Net climate impacts of production and use of woody biomass

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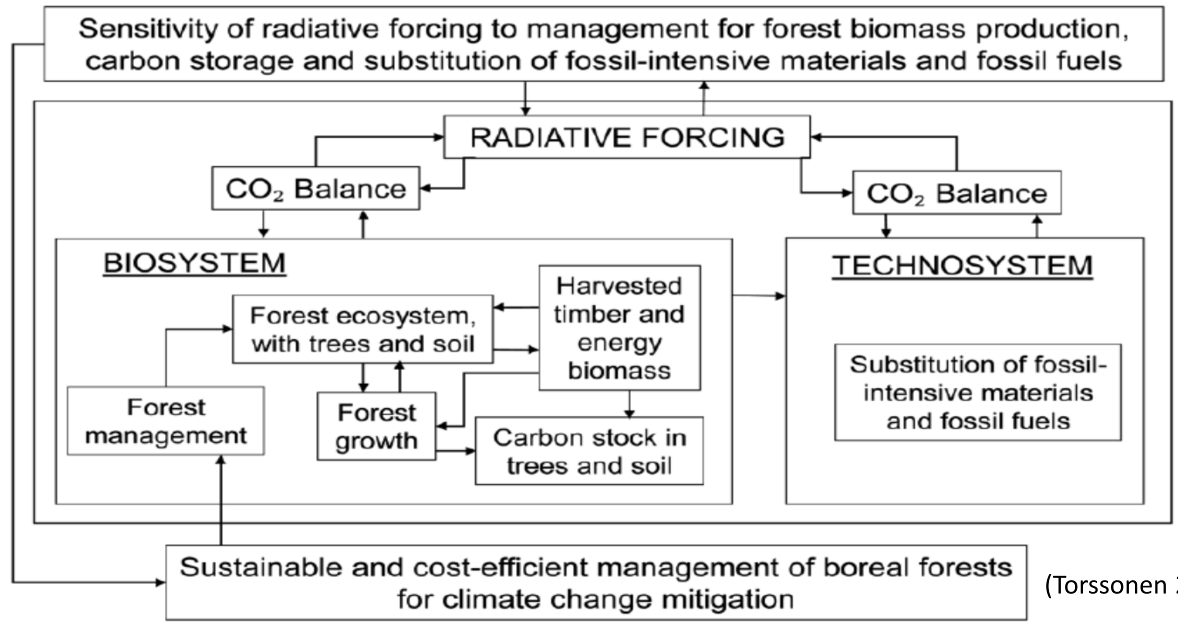


(Torssonen 2015)

Aims of this work

- We studied the sensitivity of carbon balance of forestry to wood harvesting and utilisation policies in two different kind of Finnish boreal case study areas under the current and changing climate over the next 60 years.

Carbon balance of forestry considered:

(i) changes in the carbon pools of living above- and below-ground forest biomass, dead organic matter and wood products,

(ii) carbon releases from harvesting, transporting and manufacturing, and

(iii) reduced carbon emissions due to the use of construction wood instead of fossil-intensive materials and forest biomass-based fuels instead of fossil fuels.

Materials and Methods

- The MONSU simulation-optimisation tool was used to: (i) simulate the stand development in alternative treatment schedules, (ii) calculate the carbon balance of each schedule and (iii) find the optimal combination of the schedules for three consequent 20-year periods (60 years in total).
- In the MONSU, the effects of climate change were implemented in growth simulations using the species- and site-specific growth trend functions (growth multiplier functions).
- In addition to the (i) business-as-usual (baseline) management scenario (even-aged forestry: thinning from below, harvesting only timber for wood-based products from thinning and final felling), we applied five other scenarios by changing the timing and type of thinning and the utilisation of harvested trees.
- We maximized the net present value (NPV, calculated with 2% discount rate) and carbon balance of forestry in each management scenario, considering an even-flow net income target.

