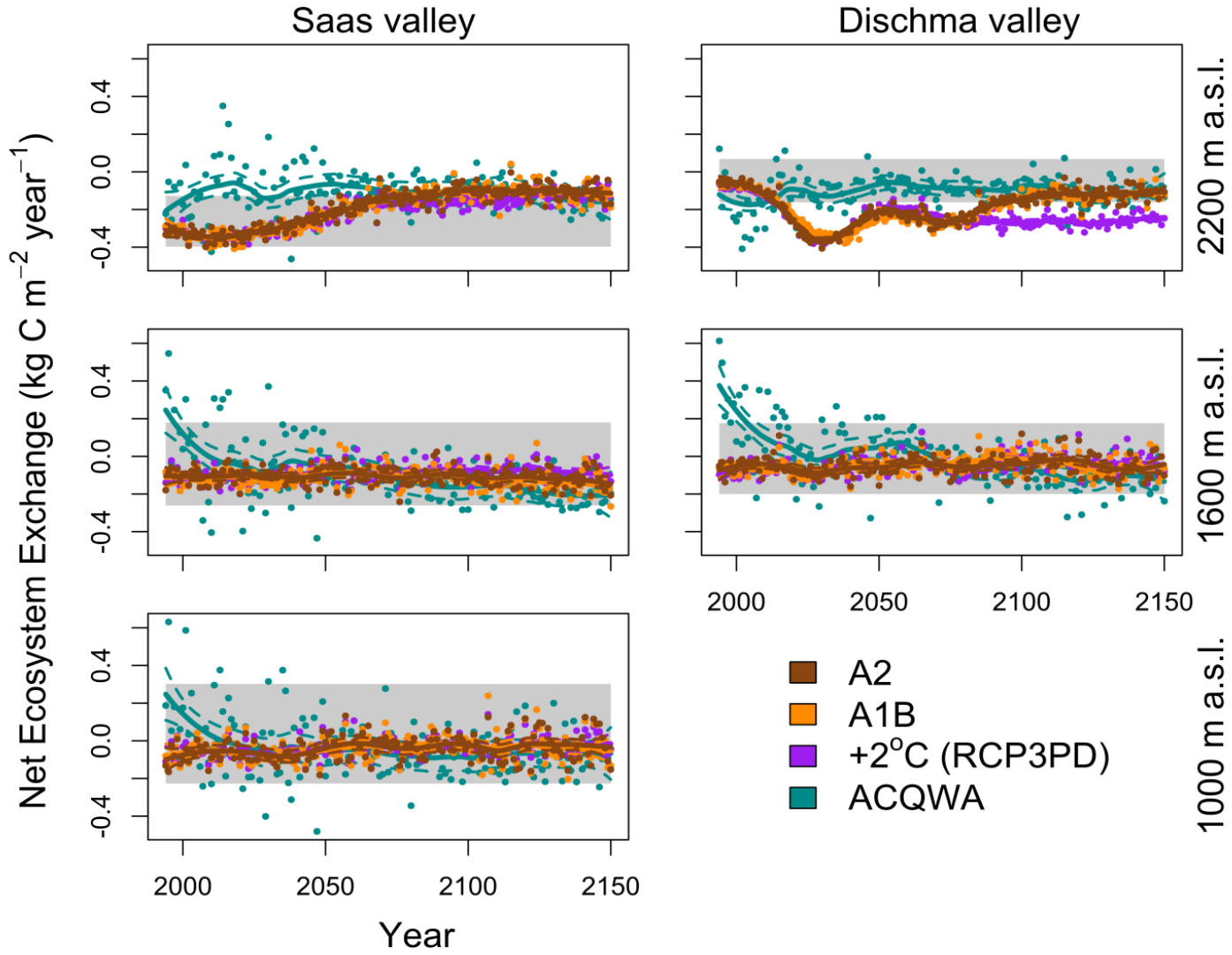
Dischma Valley



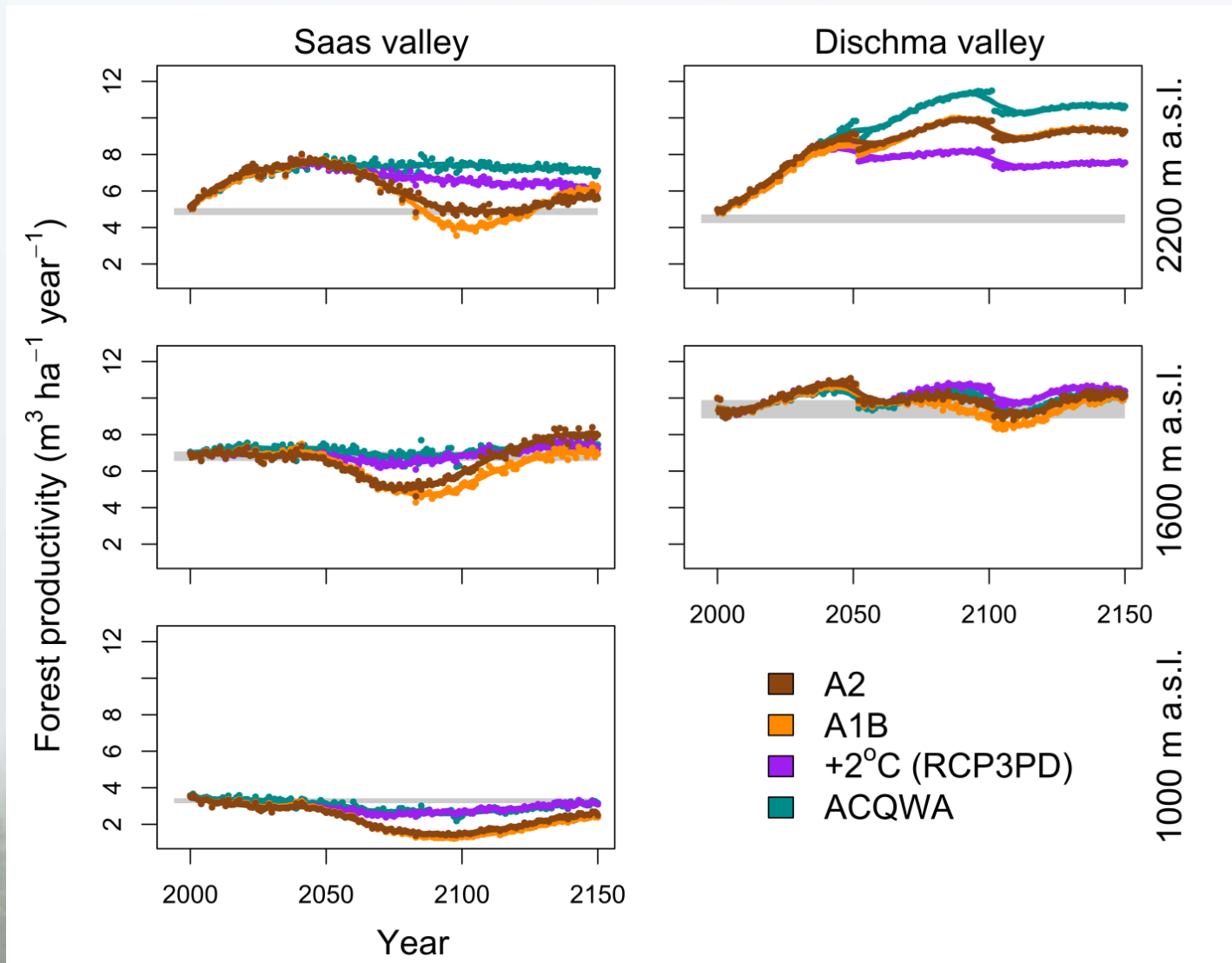
## Forest ES

- Biodiversity
- Carbon storage
- Timber
- Protection
- Bio-fuel


# Carbon



# Potential forest productivity (timber)





A background image of a dense forest of evergreen trees, heavily shrouded in mist or fog. The trees are dark green and silhouetted against a pale, hazy sky. The overall atmosphere is serene and somewhat mysterious.

# Adaptive forest management and forest health

1. Drivers of forest dynamics
2. Climate impact
3. Landscape disturbances
4. Forest ecosystem services
5. Adaptive management

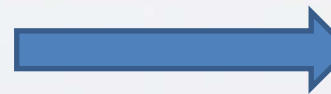
# Potential role of adaptive forest management in mitigating future drought stress



