Forest *Knowledge* *Know-how* METLA *Well-being*

Consequences of the increased production of wood based bioenergy in Finland

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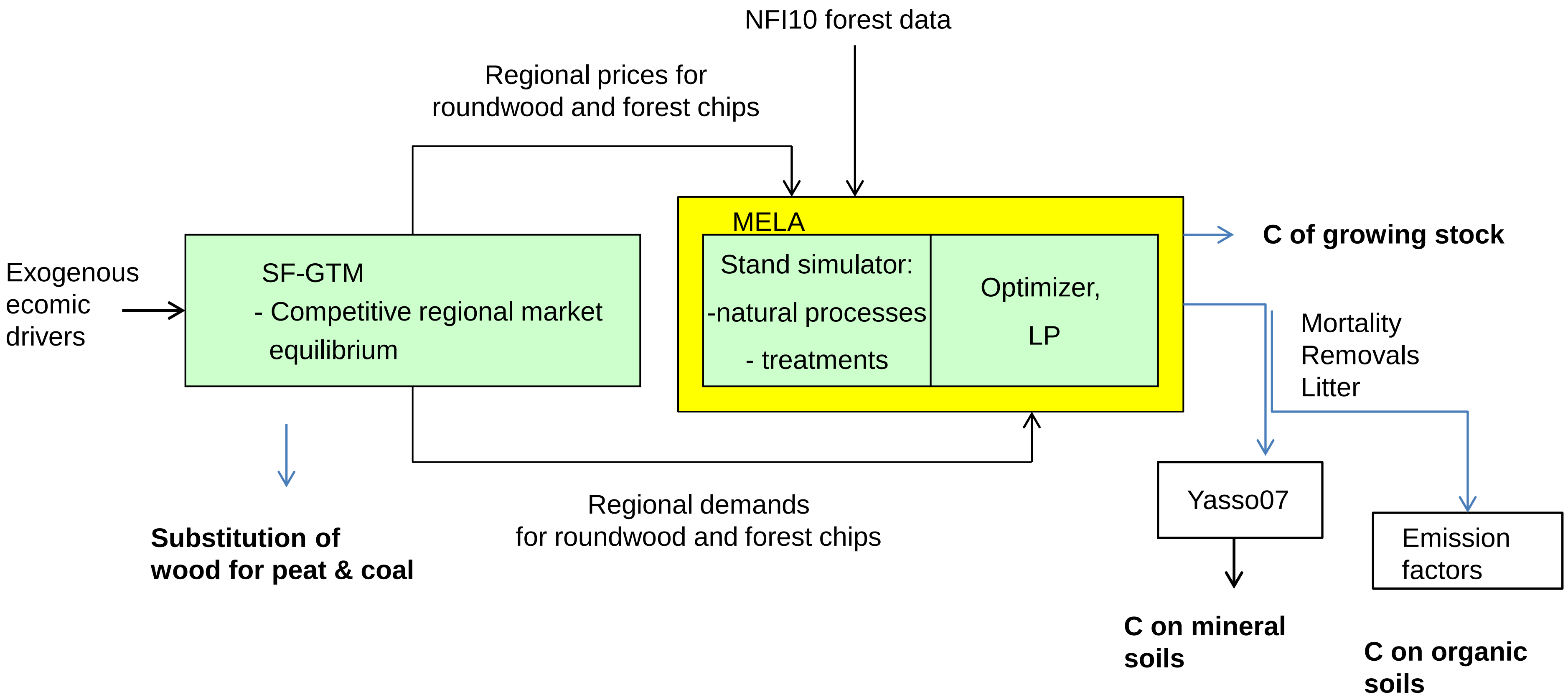
Analysis structure

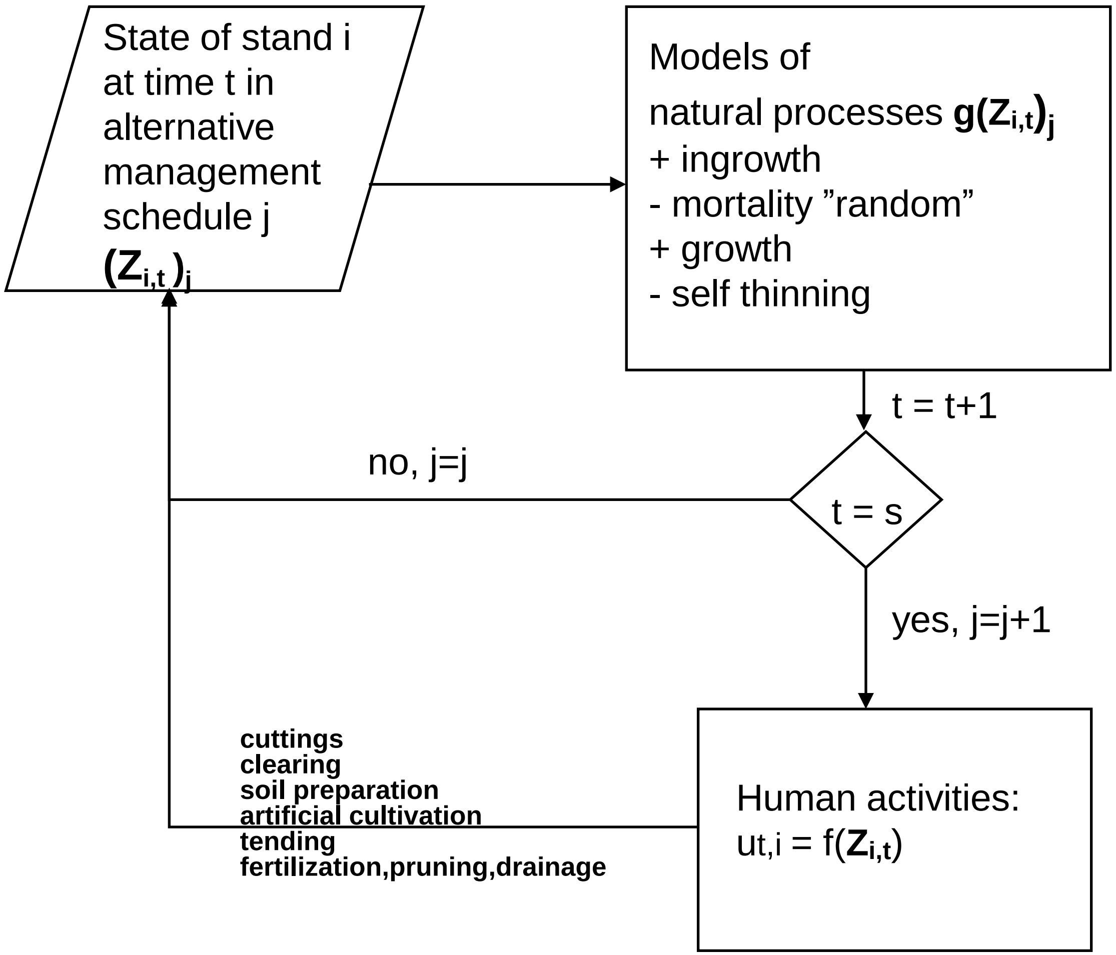


- this presentation will concentrate on the MELA part

MELA – a forest planning tool

- is a decision support system generated for Finnish conditions for solving such problems as:
  - what are the production potentials of forests and
  - how to manage forests to meet the overall goals of the society/forest owner now and in the future
- consists of
  1) Automated stand simulator based on individual tree models for producing alternative development and treatment options for stands (Siitonen et al 1996, Redsven et al 2012)
  2) Comparison of management alternatives based on linear optimization
- applied (since 1996) also in 'practical' forest planning, e.g. in the Forest Service, in forest companies and in the organizations of the non-industrial private forest owners

Simulation of management schedules



MELA INITIAL DATA “Z $_{t=0}$”

Management unit/Sample plot data (1-32):