Materials and Methods…

Scenario	Description
TB1	Baseline: Thinning from below; thinnings done according to the thinning instructions (immediately when stand basal area exceeds the 'thinning limit 'of the instructions). Only saw logs and pulpwood are harvested.
TB2	Same as TB1 except that spruce pulpwood is not harvested. Norway spruce stem parts from diameter 16 cm (minimum top diameter of log) up to 5 cm are harvested as fuel feedstock.
TB3	Same as TB2 except that postponing of thinnings in young stands are allowed (without any limit).
TA4	Same as TB3 except that thinning from below was replaced by thinning from above
TA5	Same as TA4 except that pine and birch pulpwood is not harvested. Small stems and the upper parts of log-sized pines and birches are harvested as fuel feedstock (from the top diameter of saw log until 5-cm diameter)
TA6	Same as TA4 except that 70% of tree tops, branches and stumps were harvested for biofuel in clear felling sites

- *We assumed that, compared to the baseline scenario, each of the following measures would improve carbon balance:*

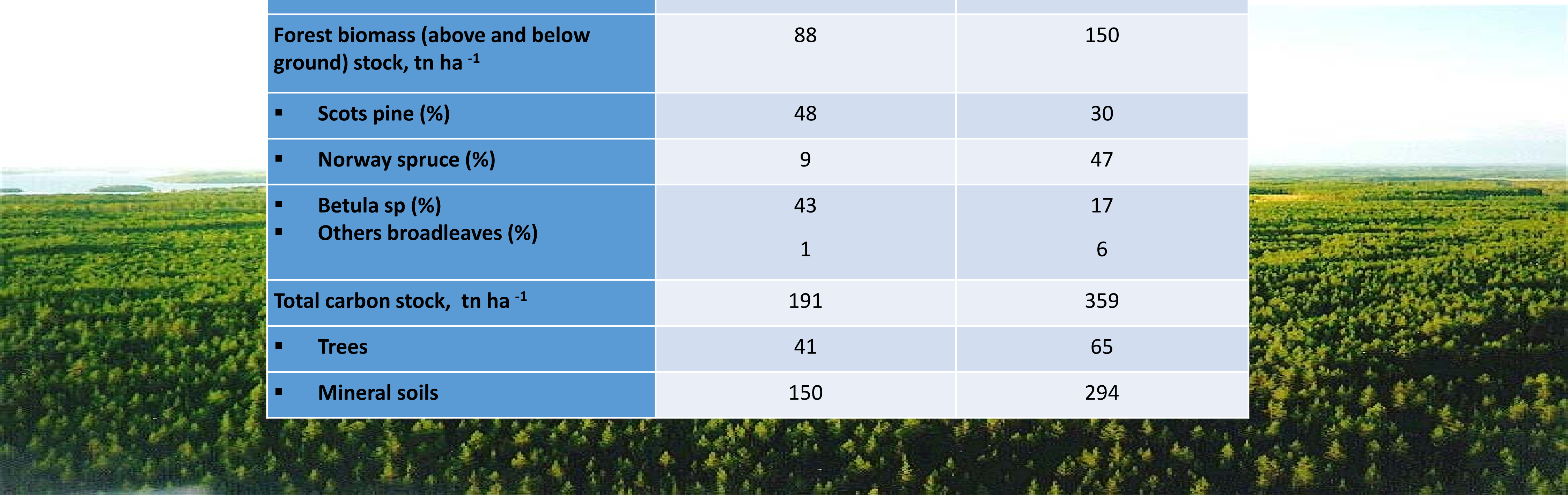
  i) using spruce pulpwood as fuel feedstock; ii) postponing the thinning of young stands; iii) replacing thinning from below by thinning from above, iv) using the pulpwood of pine and broadleaf species as fuel feedstock, and v) harvesting residues of clear-felling sites for fuel feedstock.

- Harvested trees were divided into assortments (sawlog, pulpwood and fuel feedstock), and further on into four end product classes: sawn wood and plywood; mechanical mass; chemical mass; and fuel feedstock.
- For example, only about half of the sawlog volume became sawn wood, and rest was used for the same purposes as pulpwood (chemical mass, mechanical mass and fuel feedstock).

