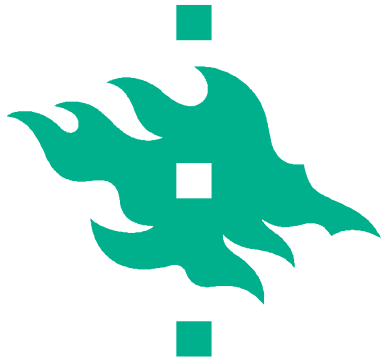


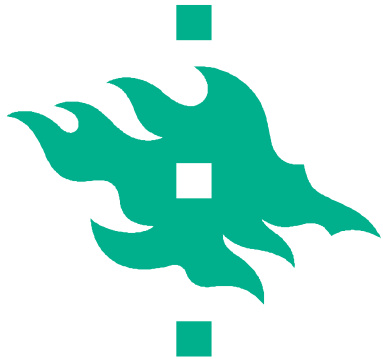
Significance of adaptation for forest management and economic returns in forests under transition due to climate change

Eero Nikinmaa, [Annikki Mäkelä](#), Lauri Valsta, Pasi Kolari, Antti Mäkinen, Erkki Tomppo



Background

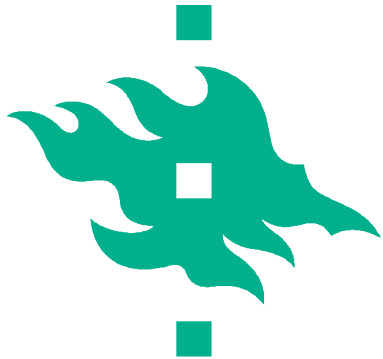
- Climate change is generally expected to increase growth potential in boreal forests
- Some studies predict increased probability of drought and other adverse effects
- How will forest management adapt to these changes?
- How are the changes in growth potential and forest management reflected in the forested landscape in the next century?



Objective

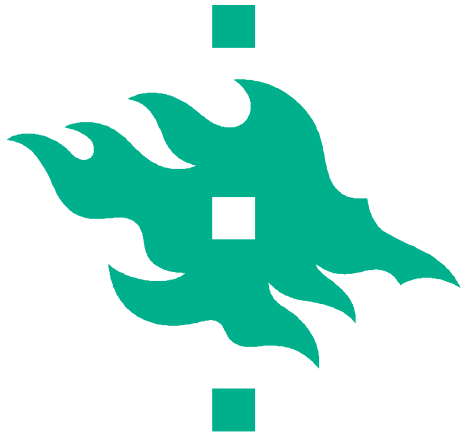
Assess the significance of management adaptations for forest production and economic returns

- climate change and management decision scenarios
- existing forest management unit (FMU)
- from present day to 2100

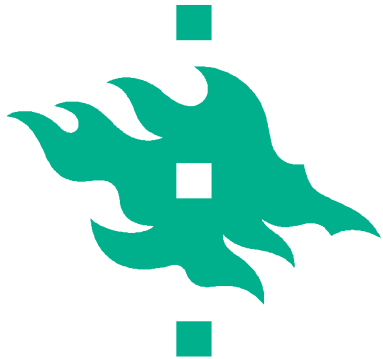


Outline

- Method
- Impacts of climate change
- Forest management
- Impacts of climate and forest management
- Conclusions



Method

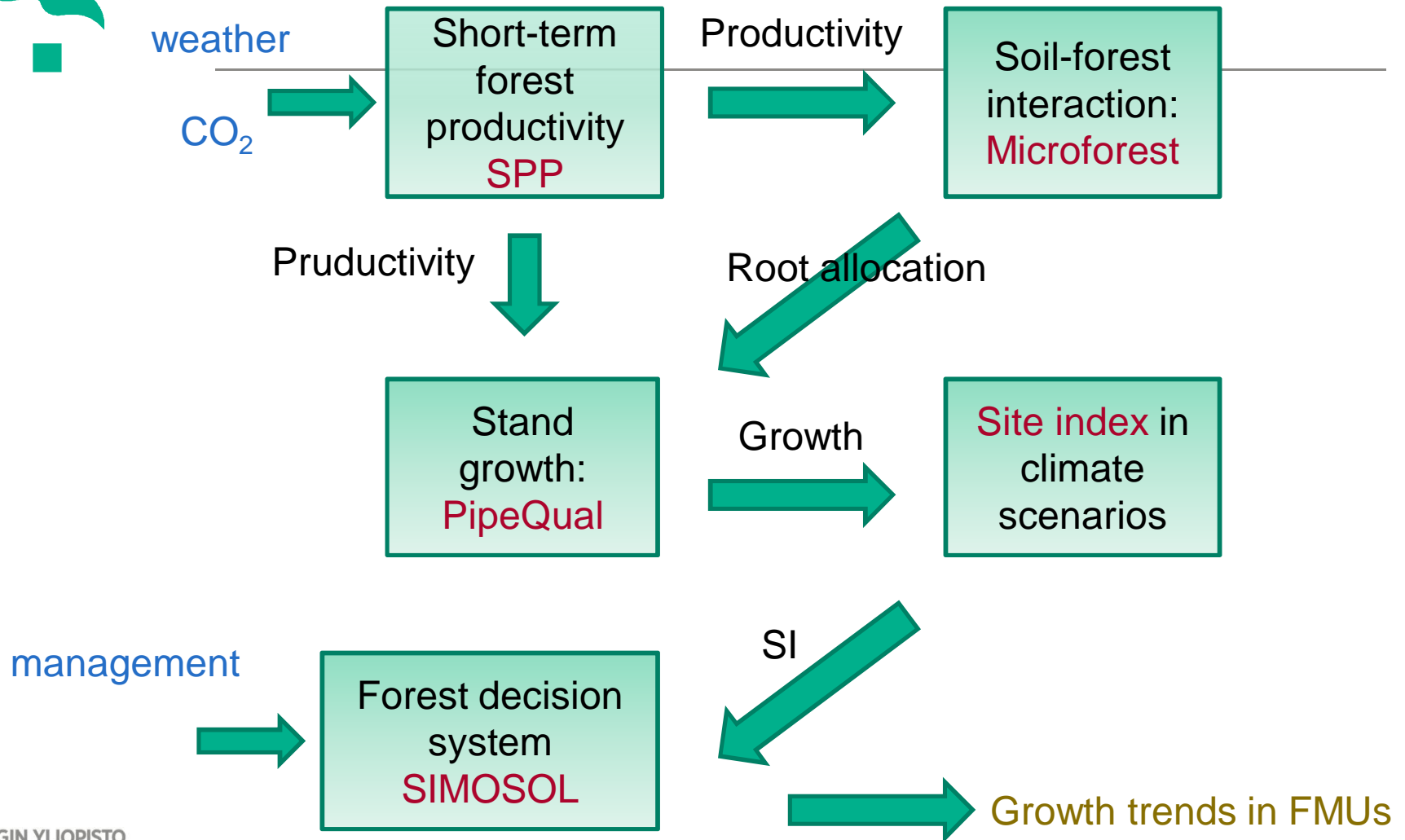


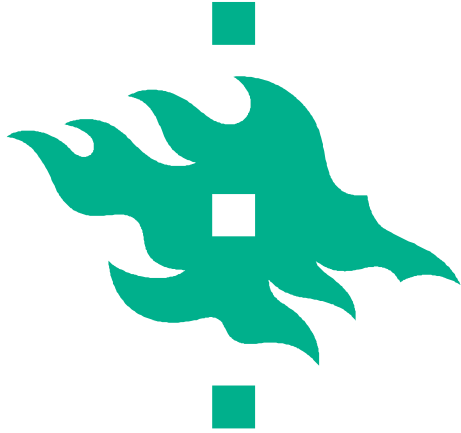
Models – state of the art

- **Models for forest management planning**
 - Decision making in FMU
 - Growth predictions from [static site index](#)
 - = [dominant height at age 100 yrs](#)
- **Models for climate change impacts**
 - Physiological models with short time scale
 - Stand growth models for rotation
 - Soil process models
 - [Variety of inputs, no built-in management-decision procedures](#)