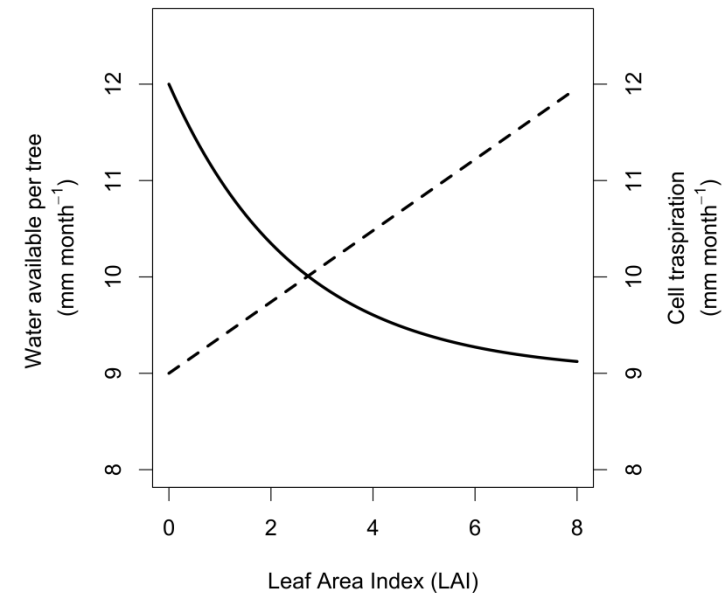
Thinning



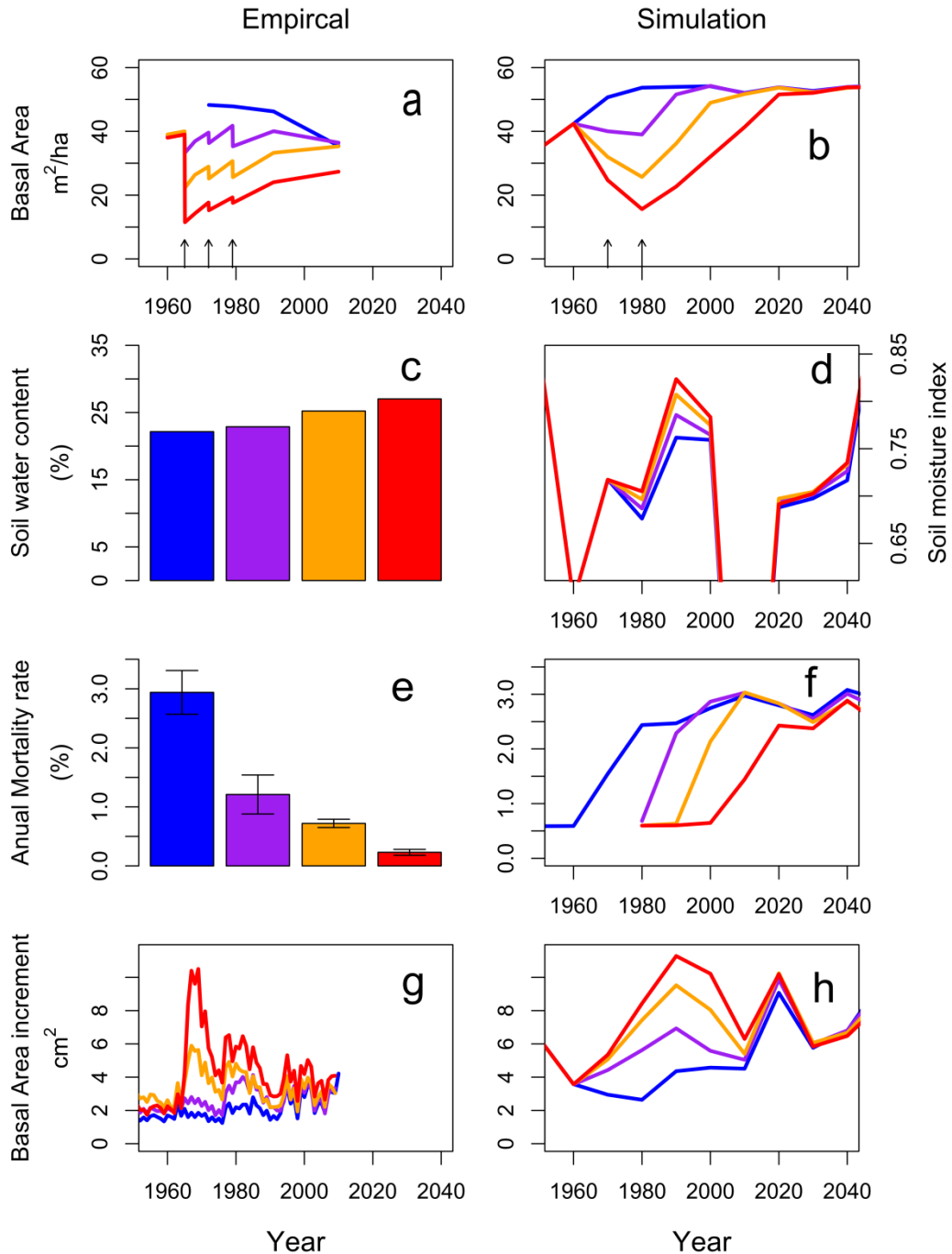
Decreased  
light competition

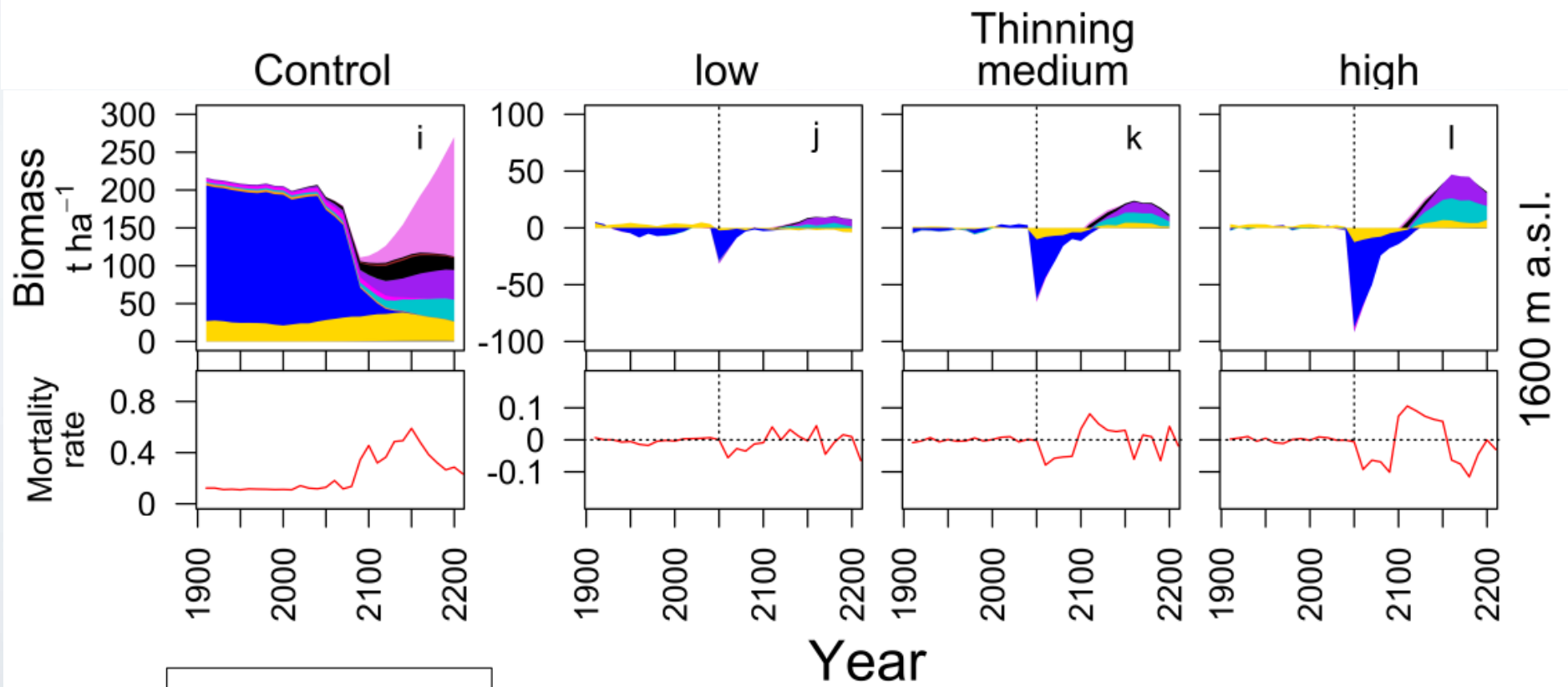


Increased  
water availability



# Drought stress and adaptive management





- *Abies alba*
- *Larix decidua*
- *Picea abies*
- *Pinus cembra*
- *Pinus mugo*
- *Pinus sylvestris*
- *Acer pseudoplatanus*
- *Quercus petraea*
- *Quercus robur*
- *Acer campestre*
- *Acer platanoides*
- *Fraxinus excelsior*
- *Quercus pubescens*
- *Sorbus aria*
- *Tilia platyphyllos*





**Lessons for sub-boreal, boreal mixed forests?**





- **Climate sensitive processes**
- **Regional differences (sensitivity, magnitude, timing)**
- **Interactions between direct and indirect impacts**
- **Forest multifunctionality, different responses**
- **Adaptive management, long term impacts**



# Questions, Thoughts