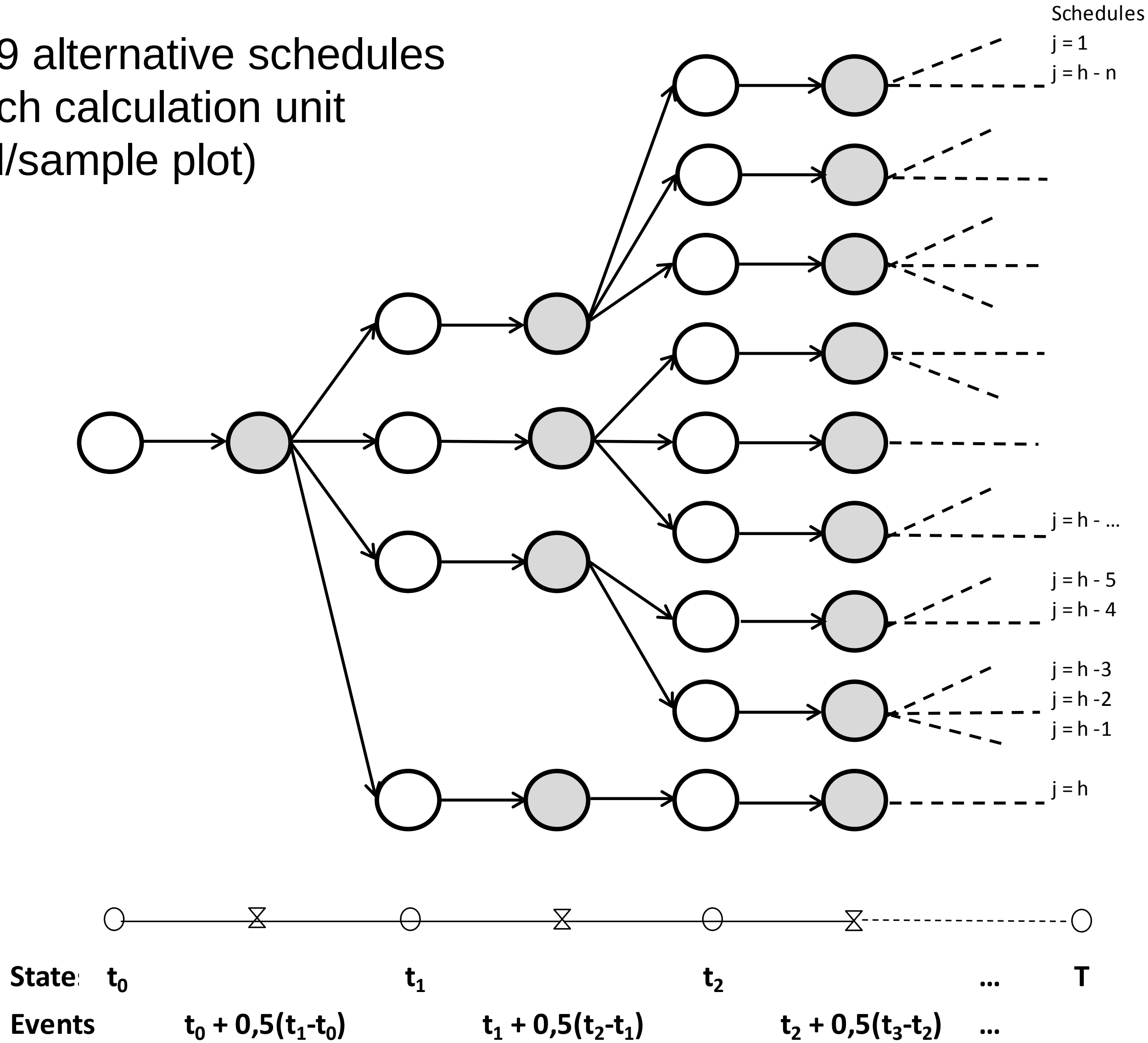
Inventory year
Area
X, Y coordinates
Height above sea level
Temperature sum
Owner category
Land-use category
Soil and peatland category
Site type category
Drainage category
Year from last treatment (by treatments)
Forestry board district
Forest management category

Sample tree data (1-20):

Number of stems/ha
Tree species
d1.3
Height
Age (both d1.3 and biological)
Reduction to model-based saw log volume
Origin
Height of the lowest living branch, m
Management category of the tree

Simulation tree of alternative management schedules

1-9999 alternative schedules
for each calculation unit
(stand/sample plot)



MELASIM: the main models

Natural processes:

e.g. Ojansuu et al. 1991, Hynynen et al. 1996, Hynynen et al. 2002, Hökkä 1996, 1997, Hökkä et al. 1997, 2000, Jutras et al. 2003

$$\mathbf{Z}_{i,t+1} = f\left(\mathbf{Z}_{i,t}, u_{i,t}\right), i = 1,\ldots,n; t = 1,\ldots,T$$

Volume and timber assortment: **Laasasenaho 1982**

Timber reduction: **Mehtätalo 2002, Päivinen** (not published)

Biomass: **Marklund 1988 and Repola 2009a, 2009b**

- d_{13} & h models

Productivity and time expenditure:

- Logging and silviculture:

  Kuitto et al. 1994, Rummukainen et al. 1995, Väkevä et al. 2001, Metsäpalkkarakenteen … 1995, 2008, 2010
- Energywood procurement:

  Laitila et al. 2004, 2007, 2010, Kärhä et al. 2004, 2006, Heikkilä et al. 2005

Optimization: integrated stand and forest level analysis

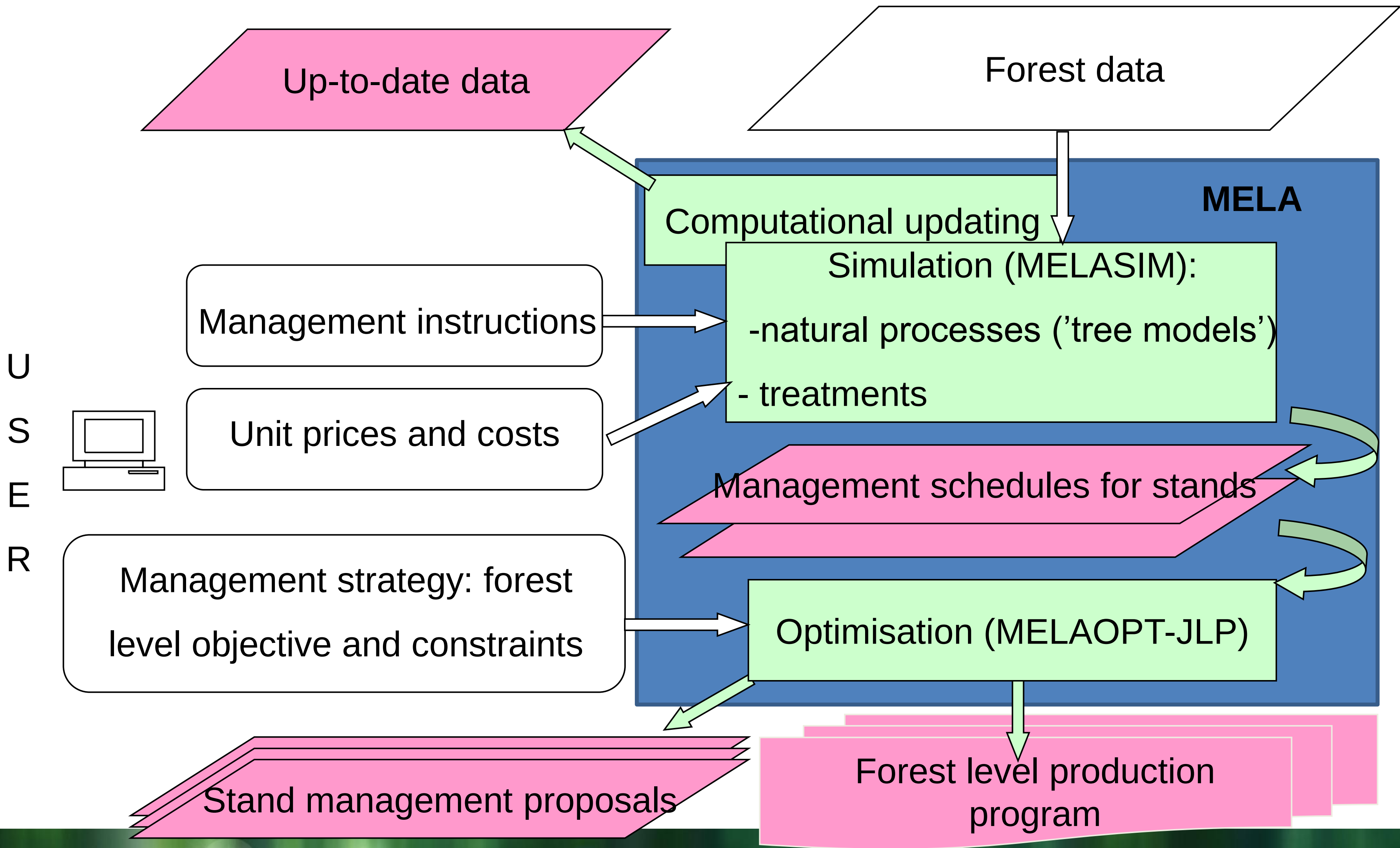
- management is solved endogenously based on forest level objectives and constraints, i.e. management is the solution of optimization
- optimal solution is received simultaneously for the whole forestry unit and individual stands
- optimization problem is open defined by the user