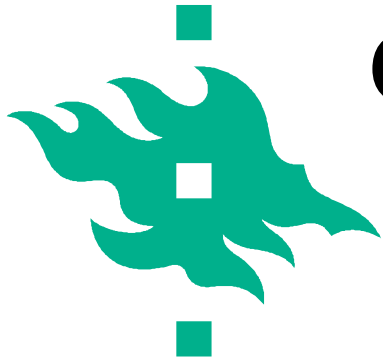


Suite of models



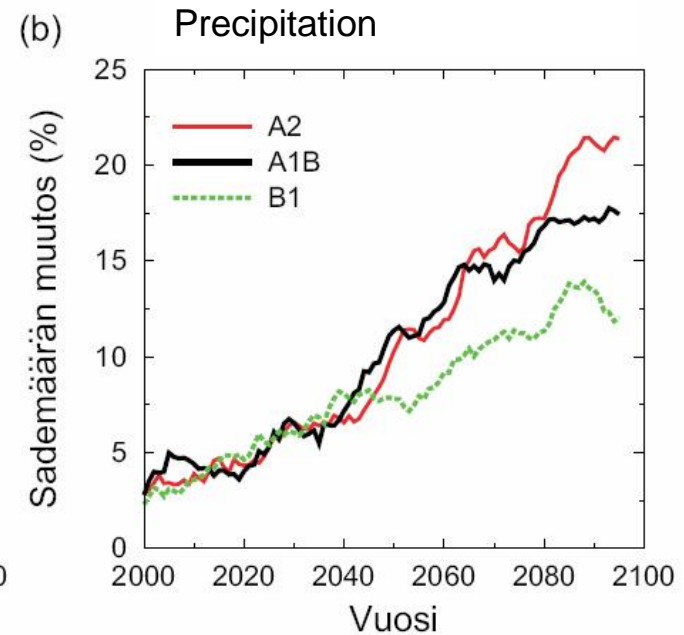
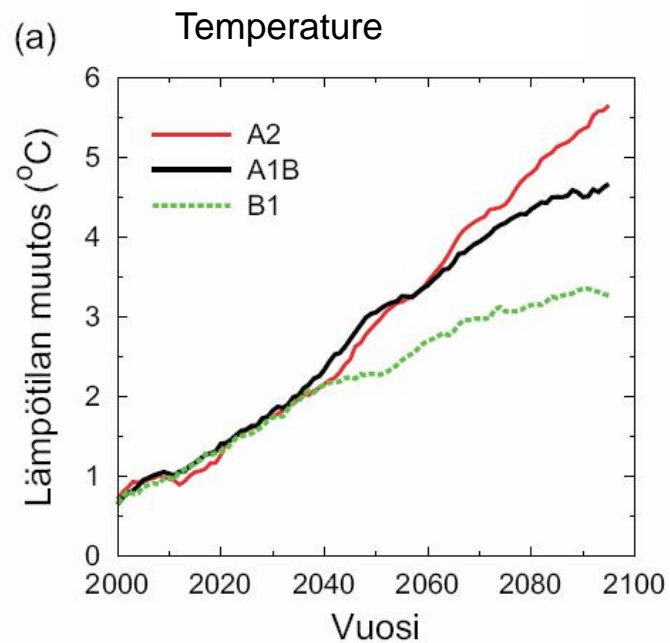
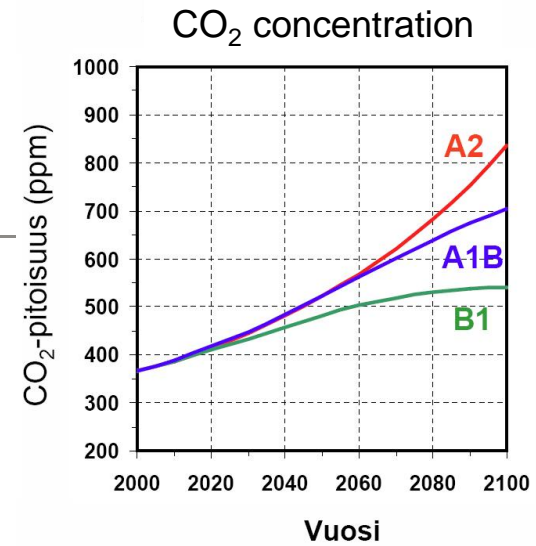


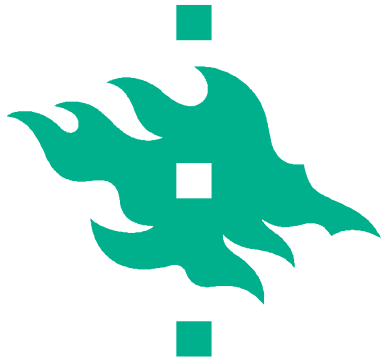
Climate impacts



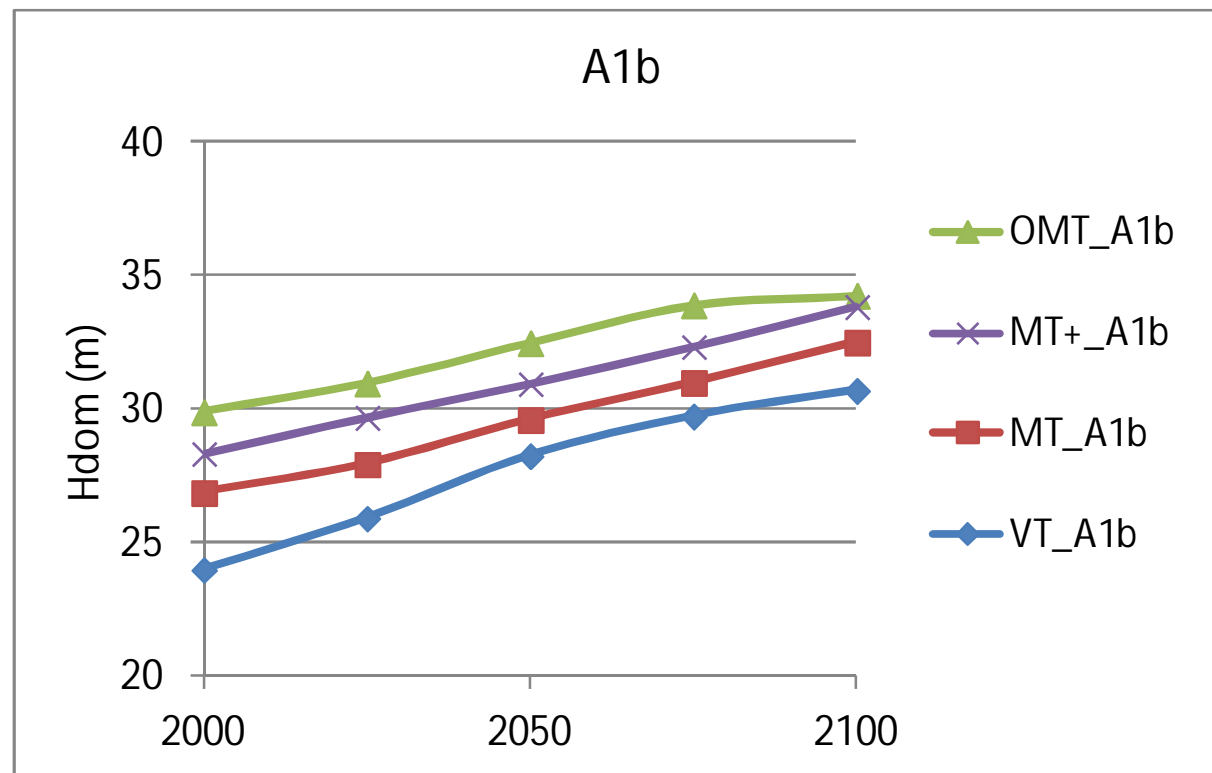
Climate scenarios

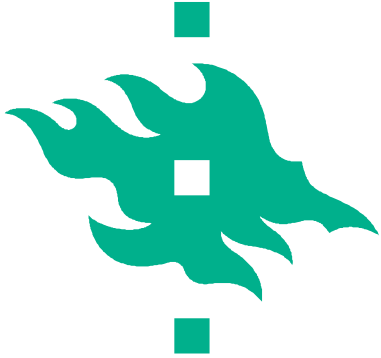
- Current climate - from local record
- B1
- A1B
- A2



