The climate change mitigation potential of forest biomass production and its utilization in Finland

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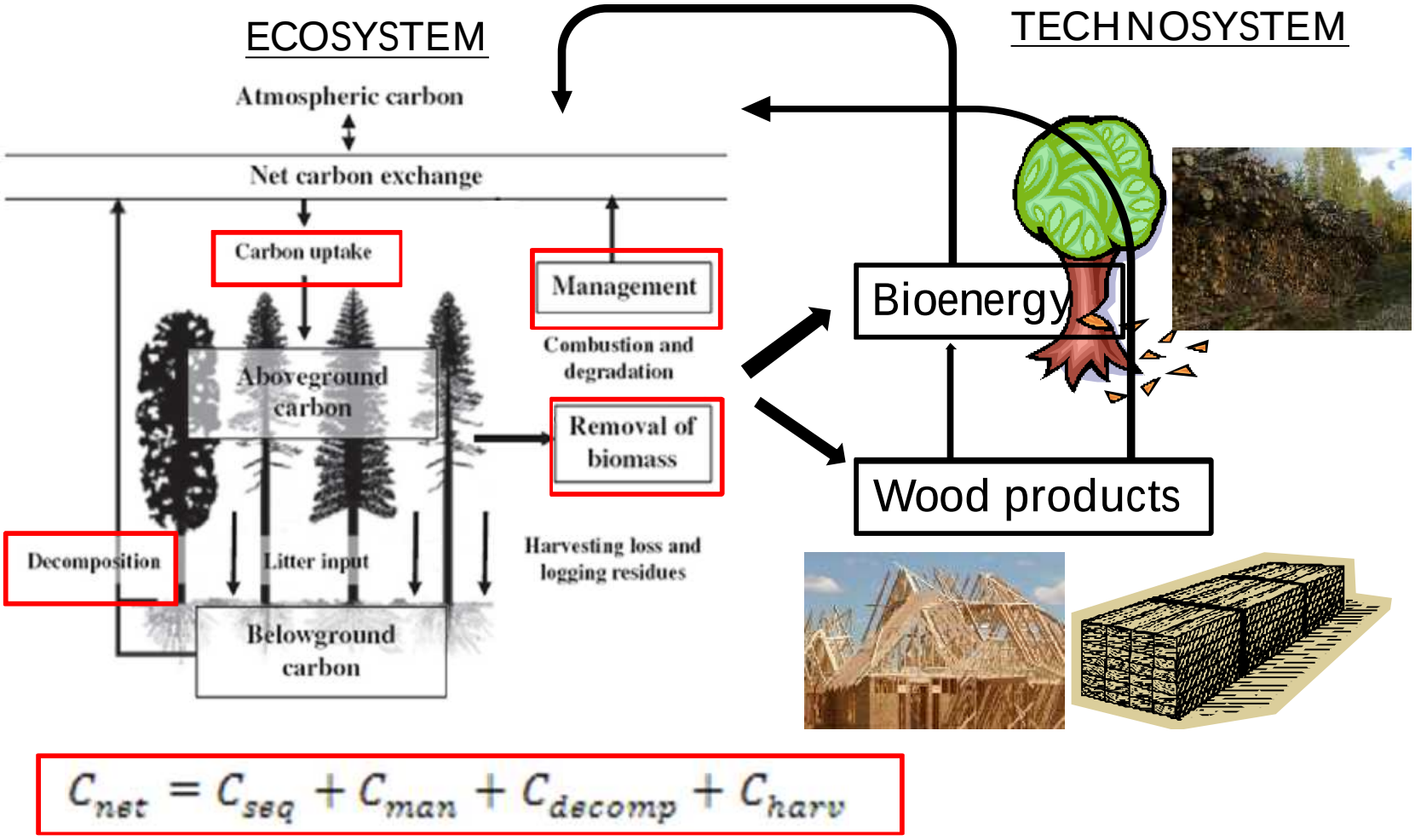
Content

- Life cycle carbon assessment for forest production and biomass utilization
  - Integration of ecosystem modelling and LCA (life cycle assessment)
  - Net CO_2 exchange calculation for biomass production and utilization under alternative forest management scenarios
- Net climate impacts of production and utilization of energy biomass and timber (saw logs and pulpwood) in fossil energy and fossil-fuel-intensive material substitution.