- In MELA we use JLP, a linear programming software package JLP (Lappi 1992)

  ❖ JLP has a outstanding capasity and speed in solving large scale multilevel problems
  - GUB (generalized upper bound) technique for embedded area constraintstekniikkaa
  - OUB (ordinary upper bound) technique for upper bounds

  ○ number of constraints of a ’standard’ LP
  = **m + 2r** (lower and upper bound)
  (m= area constraints, r = ’utility constraints’ ,2=lower and upper bound)
  $\Rightarrow$ **JLP = r**

General structure of MELA analyses



“MELA carbon -analyses”

- calculations are made by forestry centre regions based on the 10th NFI field plots
- ~50 year simulation time (10 year periods)
- **max npv 4 % subject to roundwood and energy wood targets**

  Note! No carbon targets
- **Carbon emissions in MELA are calculated as difference of sequential time points (not as a yearly difference of growth and total drain): C_{t+1} - C_t**
- ‘silviculture’ based on good practice recommendations of Tapio
- Climate change scenario A1B

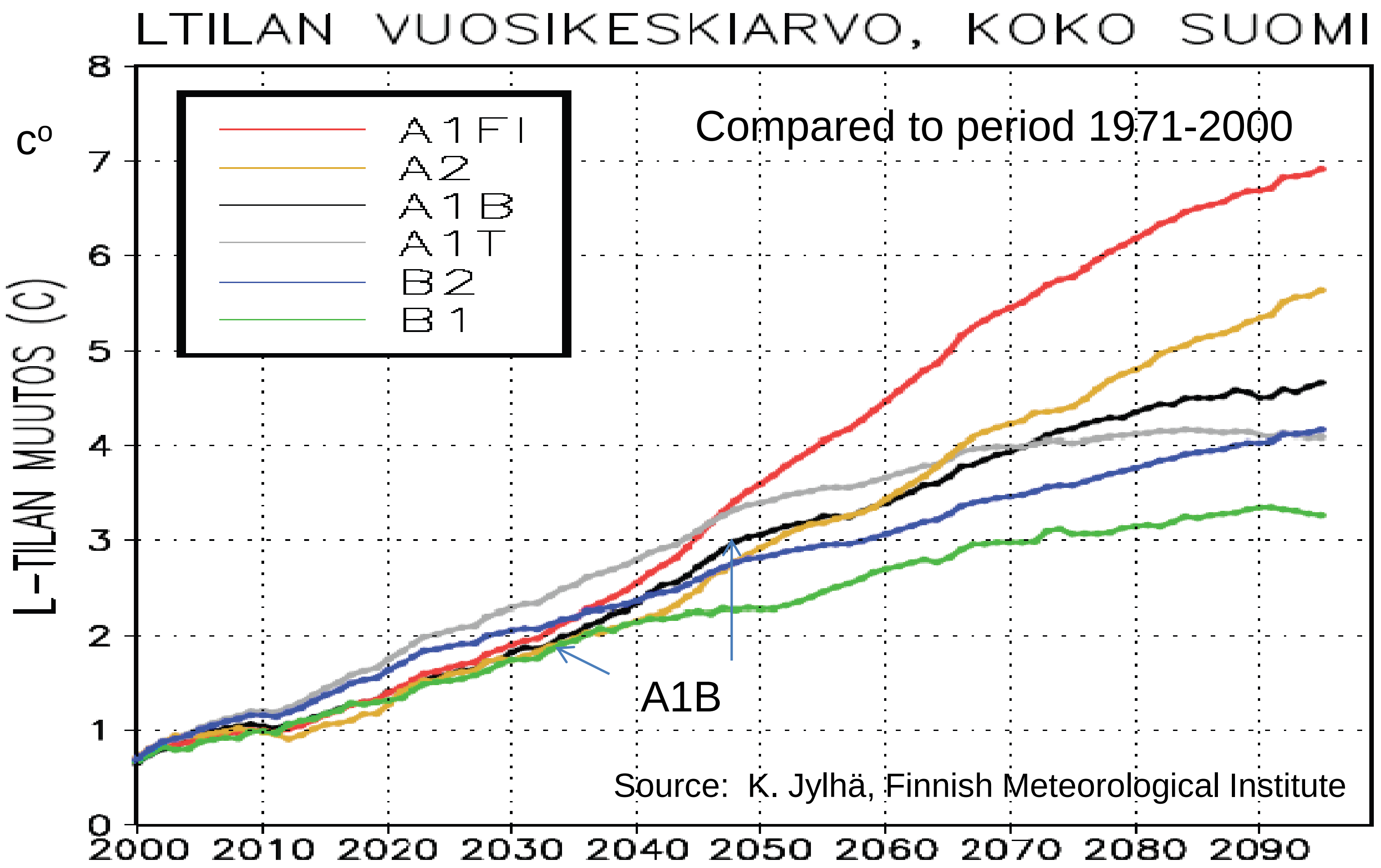
- publications:

- Kallio, A.M.I., Salminen, O. Sievänen, R. (2013) Sequester or substitute—Consequences of increased production of wood based energy on the carbon balance in Finland. Journal of Forest Economics 19 (2013) 402–415
- Sievänen, R., Salminen, O., Lehtonen, A., Ojanen, P., Liski, J.,Ruosteenoja, K. & Tuomi, M. (2014) Carbon stock changes of forest land in Finland under different levels of wood use and climate change. Annals of Forest Science (2014) 71:255–265
- Kallio, M., Salminen, O. Sievänen, R. (2014) Low Carbon Finland 2050 –platform: skenaariot metsäsektorille. Metlan työraportteja 308. (in Finnish)

