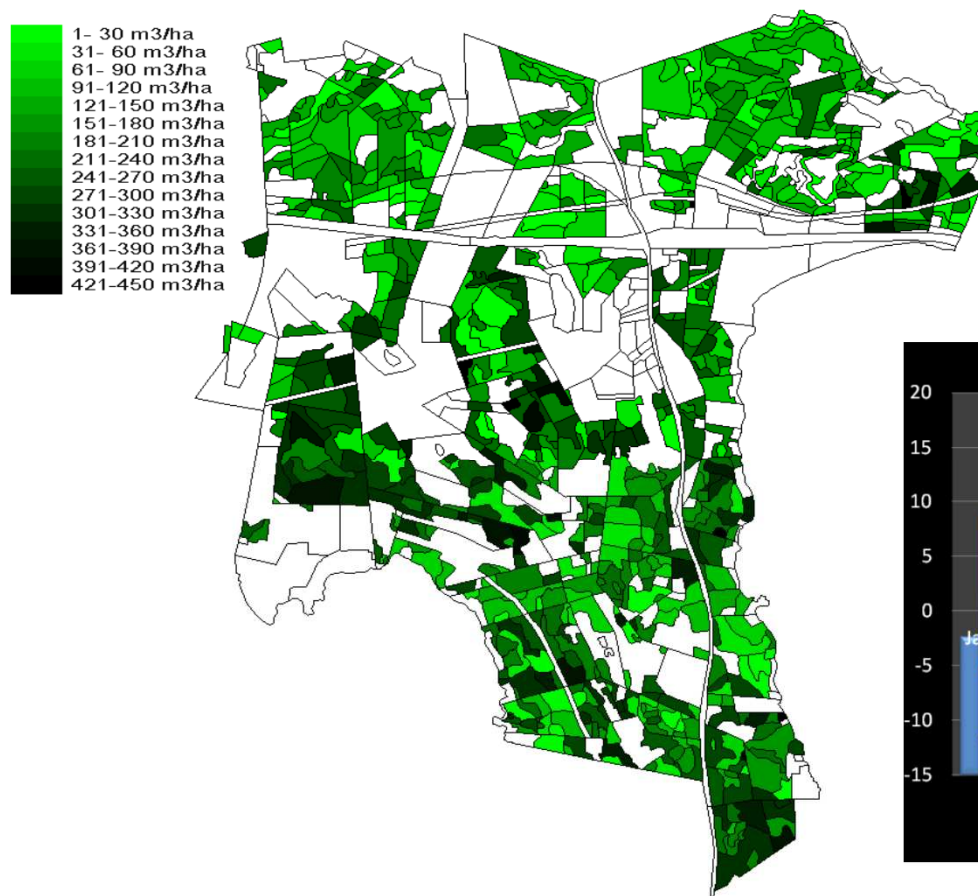


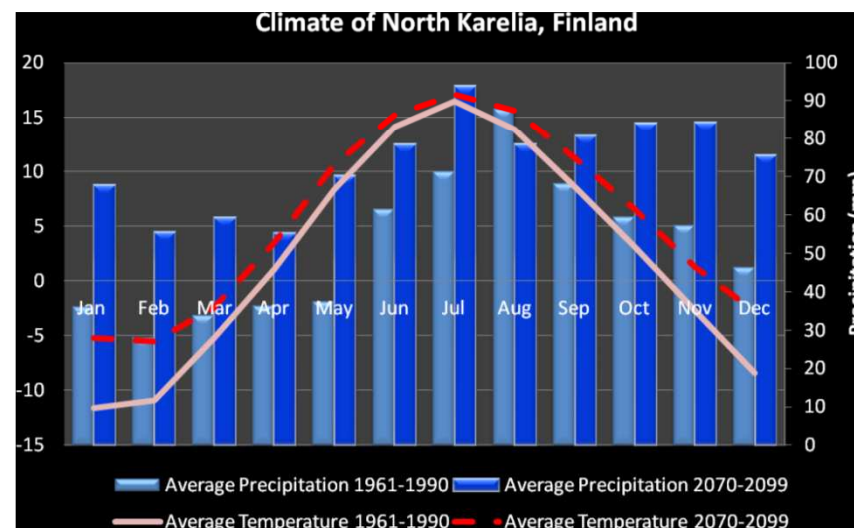
Motive: Finnish case study

Seppo Kellomäki
University of Eastern Finland
Partner 12





Finnish case study area



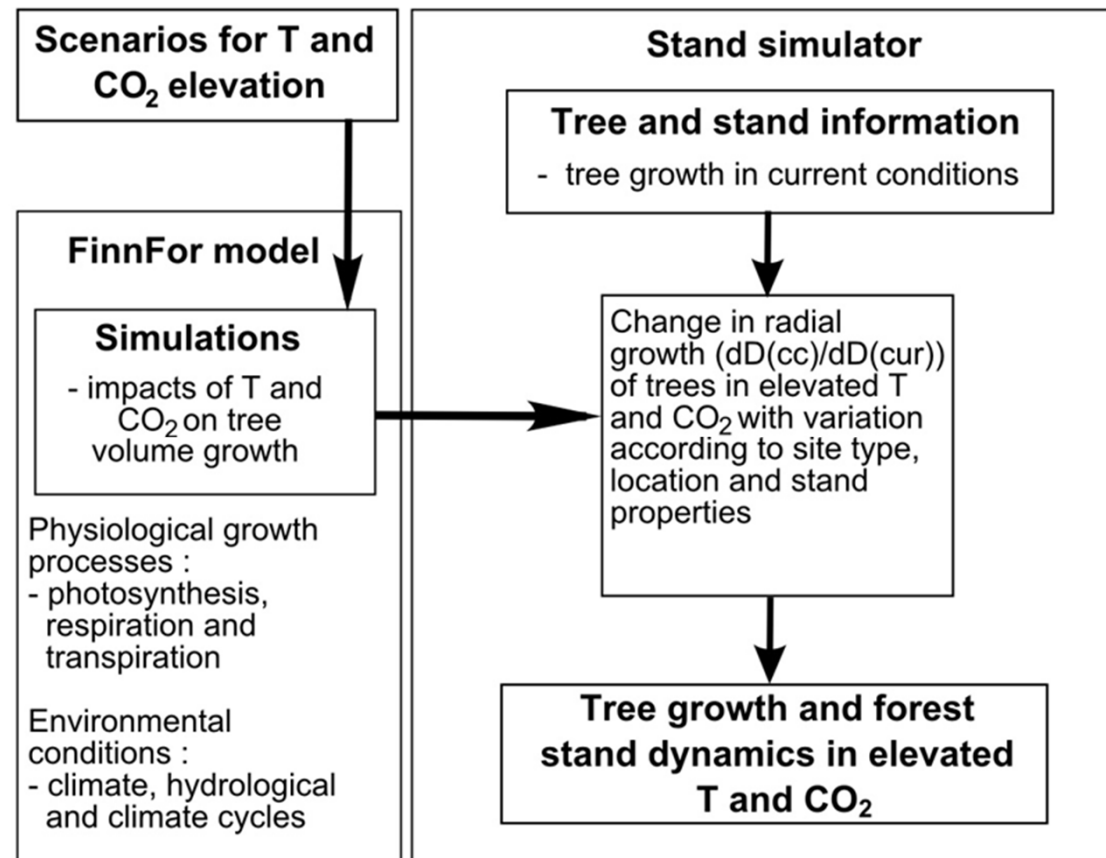
Area, ha	Volume, m3	Pine, %	Spruce, %	Birch etc, %	Fertile sites	Medium fertile sites	Poor sites
1519	233 500	53	31	16	24%	32%	44%

Age 0-19 yr	Age 20-39 yr	Age 40-59 yr	Age 60-79 yr	Age 80-99 yr	Age 100- yr
25.0%	18.3%	21.1%	11.3%	8.2%	16.1%