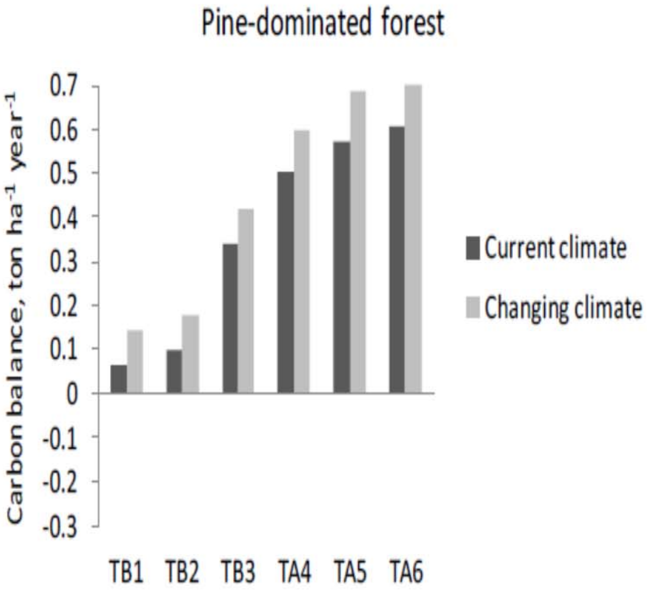
Finnish boreal case study areas (eastern Finland)

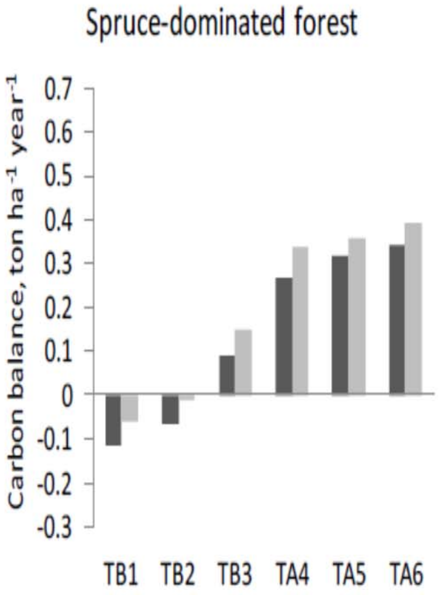
- Simulations were done under the current and gradually changing climate (A1B climate scenario) in two case study areas, first one dominated by Scots pine and broadleaf species and another by Norway spruce.

Finnish Boreal case study areas	Pine-dominated forest	Spruce-dominated forest
Forest area, ha	950	1117
Forest biomass (above and below ground) stock, tn ha $^{-1}$	88	150
▪ Scots pine (%)	48	30
▪ Norway spruce (%)	9	47
▪ Betula sp (%)	43	17
▪ Others broadleaves (%)	1	6
Total carbon stock, tn ha $^{-1}$	191	359
▪ Trees	41	65
▪ Mineral soils	150	294



Results - Carbon balance of forestry



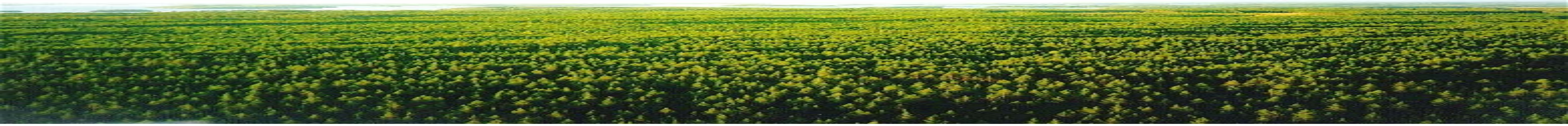


The carbon balance of the pine-dominated forest was clearly better than that of spruce-dominated forest.