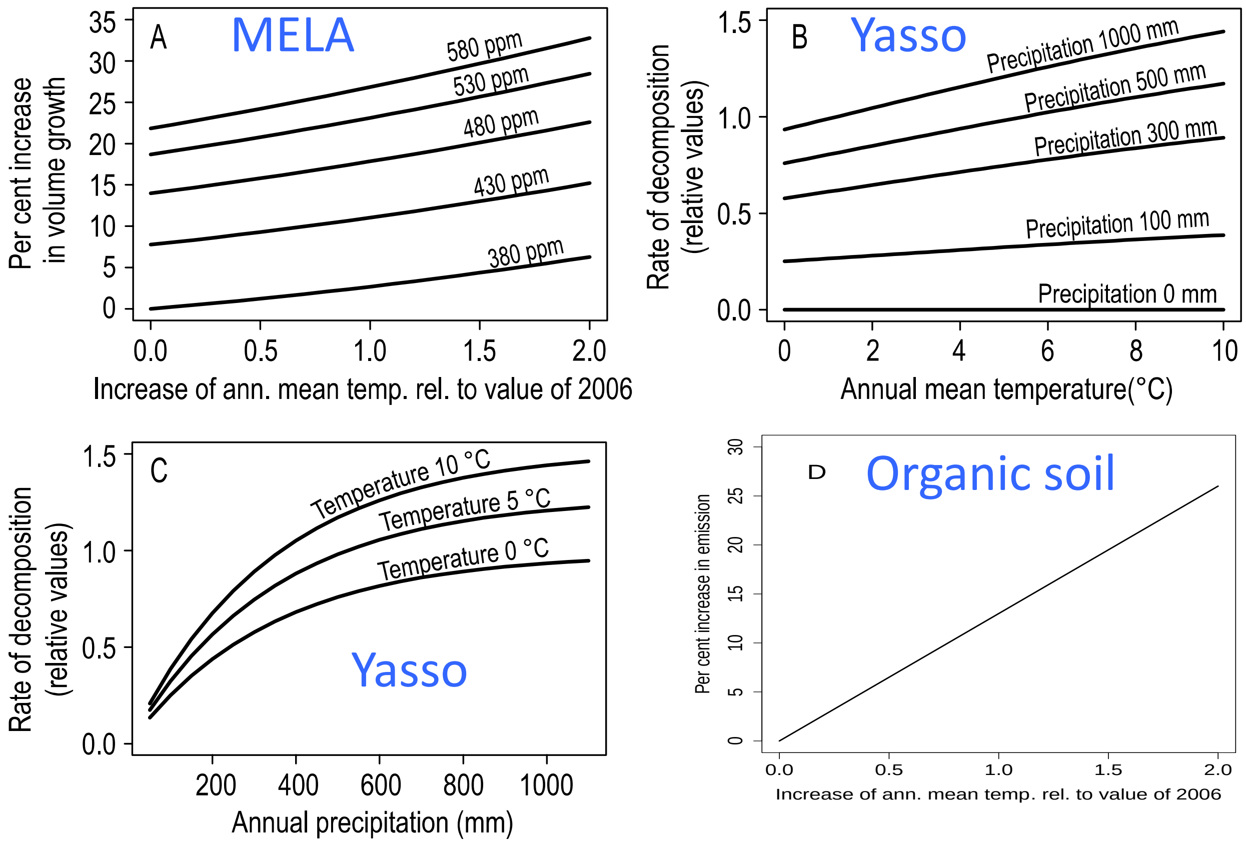
Reckoning the climate change in MELA

- Forest growth may increase by 44% untill last part of this century due to the climate change (Kellomäki et al. 2008)
- response to the climate change (temperature and CO_2) is based on the Finnfor (Kellomäki, Väisänen & Strandman 1993) process moldel
- The response is exported into the growth models of MELA via transfer variables created by Matala et al. (cf Matala 2005) that are based on the changes of temperature and CO_2

Projected change in average annual temparature in the IPCC scenarios in Finland



Effect of climate



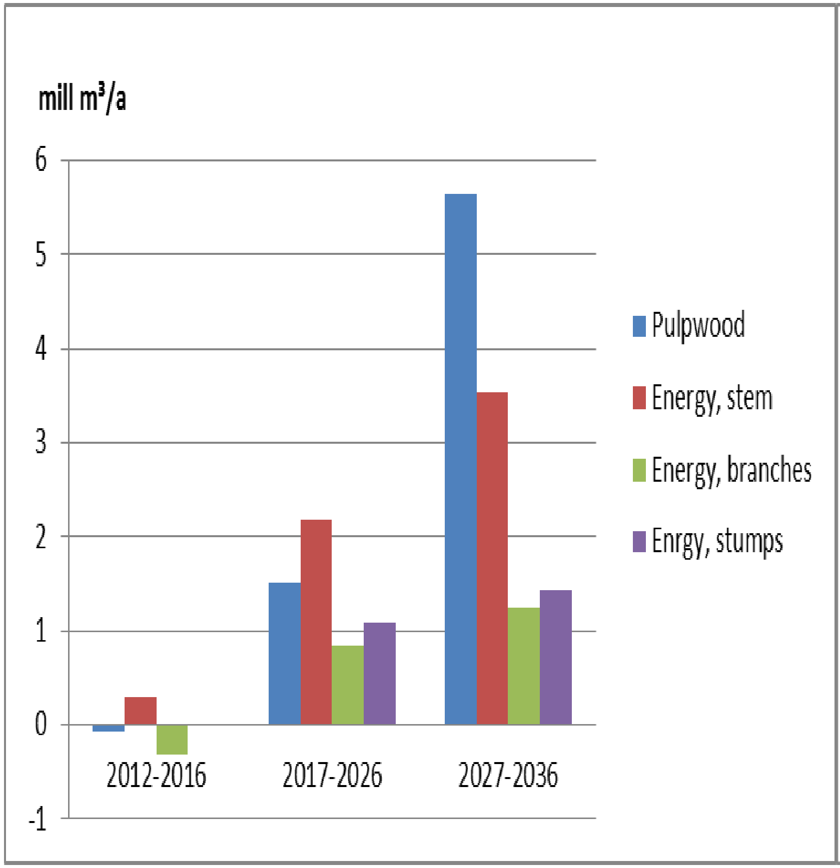
Annual mean values of temperature, precipitation, CO_2

Scenarios of Kallio et al 2013: production levels

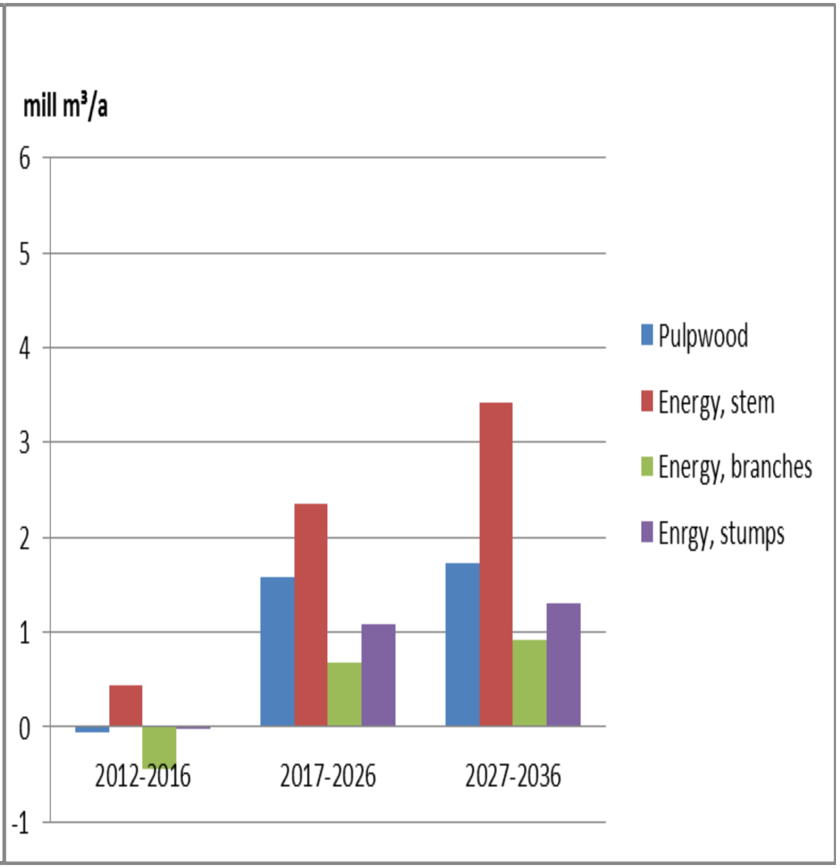
- Ref: bioenergy (forest chips) return to the level of 2007-2008
  sawtimber 11.5 Mm^3
  pulp and paper 17.5 Mt
  average cutting removal of stemwood 2012-2035 54.5 Mm^3
- Bio:
  reaching the 2020 RES targets: 13.5 Mm^3/a for heat and power and
  5 Mm^3 for diesel
  average cutting removal of stemwood 2012-2035 62 Mm^3
- Bio no BD:
  RES target only for the heat and power production: 13,5 Mm^3
  average cutting removal of stemwood 2012-2035 59 Mm^3

