The greenhouse gas balance of the eucalyptus and maritime pine forest sectors in Portugal

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Introduction

The forest sector has the potential to mitigate climate change because:

- forests are important carbon (C) pools and act as C sinks when managed in a sustainable manner;
- forest products, both in use and in landfills, contribute to the storage of C, are alternative fuels to fossil fuels at the end of their life, and as construction materials represent alternatives to more energy-intensive materials used for the same purposes;
- the energy consumed in the forest-based industry is largely based on biofuels, namely by energetic valorisation of forest waste and forest product waste.

Objective

To quantify the net balance of greenhouse gases (GHG), namely carbon dioxide (CO_2) and methane (CH_4), for the Portuguese eucalyptus (*Eucalyptus globulus*) and maritime pine (*Pinus pinaster*) forest sectors.

The species analysed in the present study are very important in Portugal because:

- maritime pine and eucalyptus forests present an occupation area of about 23% and 21% of the total forest area in Portugal, respectively;
- almost all of the wood harvested in the country consists on maritime pine and eucalyptus wood.

Methodology

Net GHG balance (as C) = C removal by forest and wood products – fossil C emissions – additional CH_4 emissions

APPROACHES

C removal by forest and wood products was estimated by using two alternative approaches:

- stock-change approach: C removal is equivalent to the change in C stocks both in forest and wood products, within national boundaries;
- atmospheric-flow approach: C removal is equivalent to the difference between gross C removal by the forest ecosystem and total C emissions arising from the decay and burning of the forest biomass throughout the forest sector, within national boundaries.

FOREST: C removal

- Stock-difference method for aboveground biomass
- C removal = difference between the C stocks measured at two points in time
- C stock = wood standing volume x biomass expansion factor x C fraction of dry biomass

FOREST: fossil C emissions

- Includes emissions from fossil fuel consumption in all motor-manual and mechanized operations performed during site preparation, stand establishment, stand tending, logging and infrastructure establishment.
- The type and frequency of the operations was established by adopting a typical forest management model for each species.
- Emissions were estimated based on the effective work time needed to perform each operation and the respective fuel consumption per hour of machine work, as well as on the specific C emission factor for each fuel consumed.

WOOD-BASED INDUSTRY: biomass-based C emissions

Pulp and paper industry:

- includes emissions from biomass (wood cooking liquor and bark) burning for on-site energy production, and emissions associated with the decay of solid wastes, wastewater and co-products;
- C emissions were obtained by performing C balances at the mill level.

Sawnwood and panel industry:

- includes emissions from solid waste burning and decay of solid wastes;
- C emission estimation relied on solid waste production rates and C content provided by the industry.

WOOD-BASED INDUSTRY: fossil C emissions

- Includes the emissions associated with the consumption of fossil fuels within the mills, for both energy production and other uses, and also the emissions associated with the trade of electricity between the mills and the national grid.
- C emissions were estimated based on the amounts of fuels consumed and electricity traded (data provided by the mills) and based on the C emission factors specific for each fuel consumed and for the electricity produced in the Portuguese grid.

WOOD PRODUCTS IN USE AND IN LANDFILL: C removal

- C removal = C inflow to the pool of wood products – C outflow from the pool of wood products
- For wood products in use: C inflow is based on statistical data of production and trade of wood products, whereas C outflow is calculated from the lifetimes of the wood products in use.
- For wood products in landfill: C inflow is based on the amount of C estimated to be going out of use and the fraction of discarded wood products going to landfills, whereas C outflow is calculated from the lifetimes of the wood products in landfill.

Results

Results for year 2000

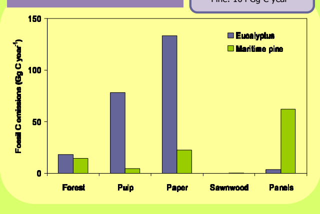
C flows

Applications of industrial wood in Portugal	Eucalyptus	Maritime pine
Pulp	96%	7%
Panels	2%	24%
Sawnwood	2%	69%

Structure of the consumption of wood products in Portugal	Eucalyptus	Maritime pine
Paper	68%	4%
Panels	20%	46%
Sawnwood	12%	50%

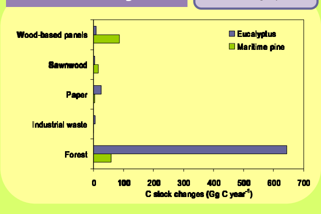
Fossil C emissions

Eucalyptus: 233 Gg C year^{-1}
Pine: 104 Gg C year^{-1}



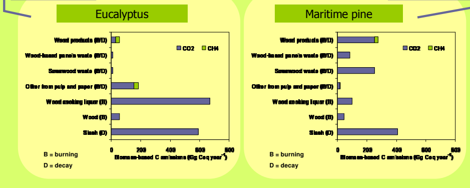
C stock changes

Eucalyptus: 686 Gg C year^{-1}
Pine: 165 Gg C year^{-1}



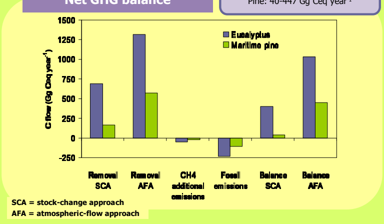
Biomass-based C emissions

1576 Gg Ceq year^{-1} (Eucalyptus) — 1181 Gg Ceq year^{-1} (Maritime pine)



Net GHG balance

Eucalyptus: 401-1033 Gg Ceq year^{-1}
Pine: 40-447 Gg Ceq year^{-1}



SCA = stock-change approach
AFA = atmospheric-flow approach

Conclusions

- The total GHG balance in the eucalyptus and maritime pine sectors in the year 2000 was a net removal of C, the magnitude of which varied with the approach considered, ranging from 401 to 1033 Gg C_{eq} year^{-1} in the eucalyptus sector, and from 40 to 447 Gg C_{eq} year^{-1} in the maritime pine sector (higher values correspond to the atmospheric-flow approach).
- Forest played a major role in C accumulation in the eucalyptus sector, while the wood products were more important than forest in the maritime pine sector.
- Fossil C emissions accounted for 8% and 13% of the total C emissions in the maritime pine and eucalyptus, respectively.
- CH_4 emissions accounted for 2% and 4% of the biomass-based C emissions in the maritime pine and eucalyptus sectors, respectively.

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