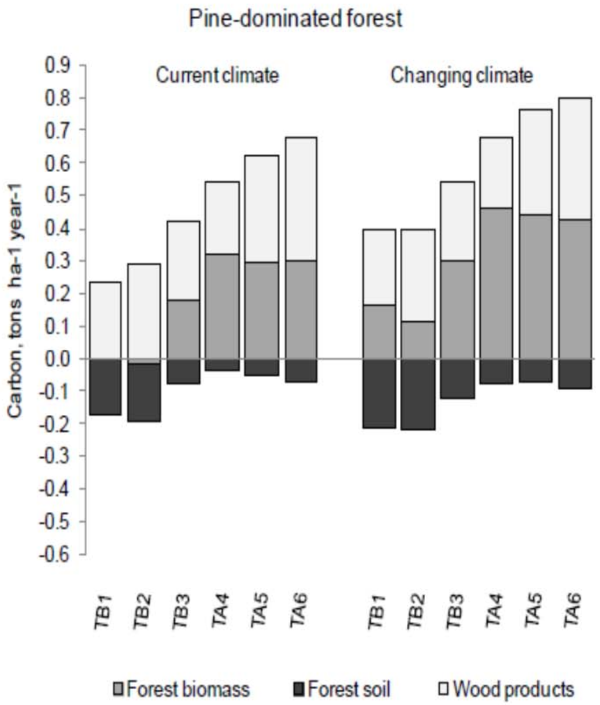
- Thinning from below (TP) scenarios, TB1 (thinnings from below, no biofuel) and TB2 (thinnings from below, Norway spruce pulpwood used for biofuel) resulted in considerably lower carbon balance than those with thinning from above (TA).

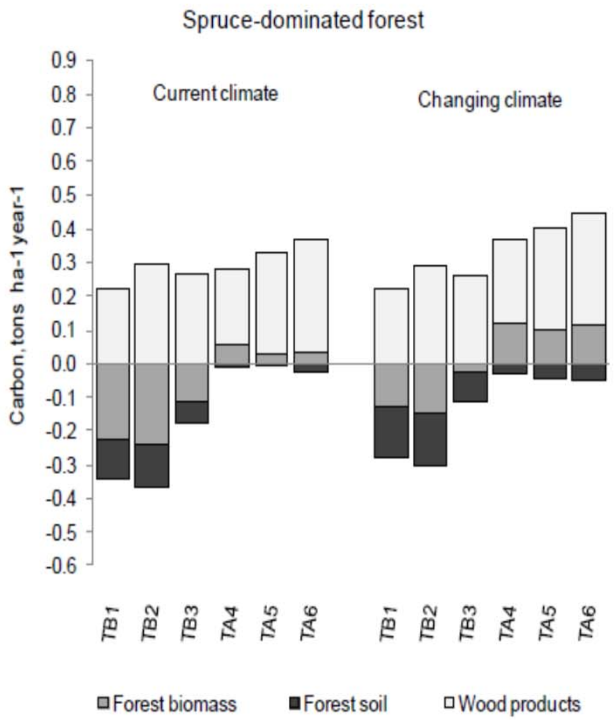
- <u>*Carbon balance of forestry could be improved considerably when*</u>*:*

(i) thinning was not obligatory immediately when the thinning limit was reached (changing from TB2 to TB3),
(ii) thinning from above was applied instead of thinning from below (changing from TB3 to TA4),
(iii) Scots pine and birch pulpwood were used as biofuel (changing from TA4 to TA5), compared to use of spruce pulpwood instead.
(iv) use of harvest residues (tree tops, branches, stumps and coarse roots) for biofuel (TA6).