=> Climate change mitigation potential of boreal forests in Finnish boreal conditions

LCA tool for forest production and biomass utilization



$$C_{net} = C_{seq} + C_{man} + C_{decomp} + C_{harv}$$

Kilpeläinen et al. 2011, 2012, 2014, 2015

LCA tool for forest production and biomass utilization

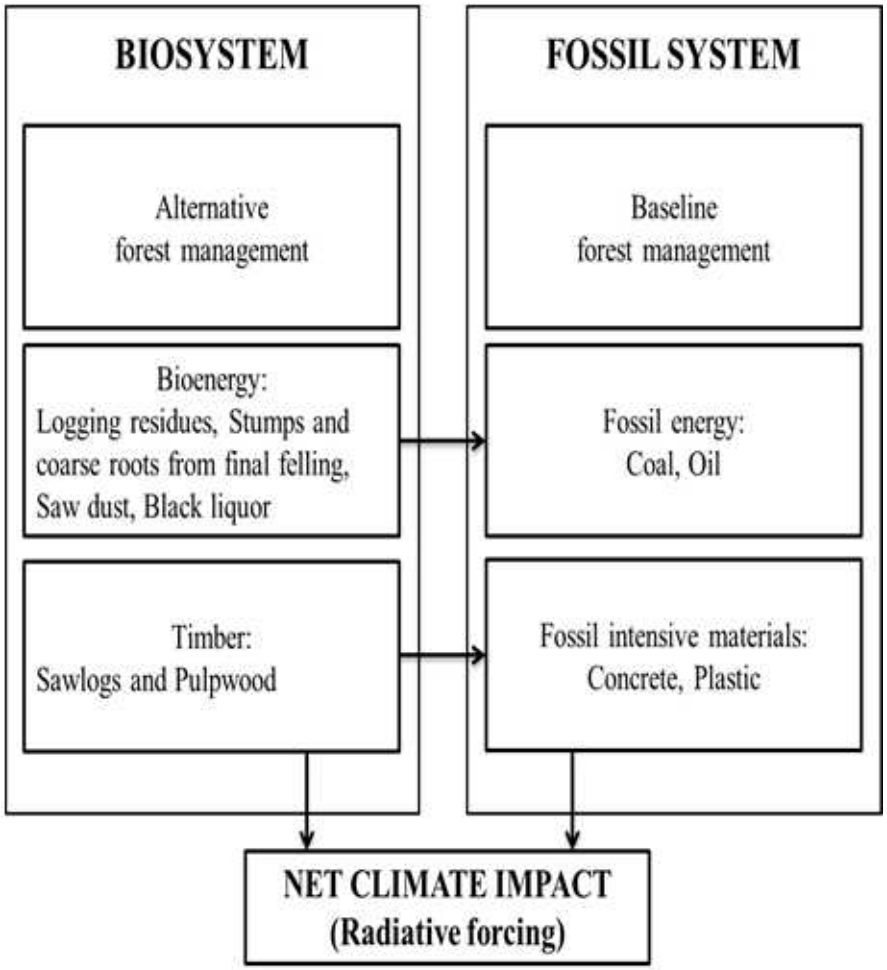
- Ecosystem model, SIMA (e.g. Kellomäki et al. 1992, 2008)
- LCA Tool for forest production (e.g. Kilpeläinen et al. 2011, 2012, 2014, 2015)
- Radiative Forcing calculator (Kilpeläinen et al. 2012, 2015; Torssonen et al. 2015)

These enable:

- Simulations of biomass production (timber and energy biomass, e.g. m^3/ha/a, tn/ha/a)
- Simulations of net ecosystem CO_2 exchange, NEE (carbon sequestration and decomposition, e.g. g CO_2 m^2/ha/a)
- Simulations of net CO_2 exchange (NEE + emissions from machinery + emissions from energy biomass combustion + degradation of wood-based products)
- Calculation of the net climate impact of biomass production and utilization of biomass in substituting fossil energy and/or fossil-intensive materials (e.g. in radiative forcing, Wm^{-2})

Simulations are possible at stand and landscape level (management unit), and by utilizing national-level forest inventory data