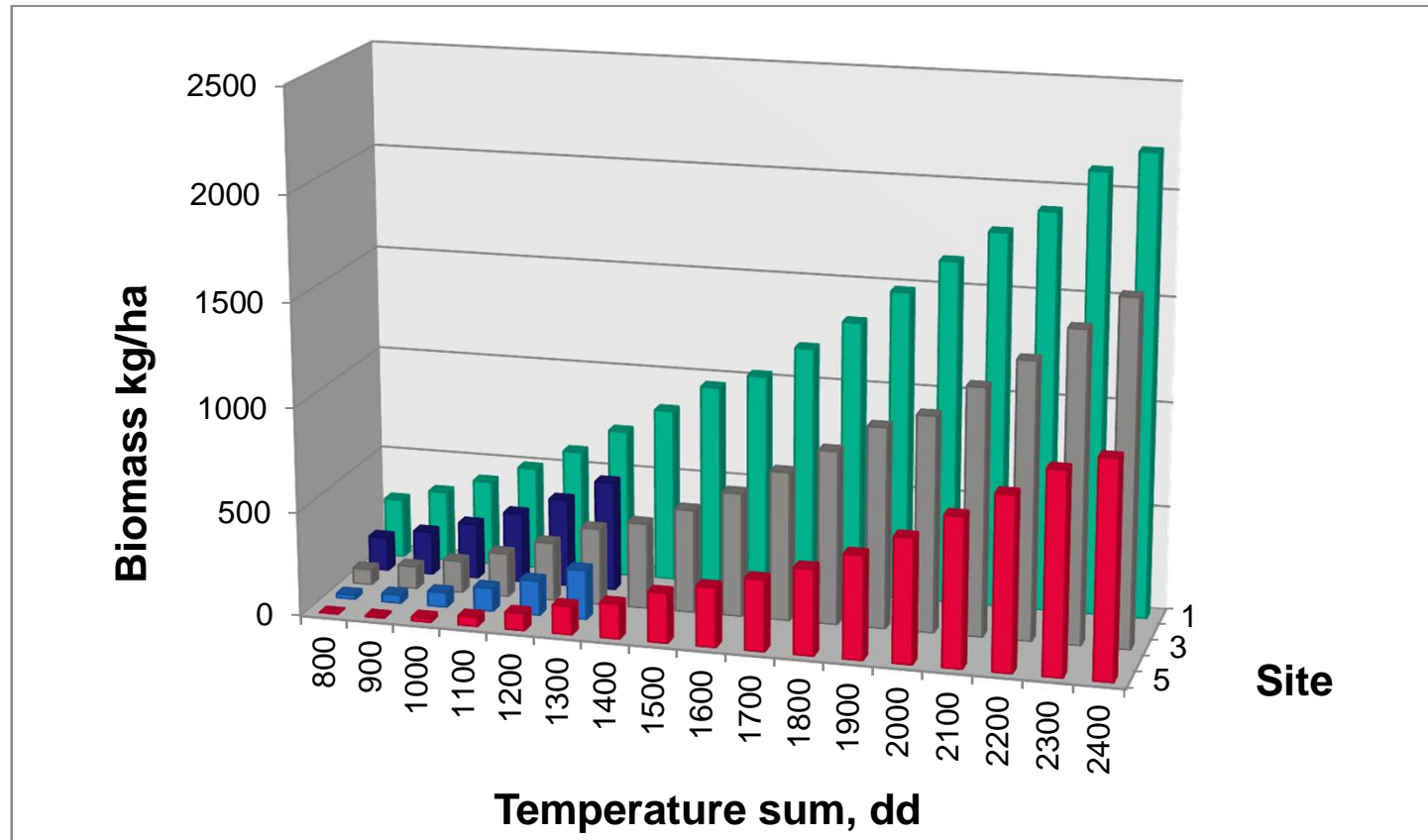


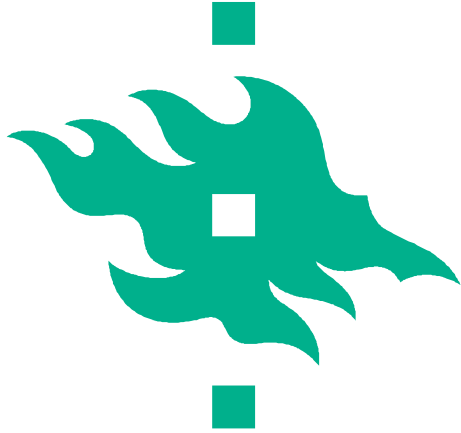
Increased growth => increased site index



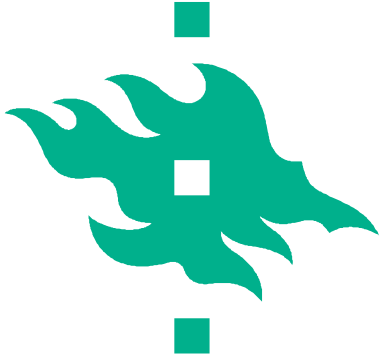


Increased site index => more ground vegetation





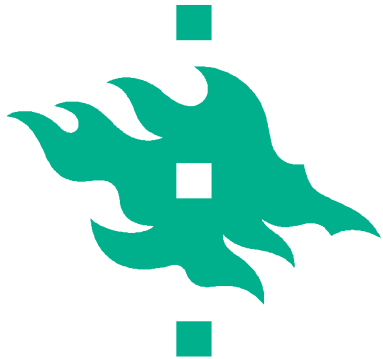
Management



Key management decisions

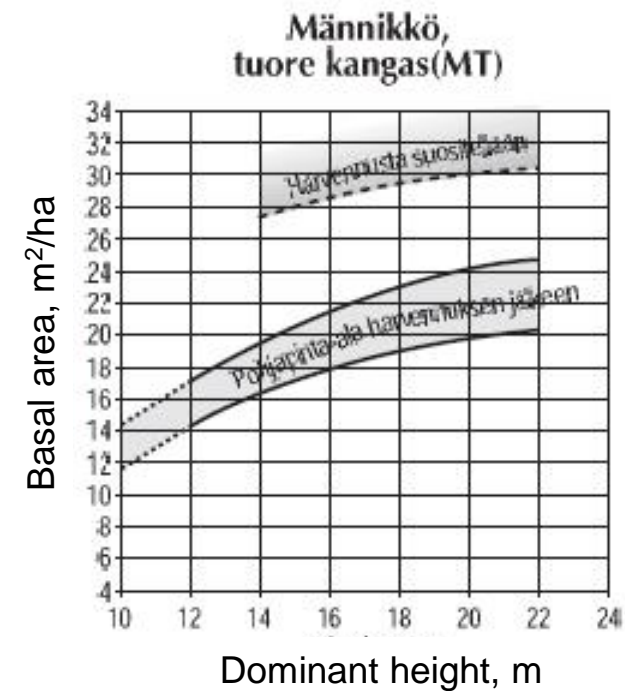
- **Regeneration:**
 - Choice of species
 - Cost of ground vegetation removal
- **Commercial thinnings:**
 - Timing and intensity of harvest
- **Final felling:**
 - Timing