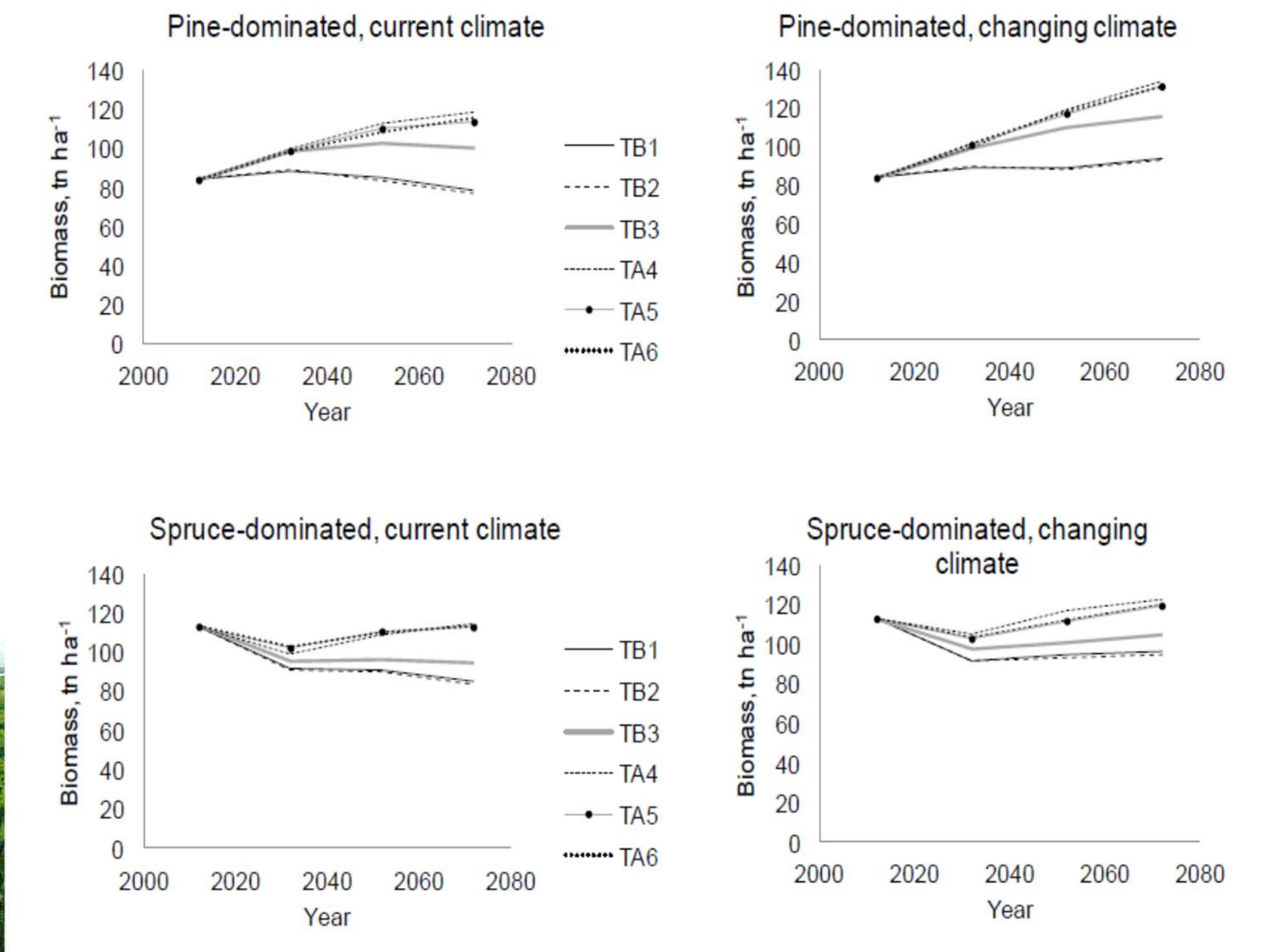


Results - Carbon balance of forestry….