Removals of Bio and Bio noBD vis-à-vis Ref

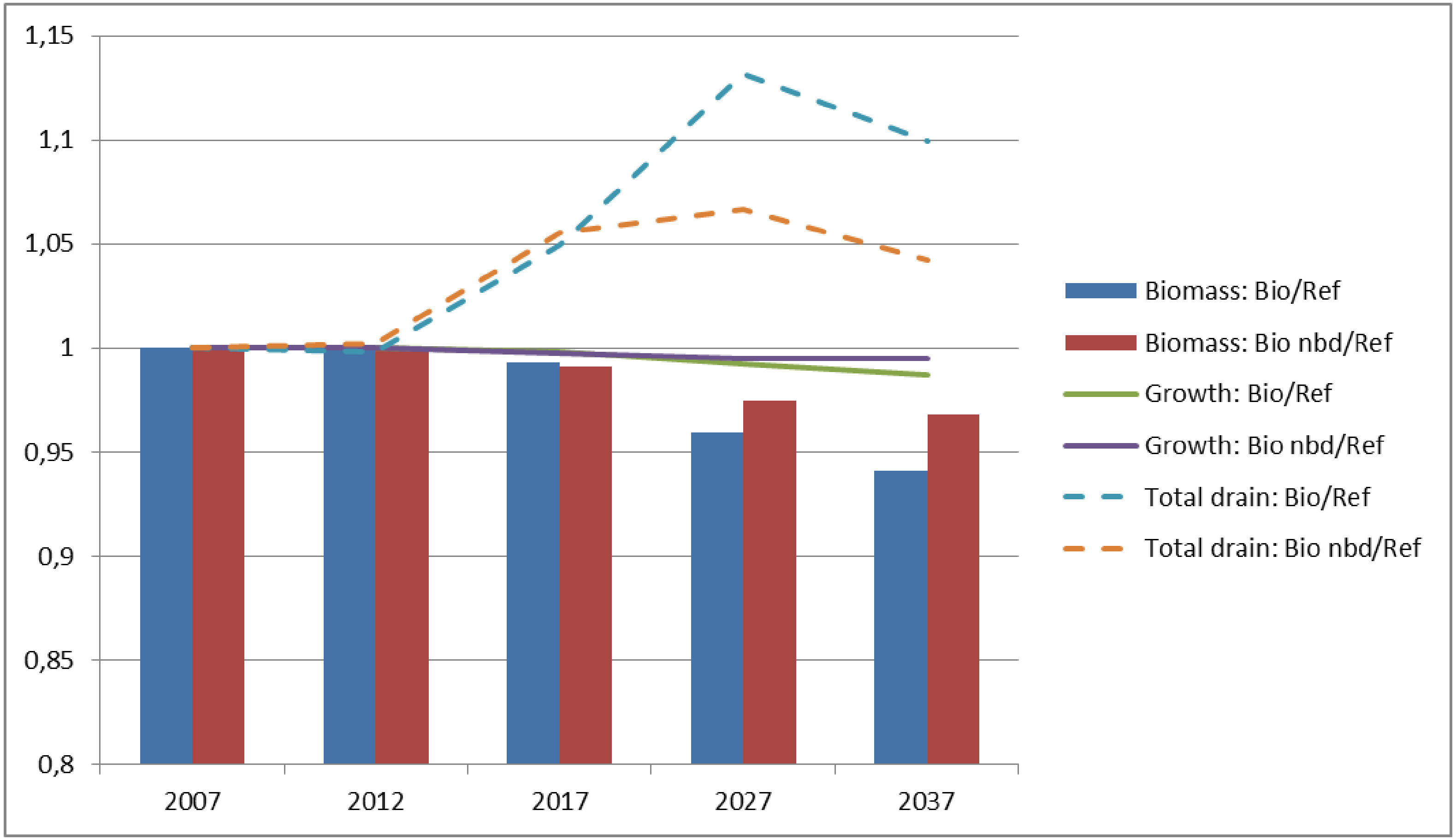
Bio – Ref



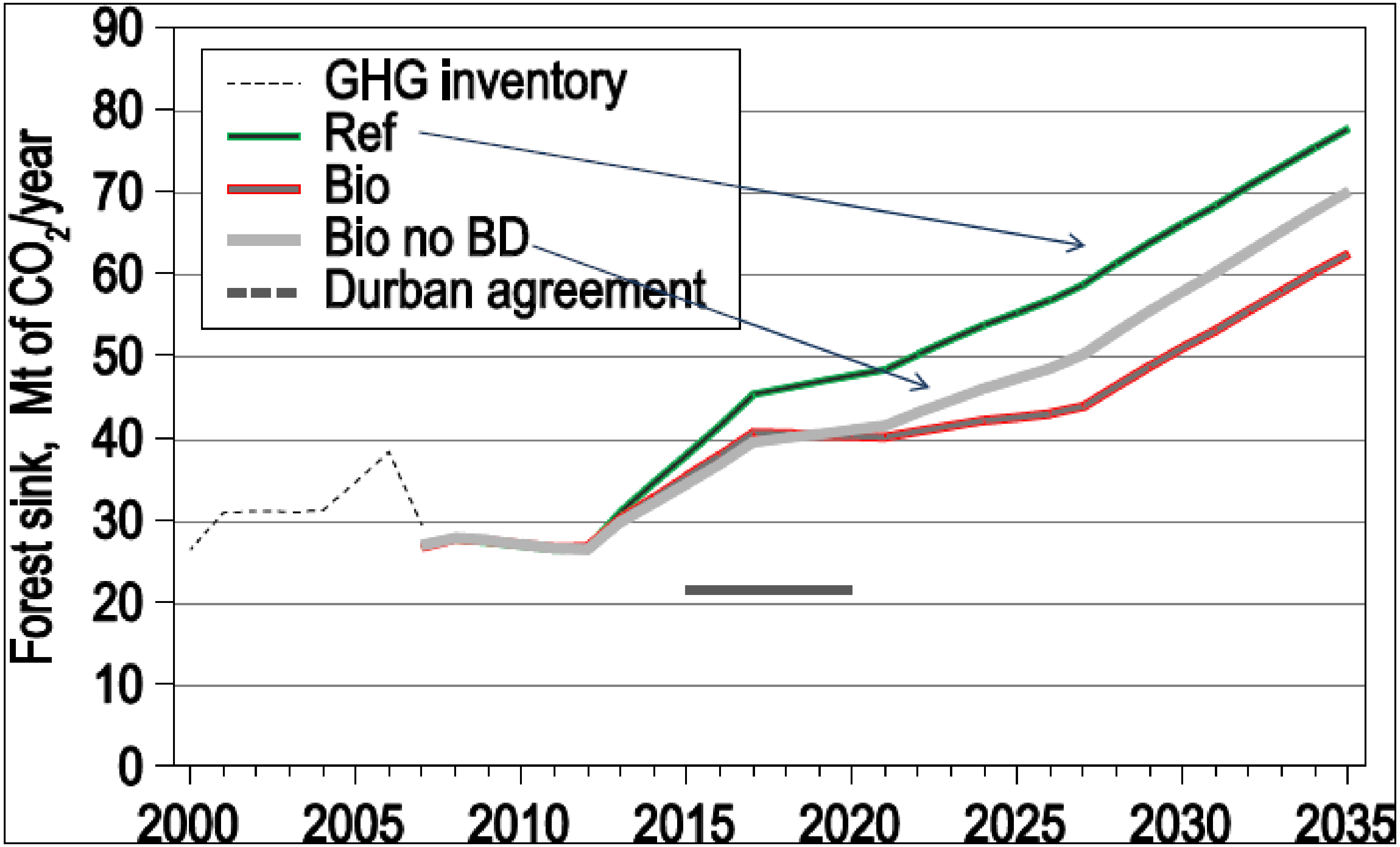
Bio no Bd - Ref



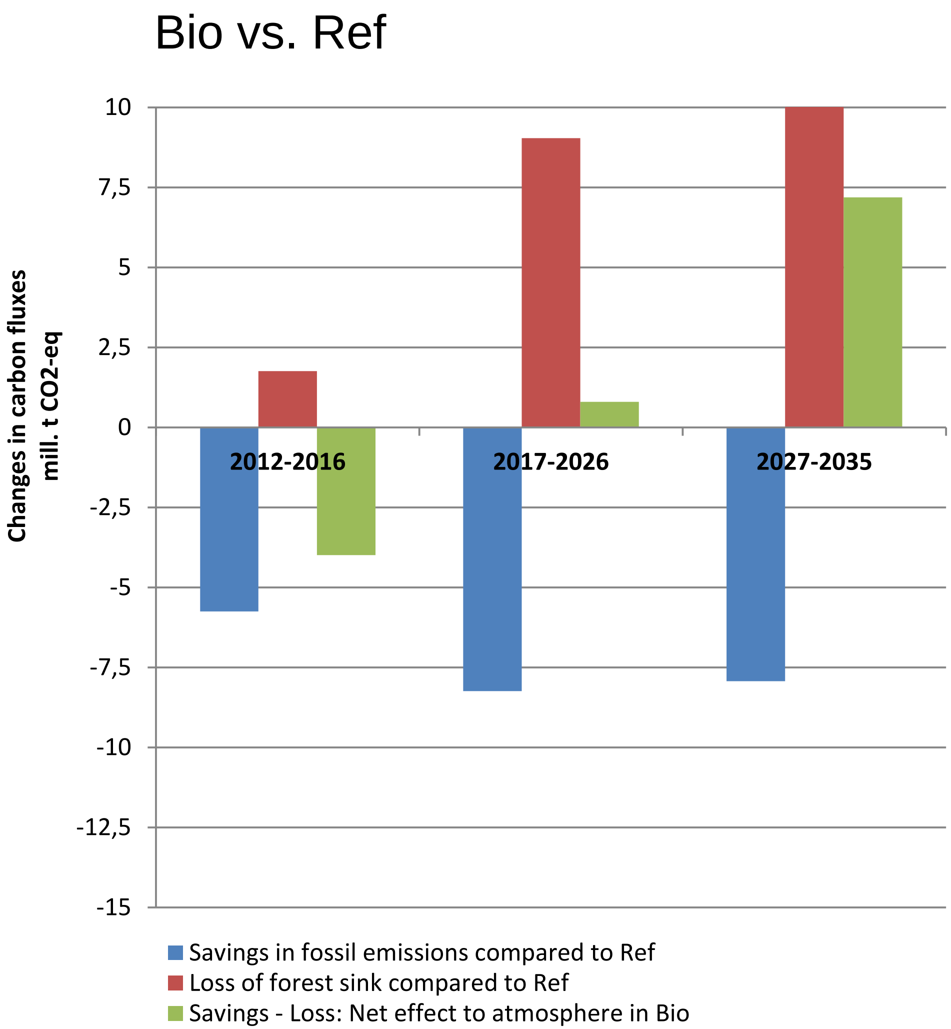
Biomass, growth and total drain of Bio and Bio noBD scenarios in respect to Ref