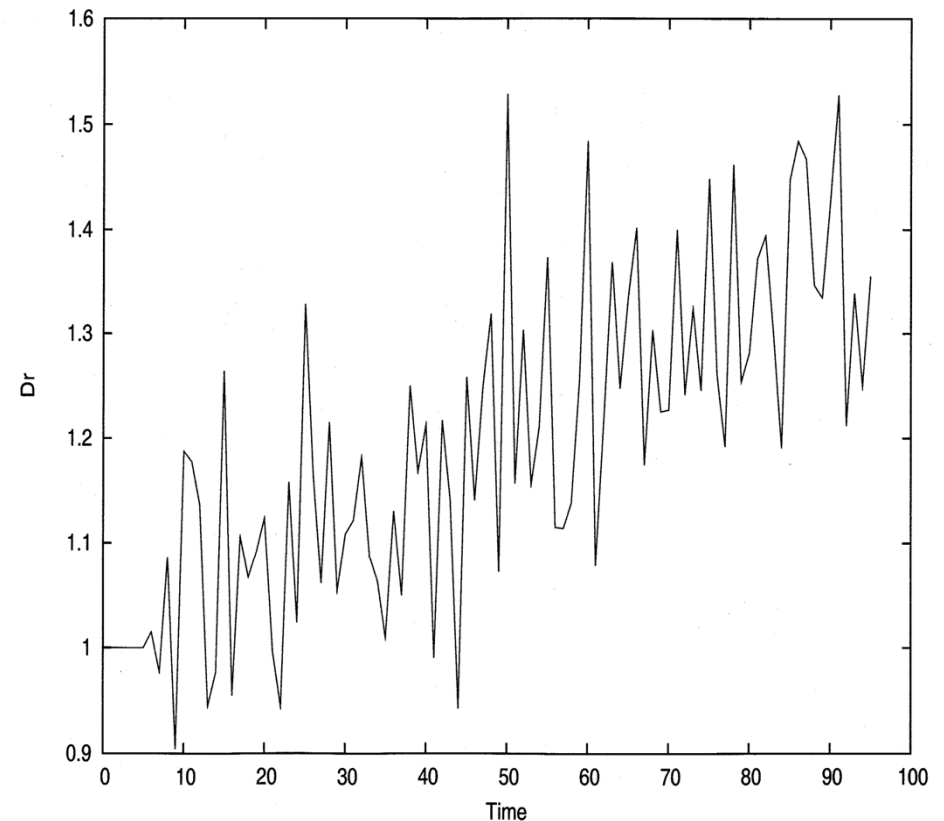
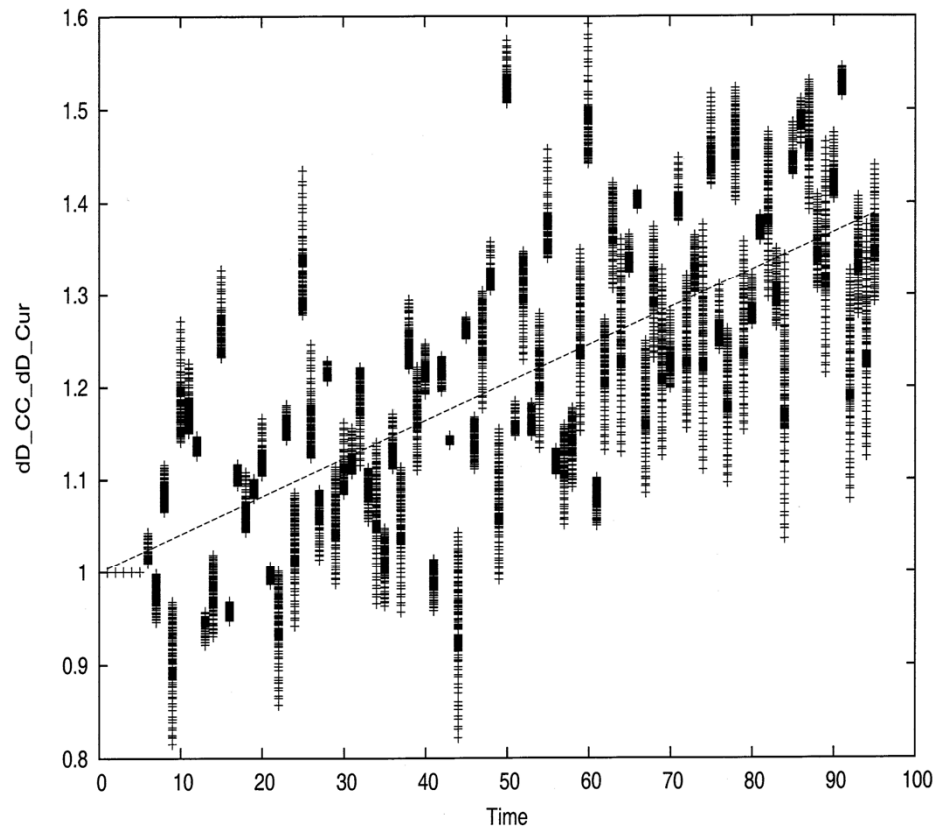
Model development by making the management planning model MONSU sensitive to climate change

- Ratio (relative change) between diameter growth under the current (dD(CUR)) and changing (dD(CC)) climate is calculated for the 10-year periods.

- $dD(CC)/dD(CUR) = f(\text{site type, stand density, diameter, tree position, climate change}(\Delta T, \Delta Pr, \Delta CO_2))$, where ΔT is the change in temperature, ΔPr the change in precipitation and ΔCO_2 the change in atmospheric CO_2 .