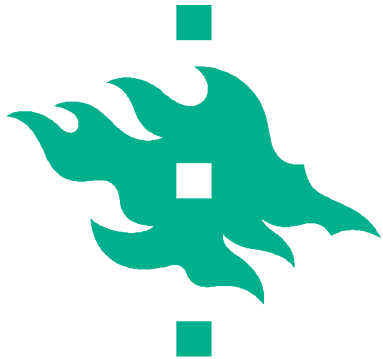




Harvest scenarios

- Current national recommendations issued by Forestry development Centre TAPIO

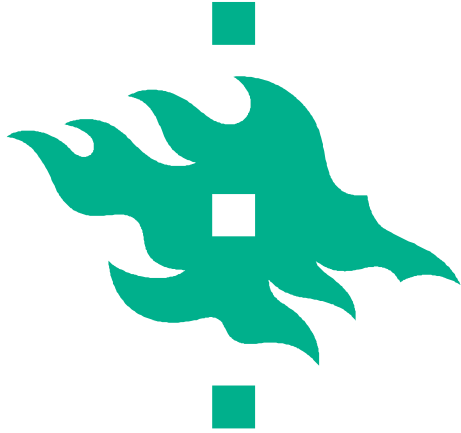




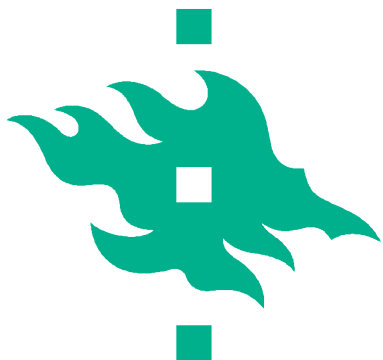
Harvest scenarios

- Adaptive management:
 - Harvest when the rate of value growth goes below current interest rate
 - These simulations assumed 3% interest



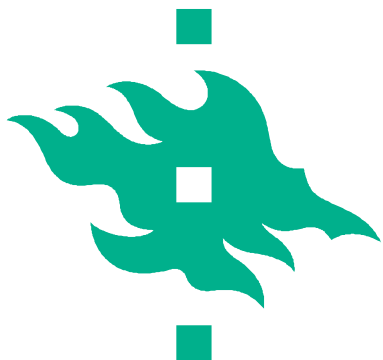


Climate and management impacts



Climate + Management scenarios

Climate	Management	
Reference	Conventional	
B1	Conventional	Adaptive
A1B	Conventional	Adaptive
A2	Conventional	Adaptive

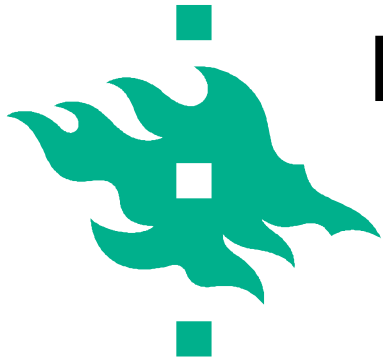


Forestry data

- National multisource forest inventory data (Finnish Forest Research Institute)
- 25 km radius around **SMEAR II** EC tower
- 20 m resolution
- ca 140000 ha

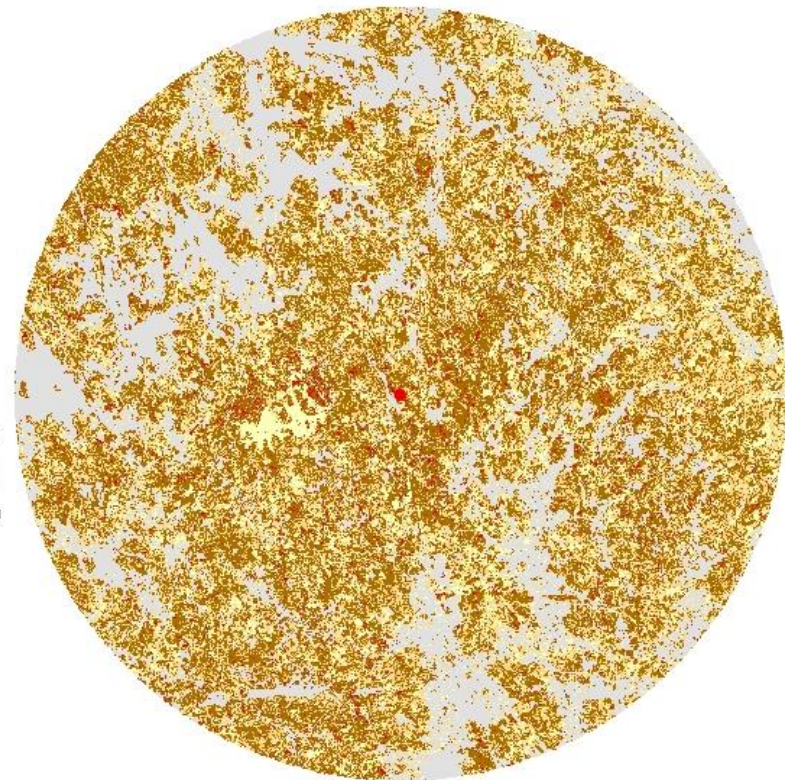
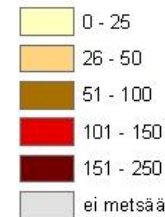


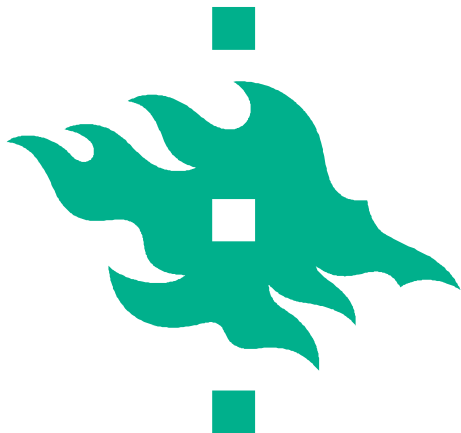
(61° 50' 50.685", 24° 17' 41.206")
www.helsinki.fi/yliopisto



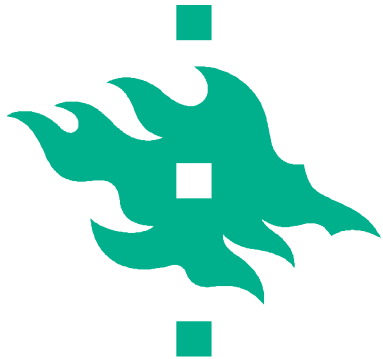
Forestry data

- Land use / cover classes
- Stand age
- Basal area
- Total volume
- Volume by species
 - Pine
 - Spruce
 - Birch
 - Other deciduous
- Example: age distribution