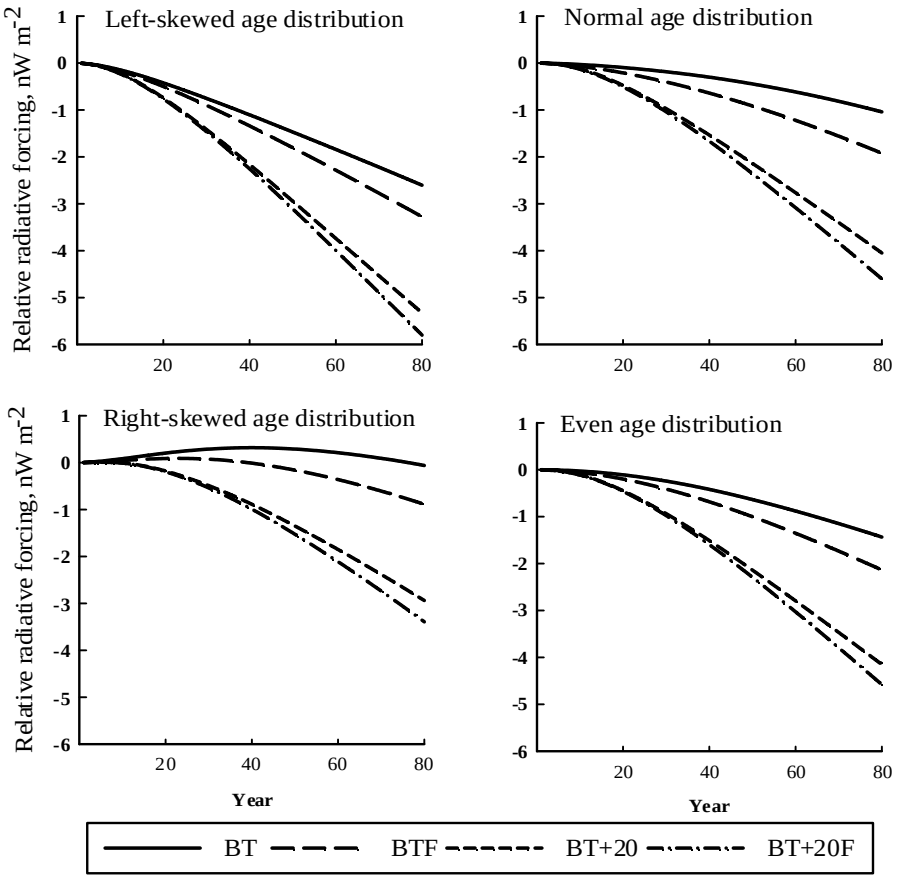
Net climate impact calculation



- Net climate impact = Annual difference in net CO_2 exchange between biosystem and fossil system
- Annual net CO_2 exchange (C_{net}) simulations for alternative biosystems/fossil systems
- Forest ecosystem is included both in biosystem and fossil system (reference situation)
- Net climate impacts of energy biomass and/or timber production and their utilization in substitution

Kilpeläinen et al. 2015

Example: Net climate impact of energy biomass utilization in alternative initial stand age structures and forest management regimes in comparison with use of coal



Energy biomass = logging residues and stumps/roots from final fellings (wood chips) in a landscape consisting of Norway spruce

-Left skewed age distribution: landscape initially with mostly young stands

-Right-skewed age distribution : landscape initially with mostly mature stands

-Normal age distribution : landscape initially with mostly middle-aged stands

-Even (stable) age distribution : all the stands on a landscape have different age

- BT = Current forest management recommendations
- BTF = Fertilization (150 kgN/ha, two times)
- BT+20 = 20% higher stocking
- BT+20F = Fertilization and 20% higher stocking

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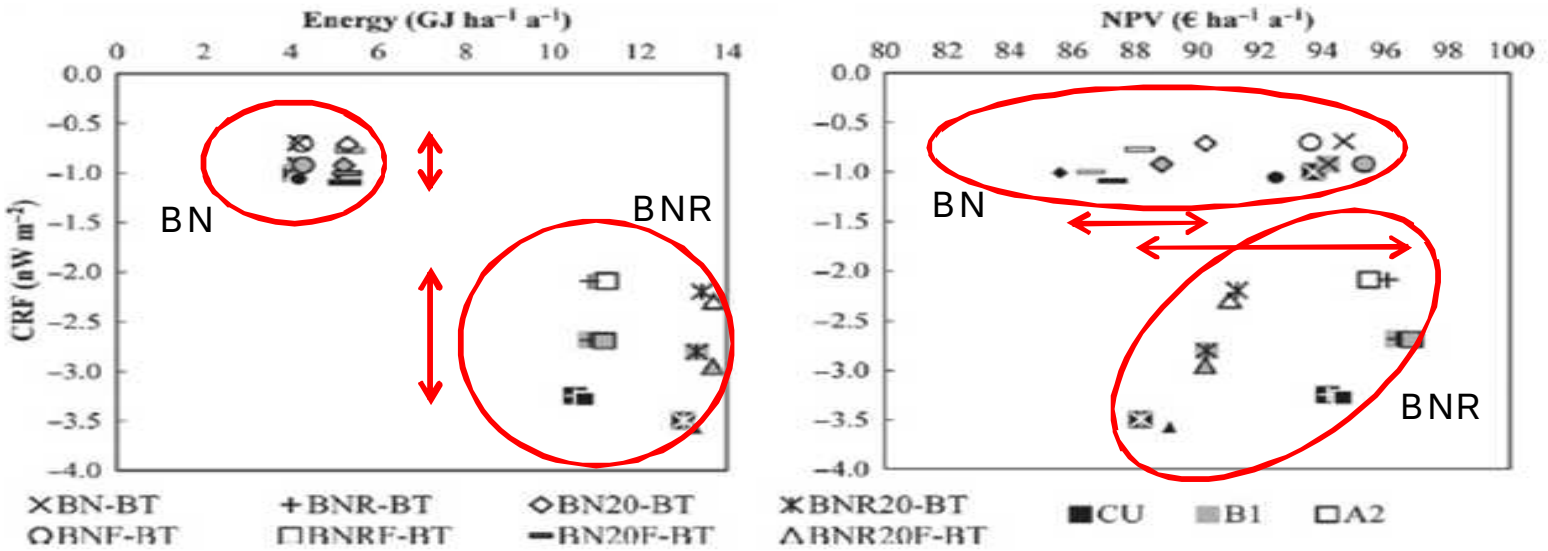
Kilpeläinen et al. 2015, unpublished