Growth trends introduced in Monsu 1(2)



Left: Clusters of points represents how all the combinations of initial stands respond to the climate change in a particular slice of time with the given climatic conditions. **Right:** the same as in the left, but for the mean values of the correction factors representing each cluster.

Growth trends introduced in Monsu 2(2)

- Regardless of trees species, the climate change increases radial growth more on poor sites than on fertile sites.

- On same site fertility type, climate change increases radial growth more in Scots pine than in birch and Norway spruce.

- Growth increase order:
Norway spruce < birch < Scots pine

Species	Site fertility	Trend for radial growth % yr ⁻¹
Scots pine	Fertile	0.362
	Medium fertile	0.414
	Poor	0.523
	Very poor	0.596
Norway spruce	Fertile	0.266
	Medium fertile	0.293
Birch	Fertile	0.328
	Medium fertile	0.334

Simulation example: optimized management at stand level 1(3)

- Initial stand: planted Scots pine and Norway spruce (2500 seedlings/ha) on sites of varying fertility.

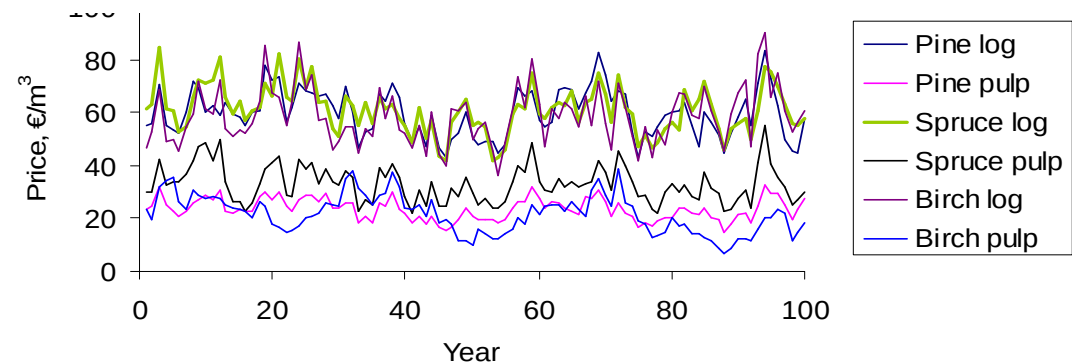
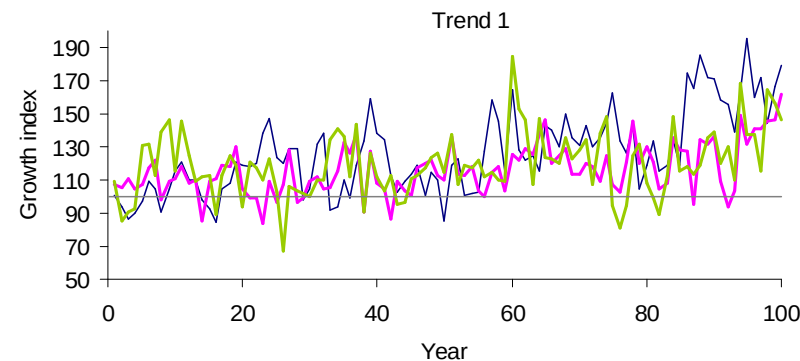
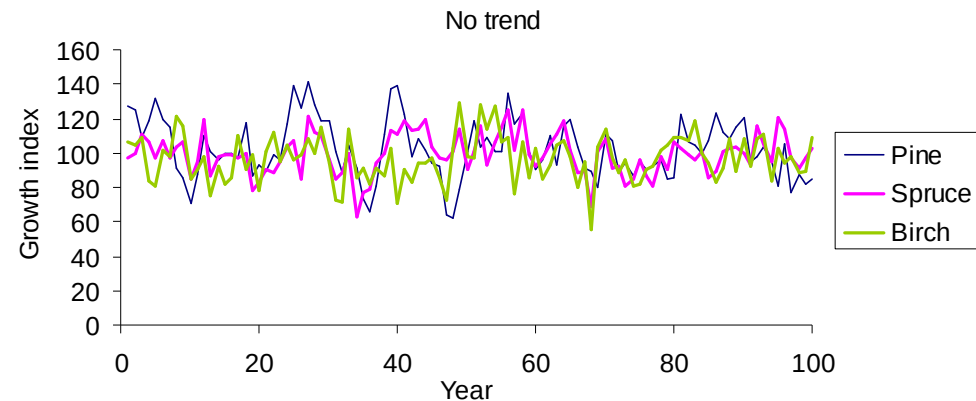
- Current (1961 - 2000) and changing climate (2000 – 2100) provided by Motive consortium.