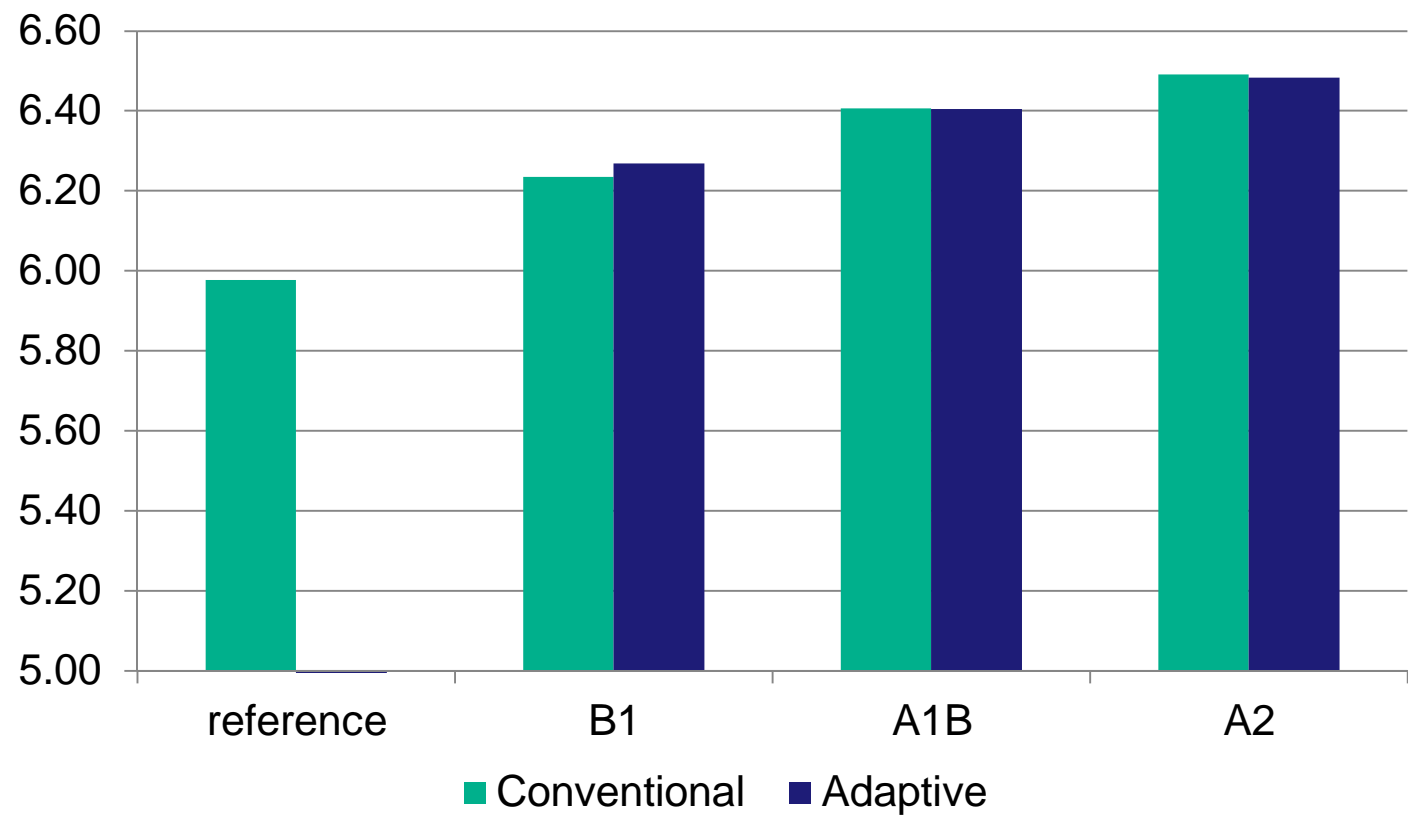


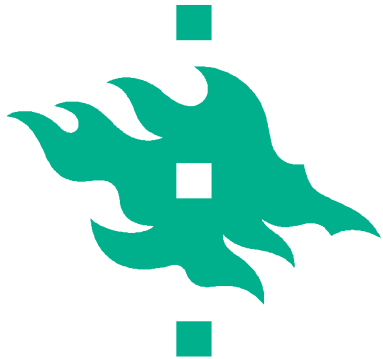


Results

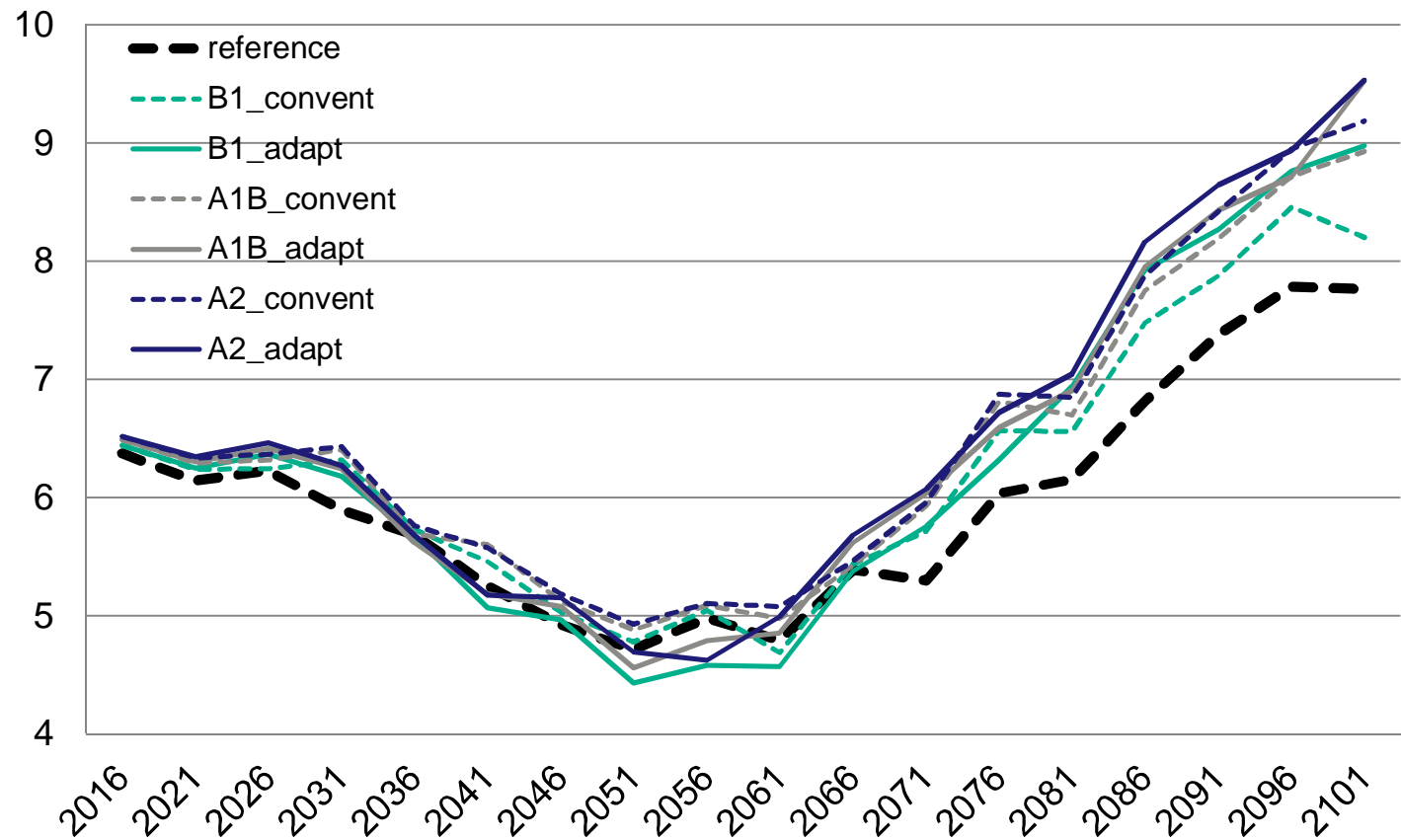


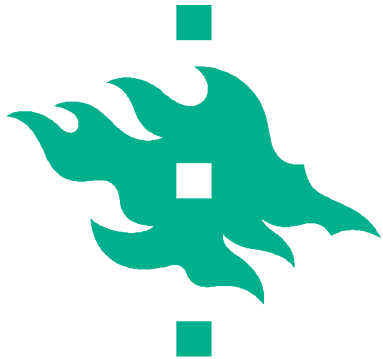
Mean volume growth m³/ha/a