Example: Net climate impact of energy biomass utilization under stable (even) age structure, alternative forest management and climate change scenario in comparison with use of coal



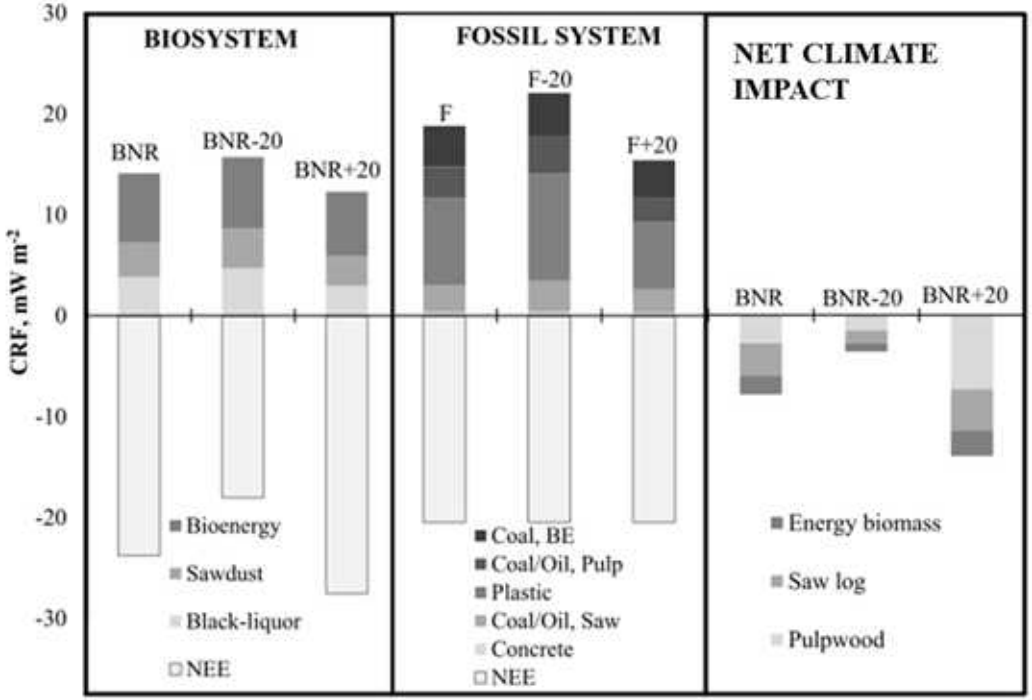
Energy biomass = logging residues (BN) and logging residues + stumps/roots from final fellings (wood chips) in a landscape consisting of Norway spruce

- Net Present Value (NPV) for the forest management scenarios includes timber and energy biomass

- Lower climate benefits from energy biomass utilization was found under climate change
- Lower NPV due to management that increases energy biomass production

Torssonen et al. 2015

Example: Net climate impact of energy biomass and timber production and utilization in Finland over 90 years



BNR = Forest production and utilization of timber and energy biomass (branches, needles, roots) under current management

BNR-20 = 20% decreased thinning thresholds compared to current management

BNR+20 = 20% increased increased thinning thresholds compared to current management

* CRF= cumulative radiative forcing for forest production and biomass utilization over the whole Finland, based on national forest inventory data

* Comparison of forest-based system (Biosystem) to corresponding fossil-based system (Fossil system)

* Substitution of fossil fuel intensive materials and fossil energy by using biomass (timber and energy biomass)

* Cumulative forcings for alternative biomass components

Kilpeläinen et al. 2015

Summary and conclusions

- Assessing the net CO_2 exchange of the ecosystem-technosystem-atmosphere continuum enables to define more precisely the role of forests in climate change mitigation.
- The use of forest-based materials and energy in substituting fossil-based materials and energy would provide an effective option for mitigating climate change.
- The climate benefits of forest biomass utilization could be increased e.g. by maintaining forest stocking higher over the rotation compared to the baseline management and/or by using fertilization. However, trade-off may exist between economic profitability of forest management (NPV) and net climate impact of energy biomass utilization.
- The climate impacts will vary substantially over time depending on the prevailing forest structure and biomass assortment (timber, energy biomass) used in substitution, and on the impacts of climate change on forests.

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