- Growth trend: not included or included.

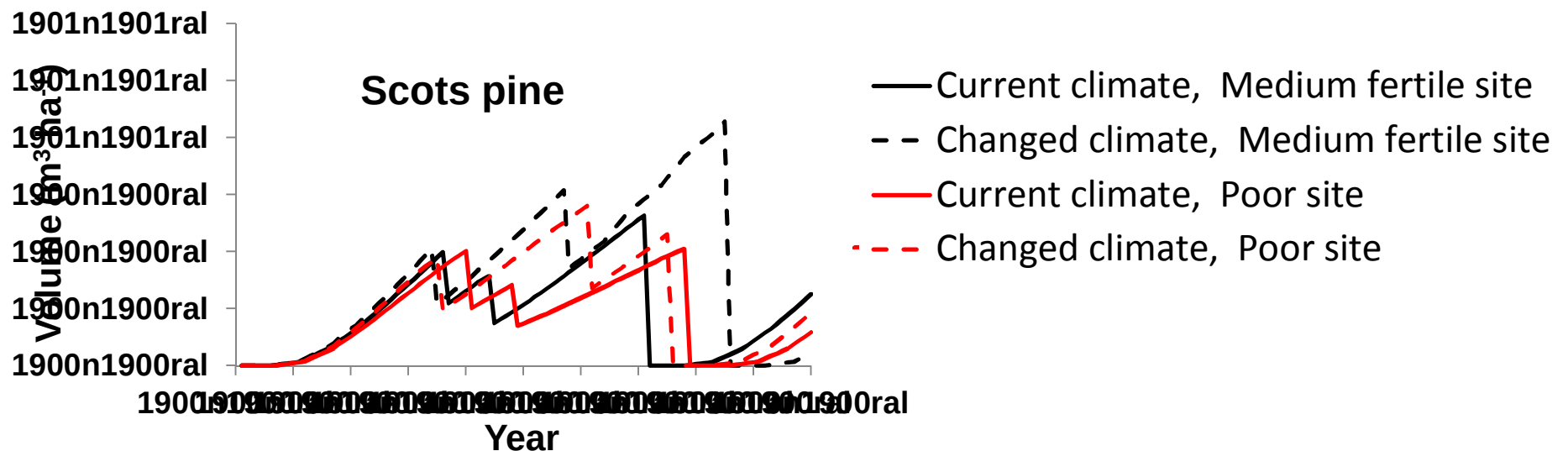
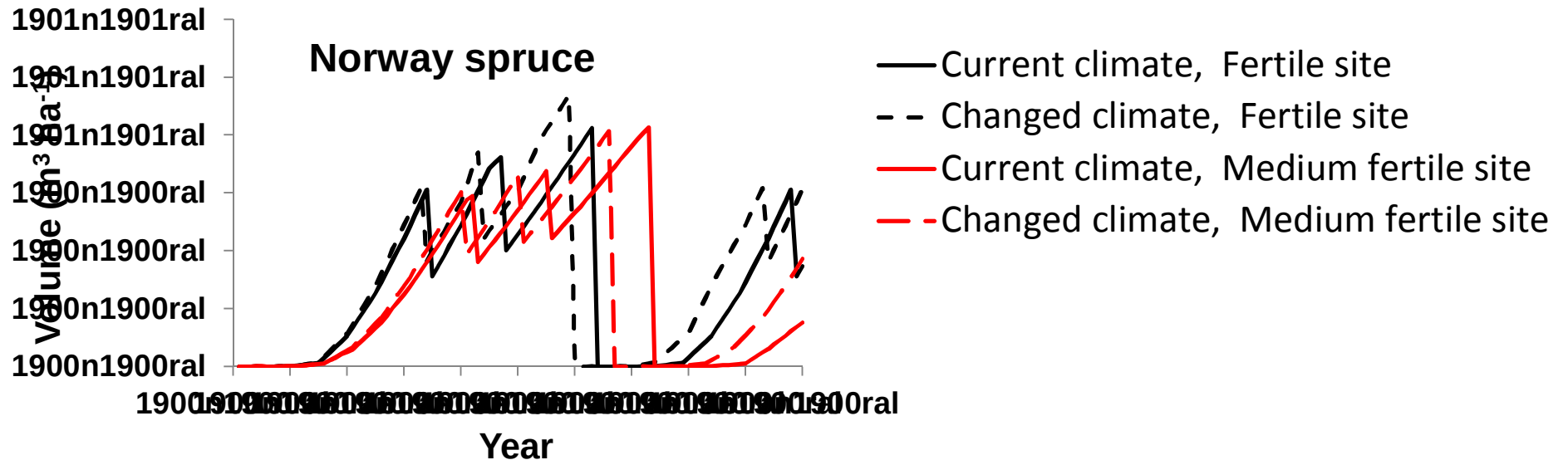
- Management: timing and intensity of thinning based on dominant height/basal area rule, timing of terminal cut based on the mean diameter criterion