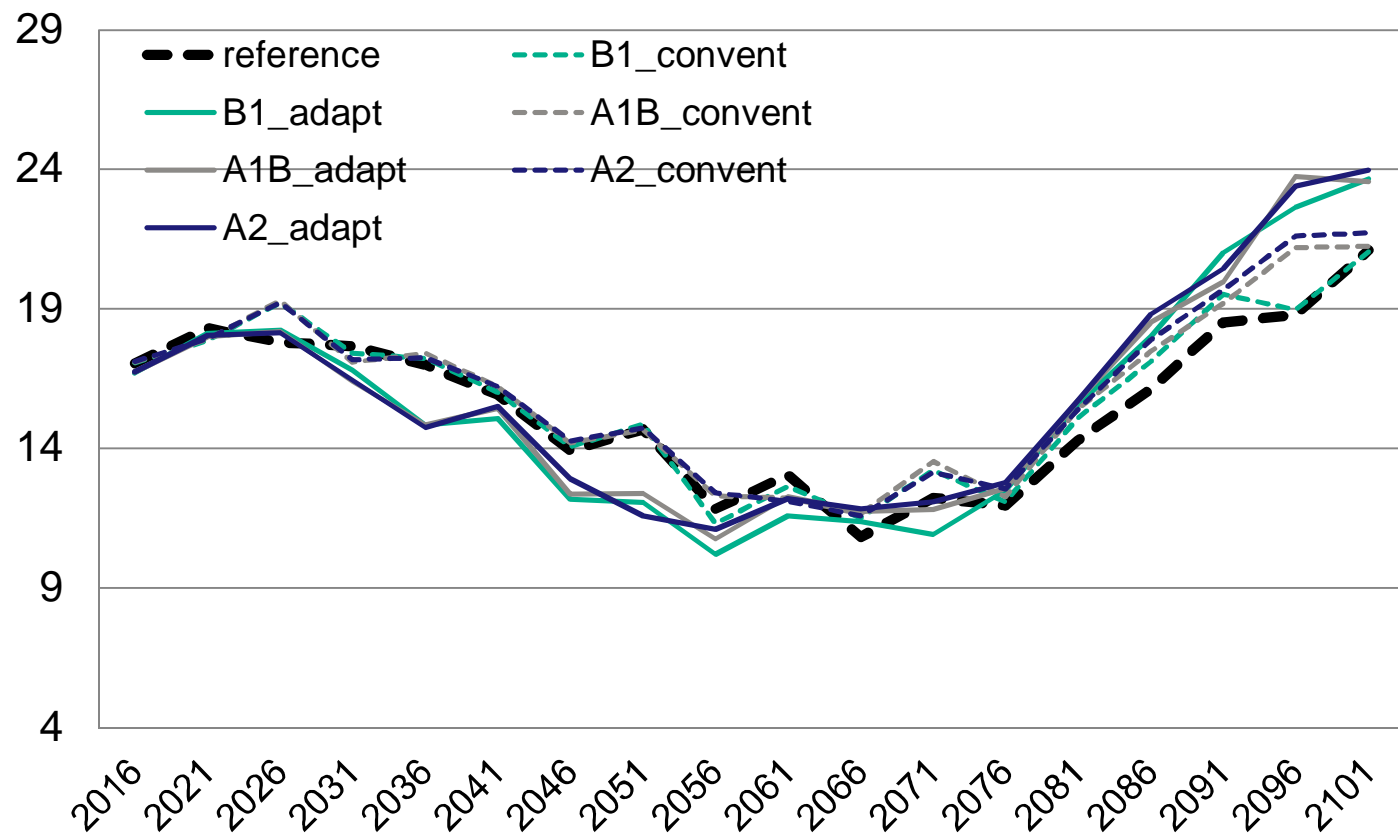


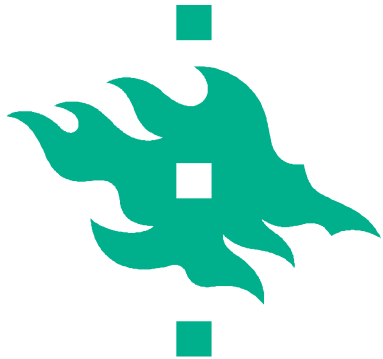
Volume growth m³/ha/a



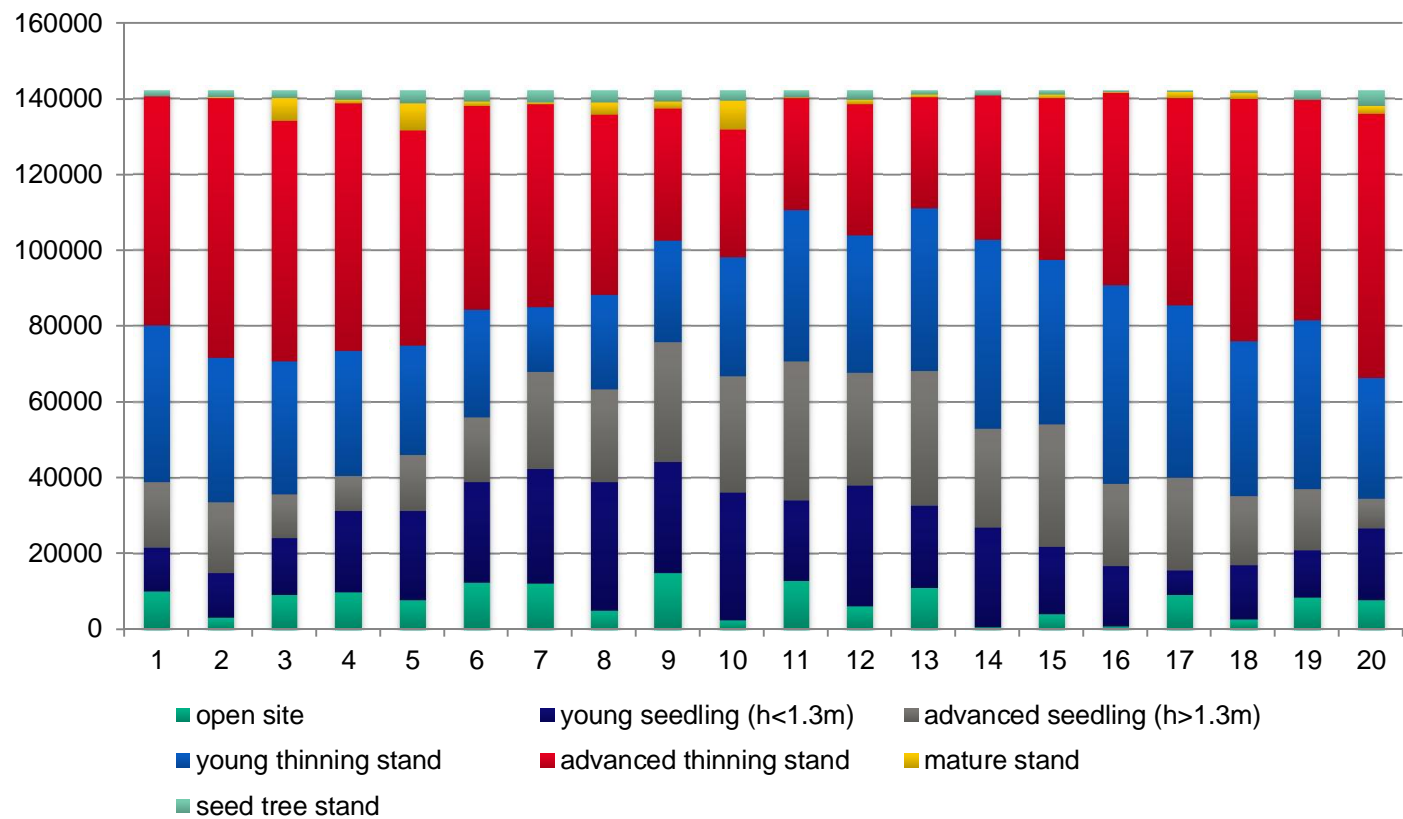


Standing stock volume mill. m³

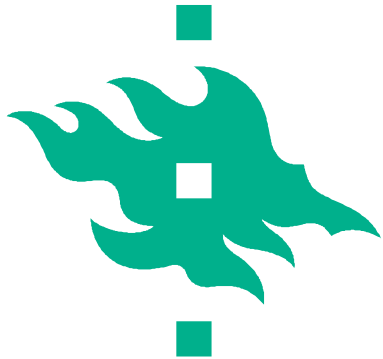