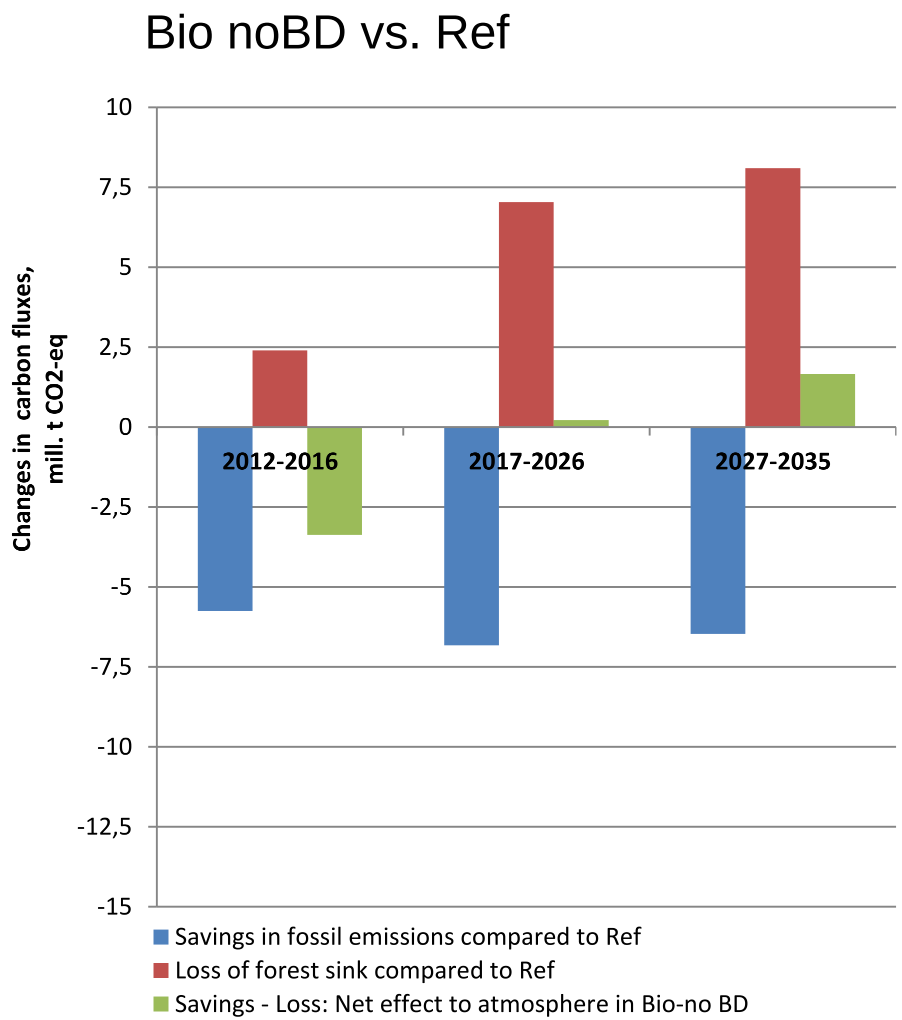


Carbon sinks (Kallio et al 2013)



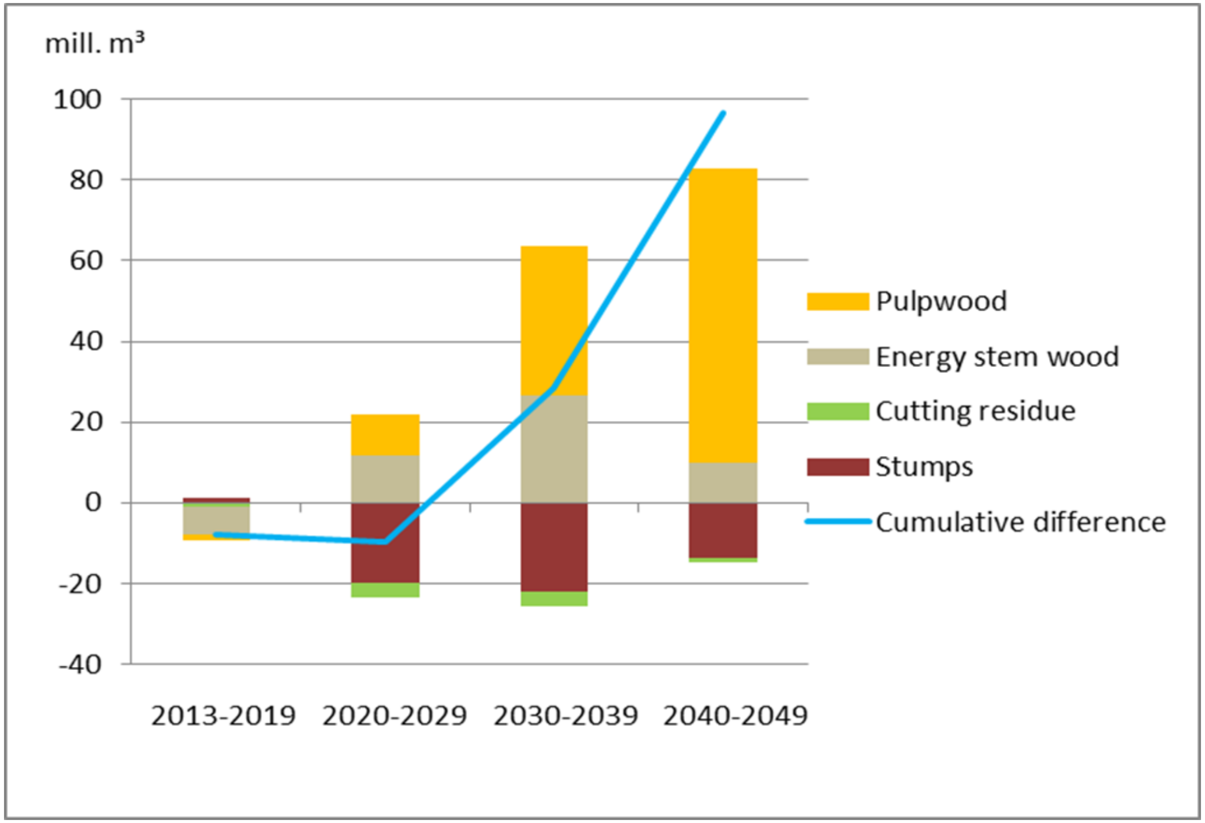
Carbon neutrality (Kallio et al 2013)