- Timber prices: stochastic

- Optimization: maximizing net present value (NPV)



Simulation example: optimized management at stand level 2(3)



Optimized management at stand level in relation to not optimized 3(3)

Climate, species, site	First thinning 1)	Second thinning	Final cut	Timber (m3/ha)	NPV (€/ha)
Current climate:					
Scots pine, poor (VT)	Delayed 1)	Earlier	Earlier	Less	More
Scots pine, medium (MT)	Delayed 1)	Earlier	Earlier	Less	More
Norway spruce, medium (MT)	Delayed 1)	Delayed 1)	Later	More	More
Norway spruce, rich (OMT)	Delayed 1)	Delayed 1)	Later	More	More
Birch, rich (OMT)	Delayed 1)	(Not opt. man.)	Later	Less	More
Changing climate:					
Scots pine, poor (VT)	Same timing 1)	Same timing 1)	Earlier	Less	More
Scots pine, medium (MT)	Delayed 1)	Delayed	Later	More	More
Norway spruce, medium (MT)	Earlier 1)	Same timing	Earlier	More	More
Norway spruce, rich (OMT)	Delayed 1)	Same timing 1)	Earlier	More	More
Birch, rich (OMT)	Delayed 1)	Delayed 1)	Later	Same	More

How to meet climate change in management planning at regional level 1(3)

Finnish case study area

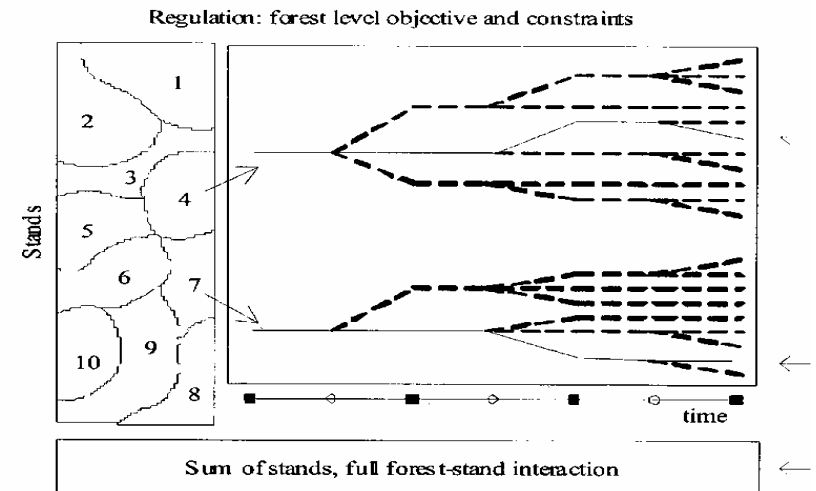
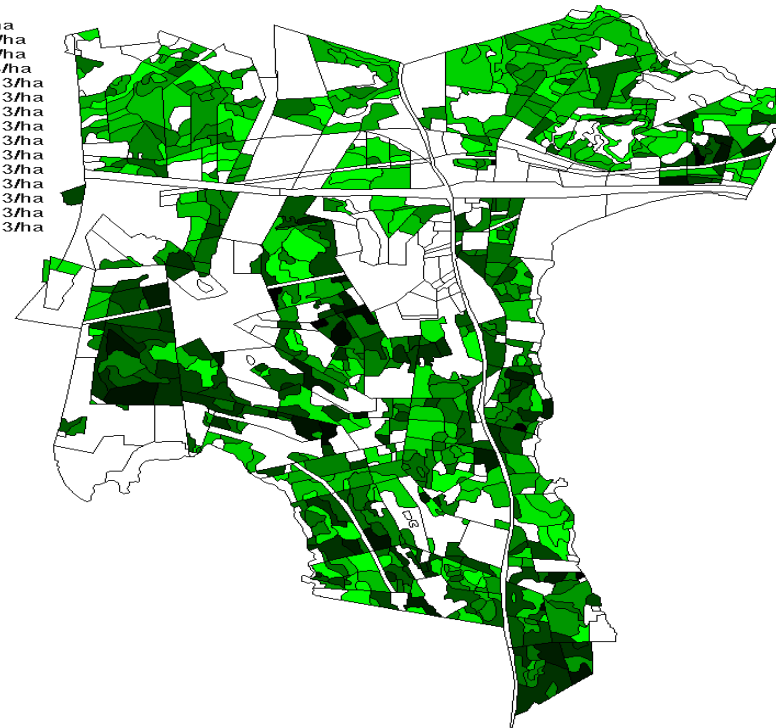
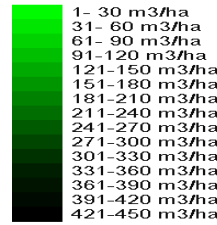
❑ Evaluation of current management practices and need to adapt them to changing climate