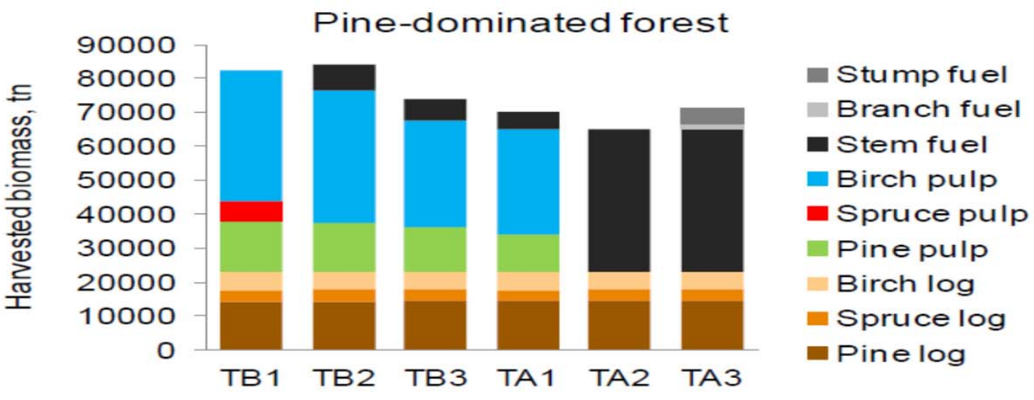


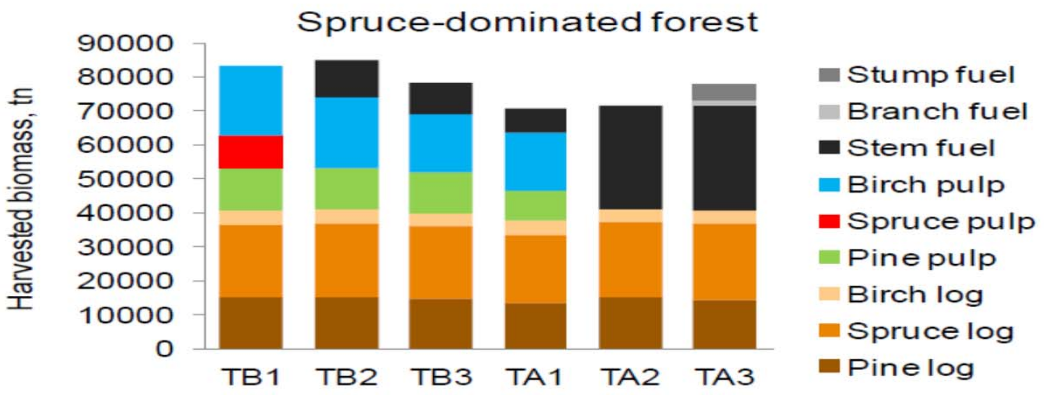
- The carbon balance of growing stock (forest biomass) increased under the changing climate.
- The carbon balance of forest soil decreased slightly under the changing climate (e.g. due to accelerated decomposition rate).
- Since income targets (and thus, harvested volume) were kept equal the additional biomass growth under the changing climate was left in the forest and climate change did not have a strong impact on the carbon balance of wood products.