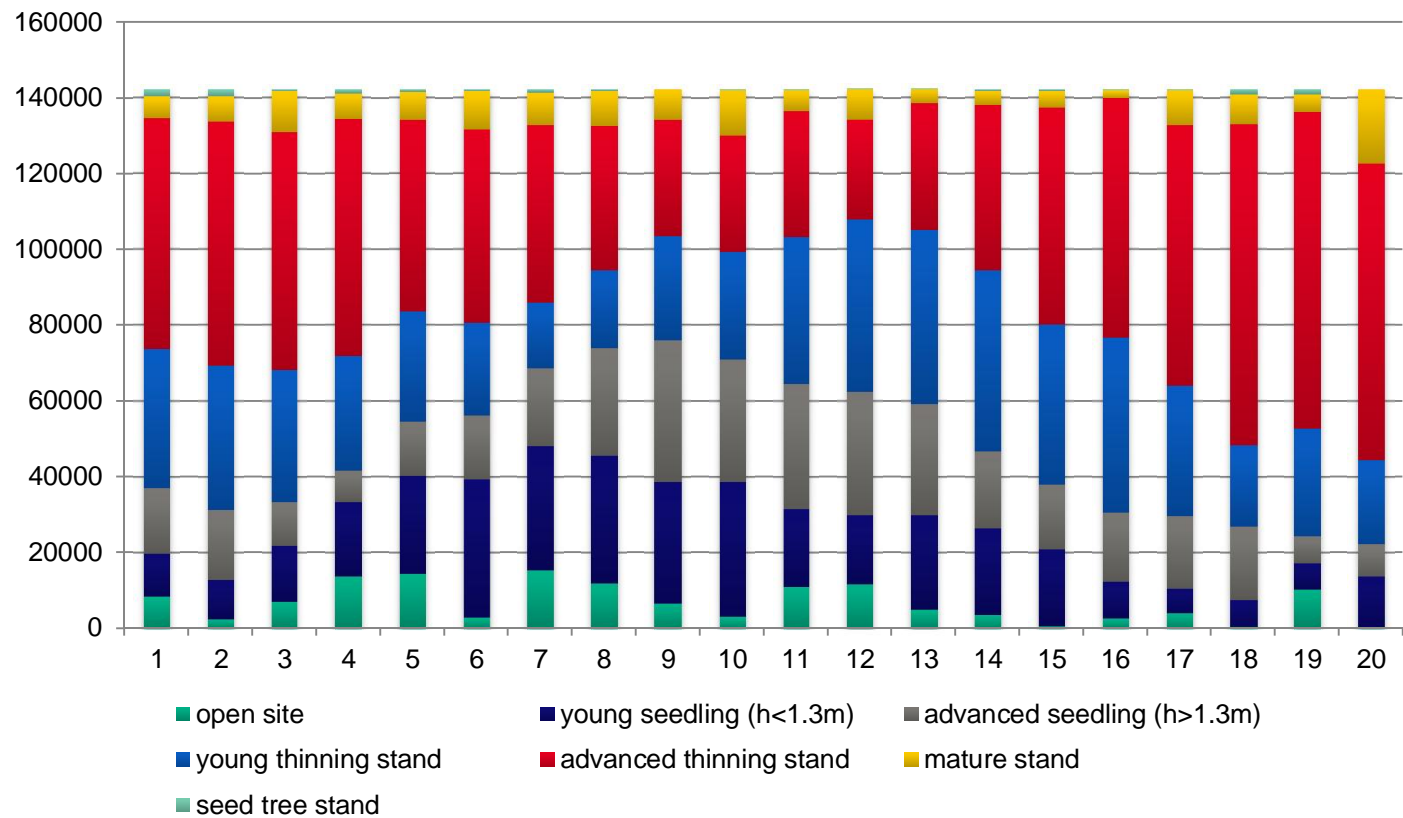
Development class distribution – reference scenario



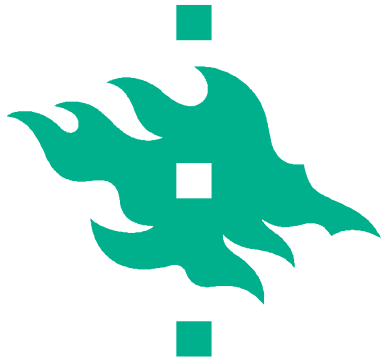
Time - # 5-year terms



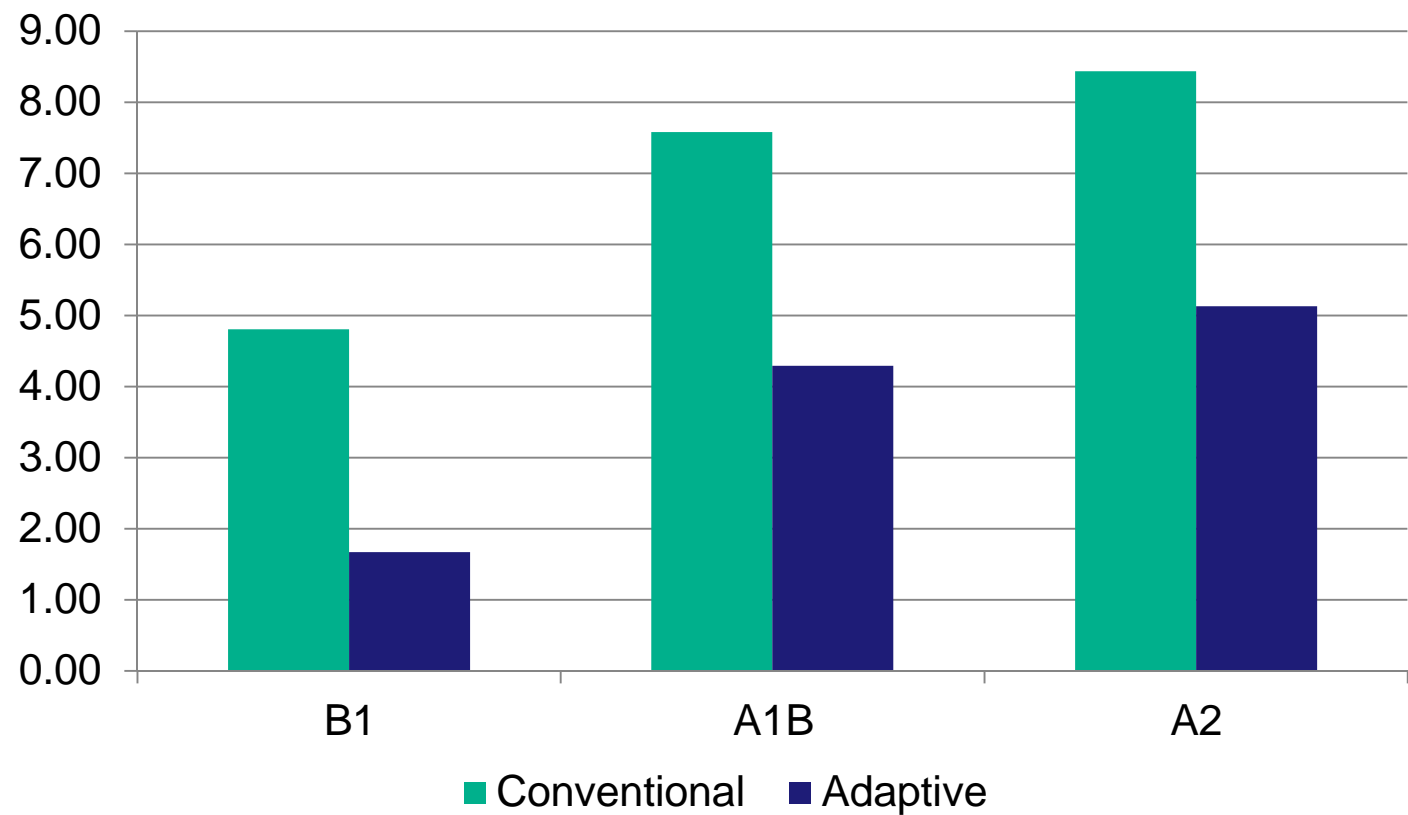
Development class distribution – A2 adaptive