Objectives:

1. Maximize NPV (3%)
2. Minimize risk of wind damage (height difference of neighboring stands)

Constraints:

Cutting removal of 20 000 m³ in three consecutive 20-year periods per each



How to meet climate change in management planning at regional level 2(3)

Variables	No wind Risk included	Wind risk included
Growth under CC compared to CU	Higher (5-24%)	Higher (6-18%)
NPV (CU and CC)	Higher (5-7%)	
Height diff. of neighbor. stands (CU and CC)	Higher	Lower
Length of vulnerable edges (CU and CC)	Higher	Lower

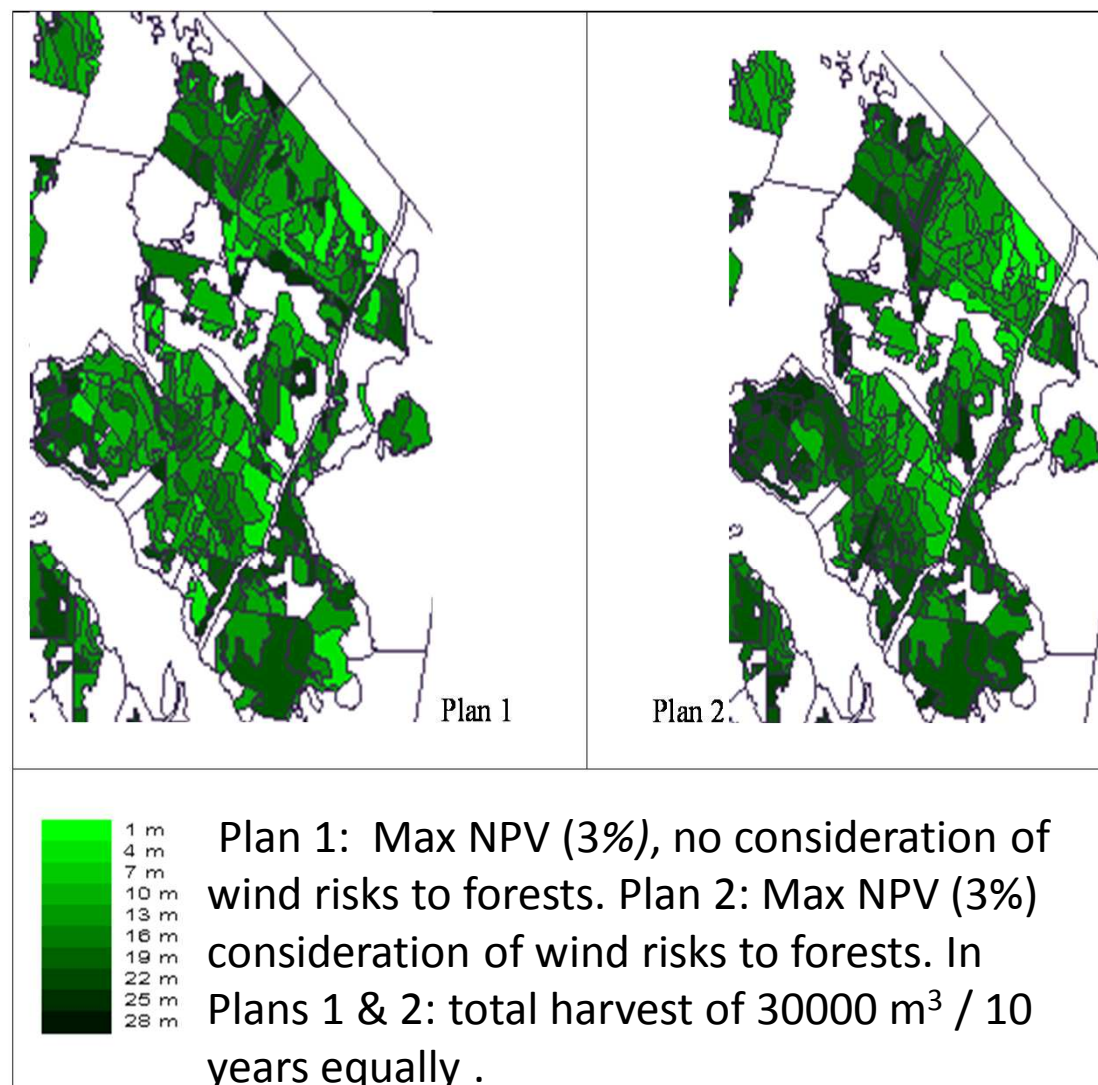
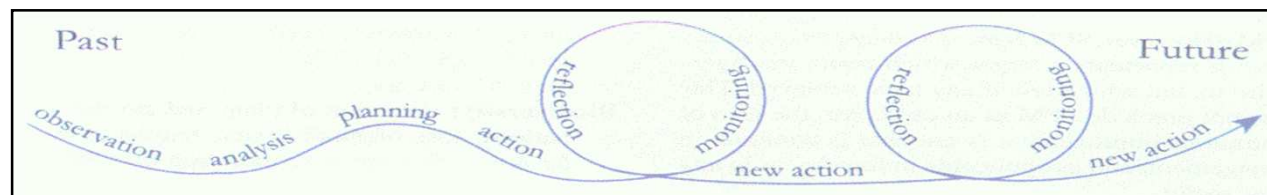