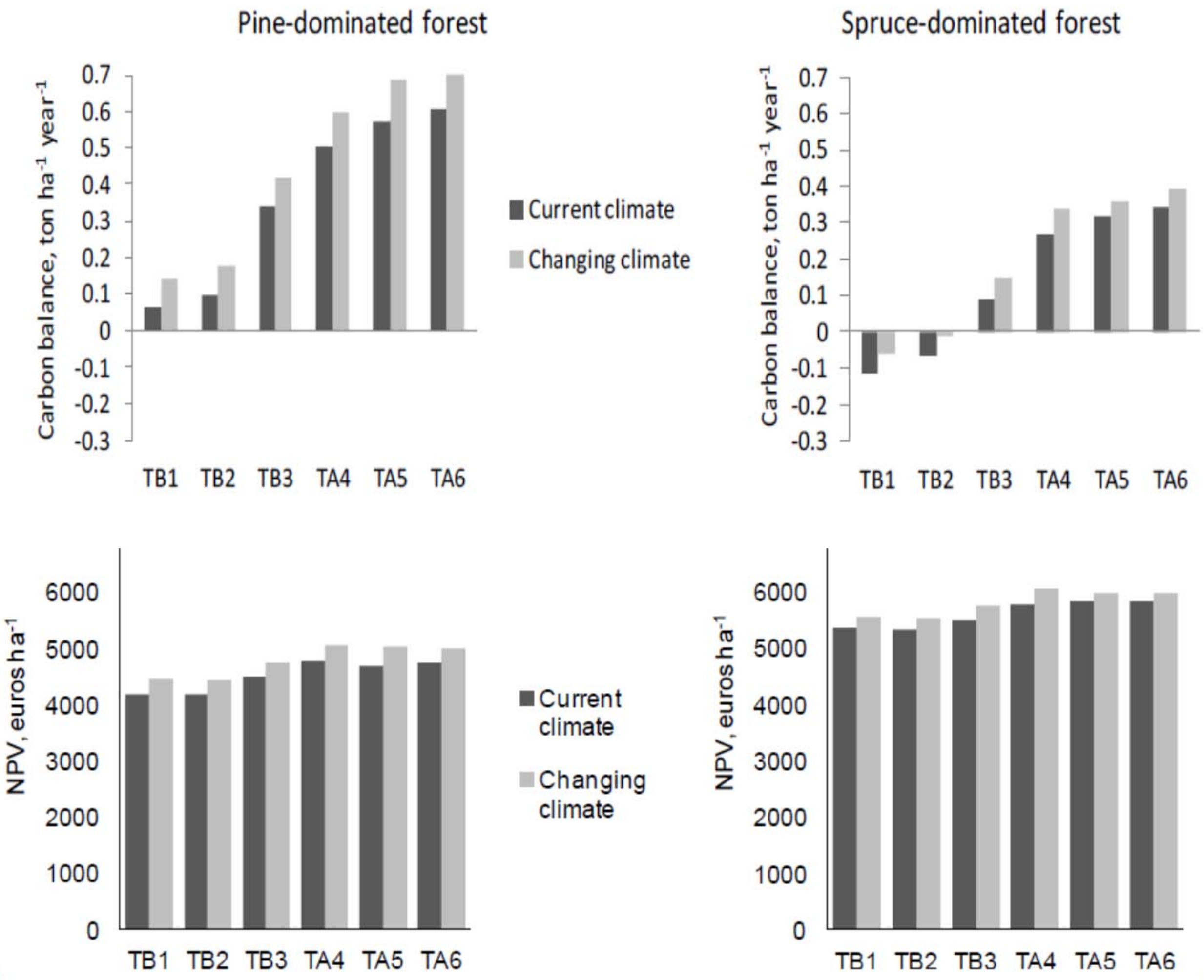
- Management scenarios and climate change affected together the development of forest biomass stock.
- Forest biomass stock was up to 13 and 22 % higher in the spruce- and pine-dominated forests under the changing climate compared to the current climate at the end of the 60 years simulation period.

Results - Carbon balance of forestry….





- Use of spruce pulpwood as biofuel feedstock improved carbon balance clearly less than use of pine and birch pulpwood (with higher harvested volume and biomass).
- BUT, the carbon balance improved 0.120 (pine-dominated forest) and 0.139 (spruce-dominated forest) tn m^{-3} of spruce pulpwood used as biofuel.
- The use of pine and birch pulpwood as biofuel improved the carbon balance of forestry only by 0.050 (pine-dominated forest) and 0.064 (spruce-dominated forest) tn m^{-3}.
- *Thus, effect of using Norway pulpwood for energy production was about 2.5 times greater!*
- Also the carbon balance of forestry improved by 0.28–0.30 tons per one dry ton of harvest residues used (tree tops, branches, stumps and coarse roots).



Conclusions

- Postponing the thinning of young stands compared to the baseline management and using thinning from above instead of thinning from below improved carbon balance of forestry (and the economic profitability, NPV).
- The use of pulpwood, logging residues and stumps as biofuel also increased carbon balance of forestry.
- Climate warming increased carbon balance of forestry (and NPV) due to increase of growth and carbon stocks of forests, with fixed harvest levels.
- The carbon balance of forestry is affected also by the prevailing forest structure and environmental conditions (climate, site).