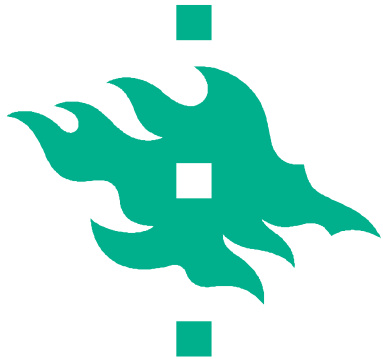


Time - # 5-year terms

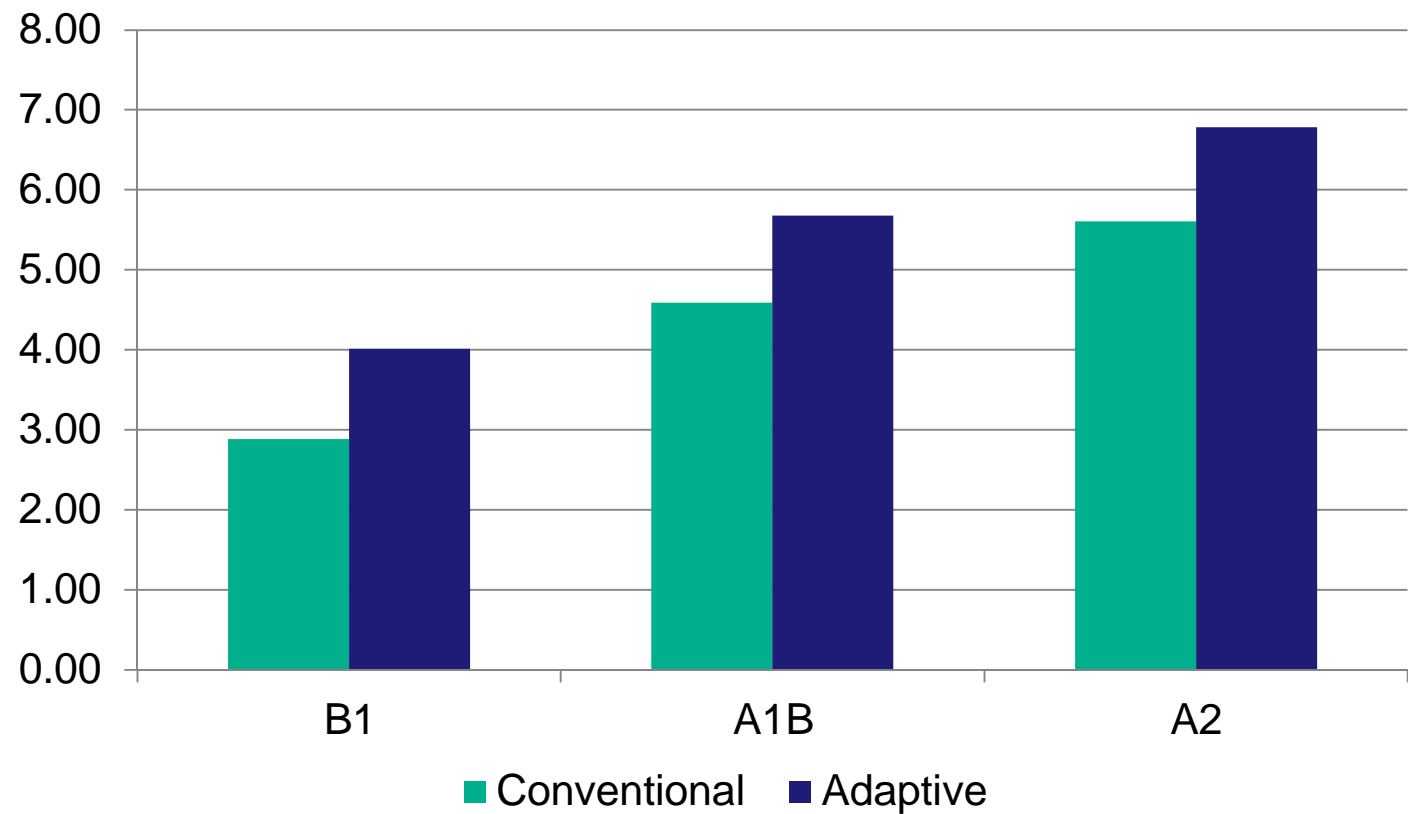


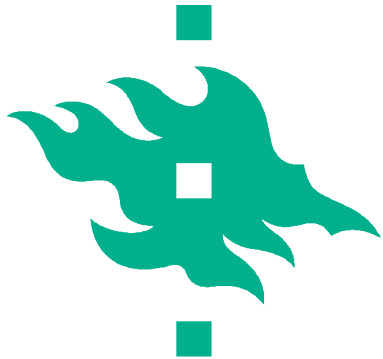
Total harvests – difference from reference (%)





Net Present Value – difference from reference (%)



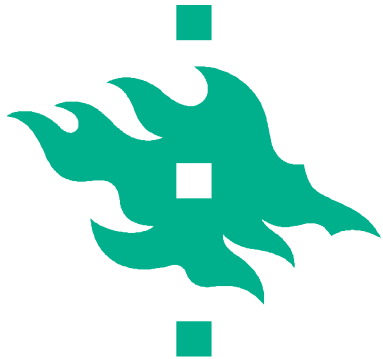


Conclusions and outlook

- Climate change drives total productivity
- Management method determines stand structure and revenue from harvests
- Changing climate moves harvests earlier
- Impacts at FMU scale are less than at stand scale

- Risk of damage not included in this study (wind, fire, insects, dry spells)
- Previous studies show that earlier harvests reduce risk of damage => adaptive management preferred

- **Outlook:** include variability of weather and risk of damage



Key results

- Leaf-specific productivity increases up to 25%
- No significant increase in leaf-specific water use
- Increased N availability
- => increased growth