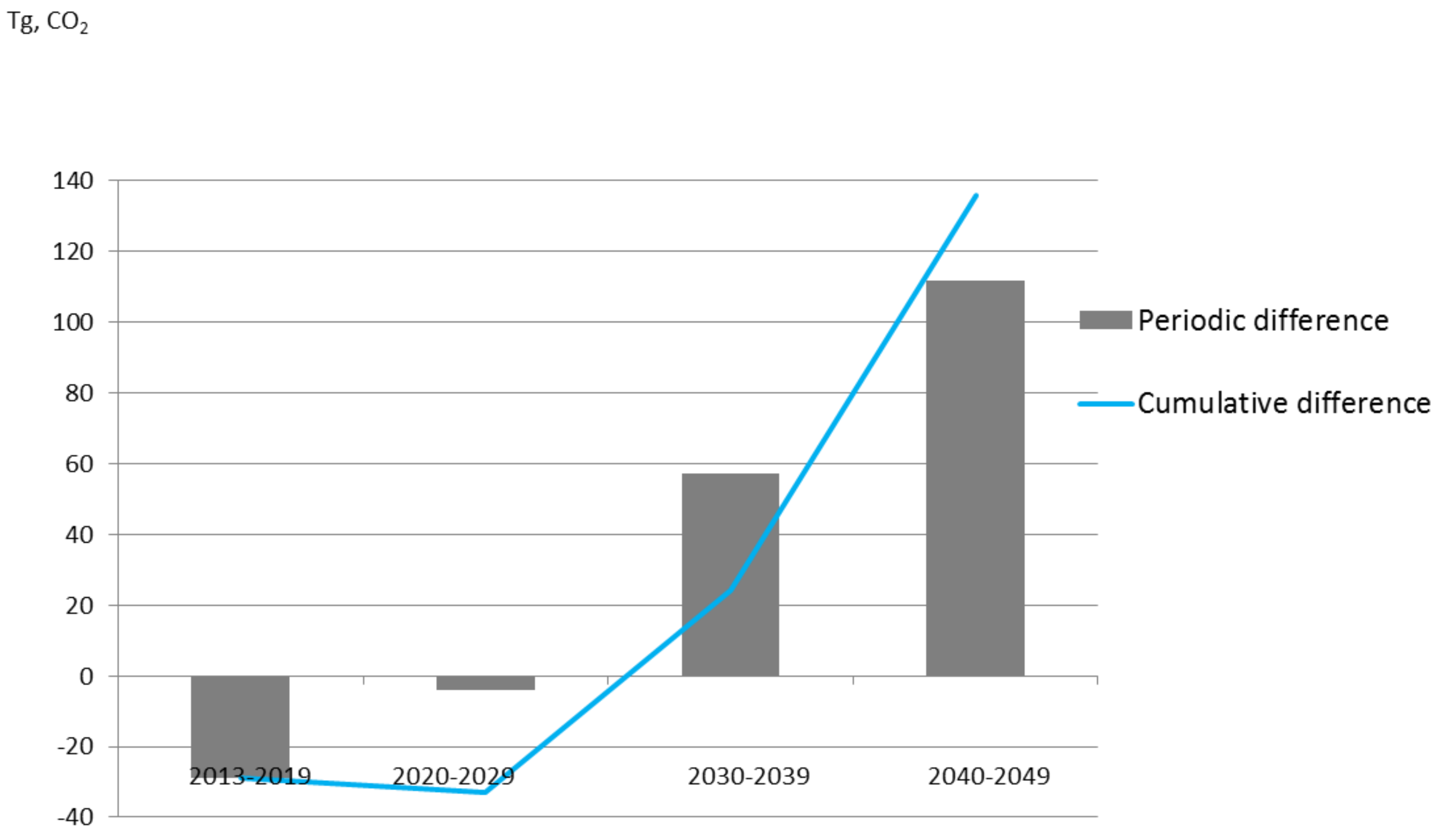
Kallio et al 2014:

- using similar calculation frame the effect of increasing usage of forest chips on the carbon sequestration was studied with the scenarios of 'Jatkuva kasvu' and 'Jatkuva kasvu H'



- removal diffrences of 'Jatkuva kasvu' and ' Jatkuva kasvu H'

Kallio et al 2014: differences of carbon sequestraion



= > corresponding results than Kallio et al 2013 and Sievänen et al 2014, i.e. ingreasing usage of forest chips mainly based stemwood is not effective as recarded to the climate

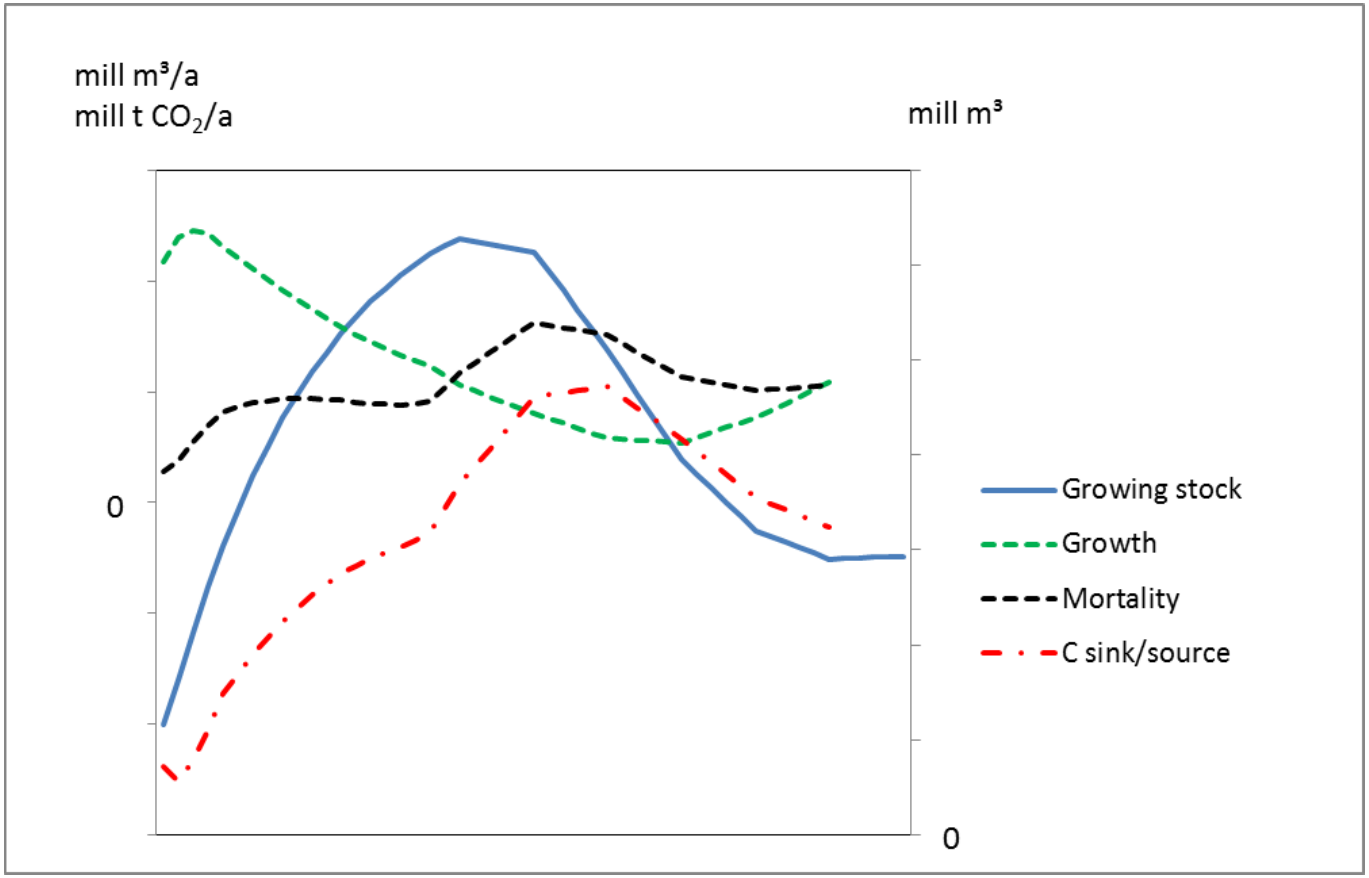
Results suggest that reaching the Finnish bioenergy targets based on increasing use of forest chips:

- Has negative impact on the atmospheric CO_2 at least when the increase of bioenergy is based on felling of trees which are in well growing phase
- But is vital for Finland’s compliance with EU RES 2020
- Does not jeopardize the Finnish Durban reference level
- Sequestration policy may be vulnerable to risks like wildfires, windfalls,deseases, pests… These risks were not taken into account
- Note that results are also bounded with
  - the current structure of Finnish forests
  - the optimization task (carbon was neither target nor a constraint)