Fig 1. Stand height variation in managed forests after 60 years from now for forest plans, when gradual climate change was assumed

Lessons for future: climate change may increase and decrease growth of trees over time in Norway spruce in Finnish conditions

Climatic zone and temperature sum	Site type	NPP (Mg C ha ⁻¹ year ⁻¹)					
		2000–2030		2030–2060		2060–2099	
		CUR	CC	CUR	CC	CUR	CC
I	OMT	4.6	4.9 (5.2)	4.9	4.9 (-0.8)	4.4	3.9 (-12.7)
> 1200 d.d.	MT	4.6	4.8 (4.4)	5.4	5.4 (-0.7)	4.6	4.0 (-13.9)
	Mean	4.6	4.8 (4.8)	5.2	5.1 (-0.7)	4.5	4.0 (-13.3)
II	OMT	4.2	4.5 (6.6)	4.6	4.6 (-0.2)	4.0	3.6 (-10.1)
1000 -1200 d.d.	MT	4.3	4.6 (6.5)	4.9	4.9 (-0.1)	4.2	3.8 (-11.3)
	Mean	4.3	4.5 (6.6)	4.7	4.7 (-0.2)	4.1	3.7 (-10.7)
III	OMT	3.7	4.0 (8.7)	3.8	4.2 (10.1)	3.9	4.6 (17.1)
750 – 1000 d.d.	MT	3.4	3.6 (8.6)	3.6	4.0 (8.8)	3.4	4.0 (16.7)
	Mean	3.5	3.8 (8.6)	3.7	4.1 (9.5)	3.7	4.3 (17.0)
IV	OMT	–	–	–	–	–	–
600 – 750 d.d.	MT	1.3	1.4 (12.6)	1.3	1.6 (18.0)	1.6	1.9 (23.8)
	Mean	1.3	1.4 (12.6)	1.3	1.6 (18.0)	1.6	1.9 (23.8)

Adaptive management is to proceed step by step in response to expected changes in the selected planning horizon used in management



Conclusions

- Under the changing climate, the production of northern boreal forests are expected to increase in general. However, the growth of Norway spruce with shallow rooting may decline especially in southern Finland on sites with relatively low water holding capacity due to increased drought risk.**
- The decrease in duration of frozen soil period will increase the risk of wind (and snow) damage in forests regardless of any change in windiness.**
- The current forest management may need to be modified to adapt for foreseen climate change and to mitigate the climate change (e.g. site-specific preference of tree species, thinning regimes, rotation length).**
- By considering wind risk in forest planning, mortality and NPV losses could be decreased.**
- The sensitivity of dynamics and productivity of forest ecosystems to foreseen climate projections and management can be studied by employing ecosystem and forest planning models such as used in Finnish case study.**