Increased use of wood based energy means also

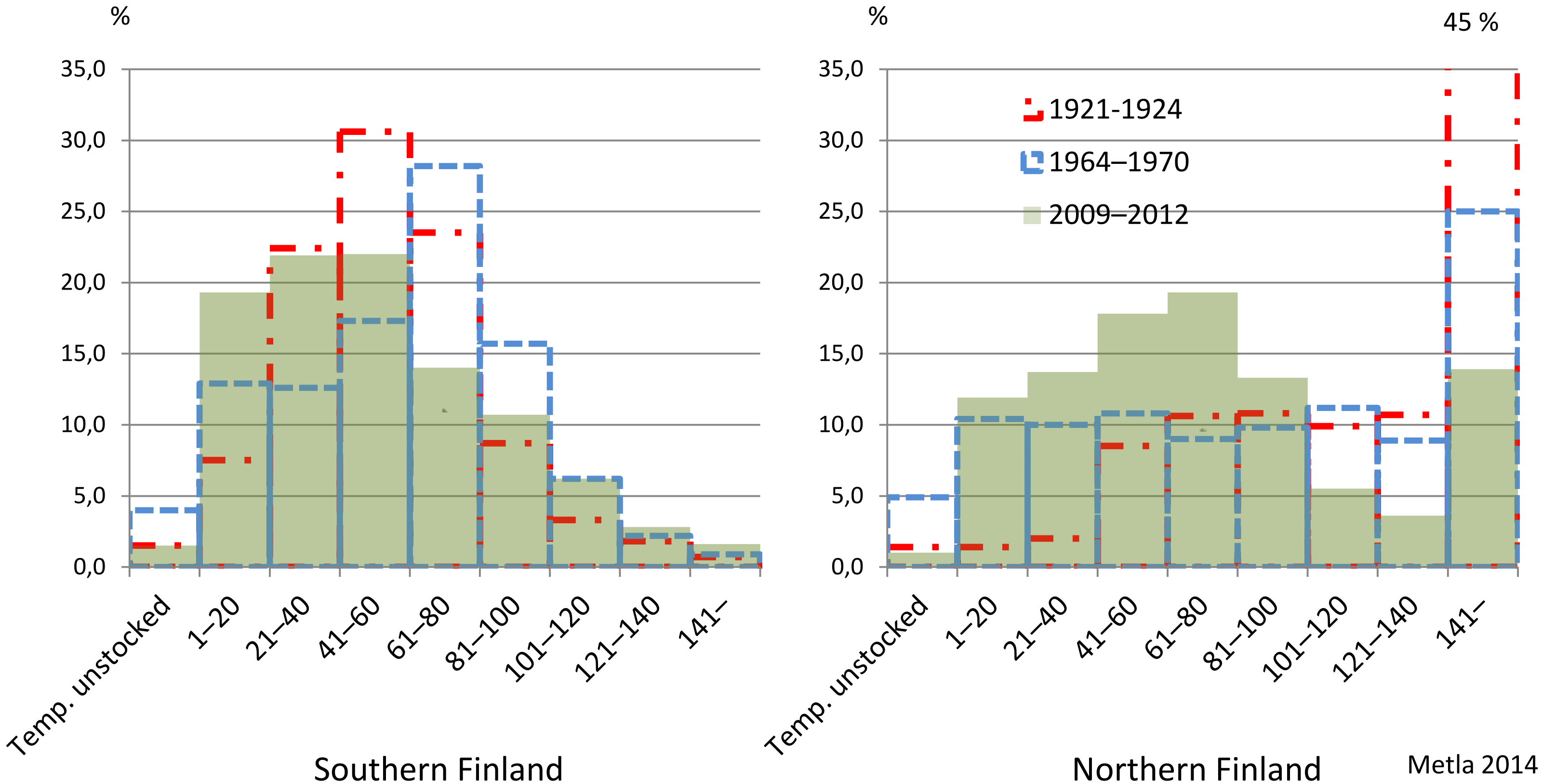
- higher (pulp)wood prices
  - Increase forest owners income & motivates forest management
  - Improve profitability of sawnwood production
- more jobs, although energy wood will , at least partly, replace domestic peat
- Improved trade balance and self-sufficiency, when oil and coal are repleced

However, forests as sustainable carbon sink necessitate treatments (1)



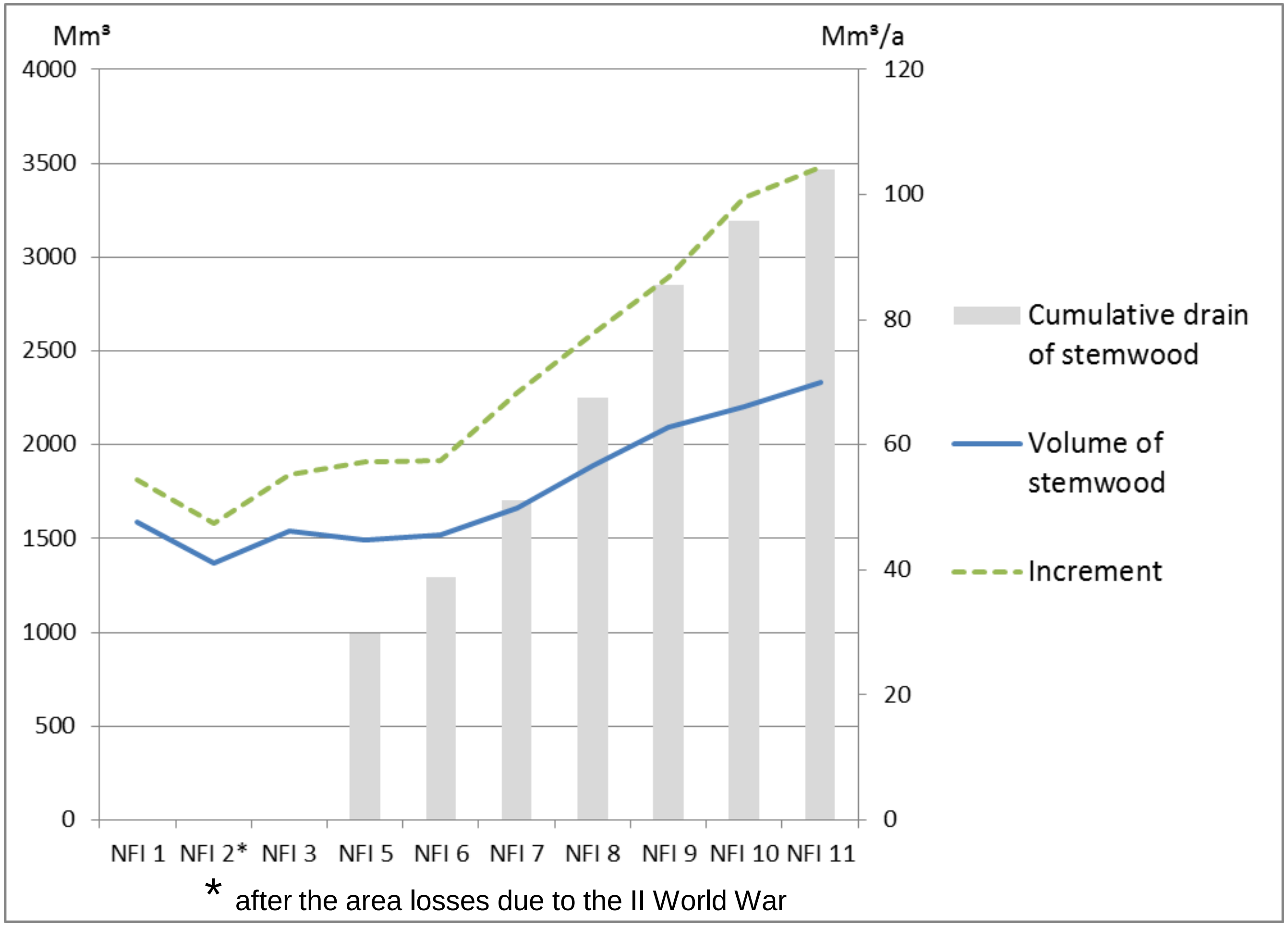
- a long-term development of forests without treatments

Forests as sustainable carbon sink necessitate treatments (2)



Age structure of the Finnish forests NFI 1 - NFI 5 - NFI 11

Forests as sustainable carbon sink necessitate treatments (3)



Development of the Finnish forests NFI1 (1921-24) - NFI11 (2009-2012)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Thank you