



A circular inset image shows a dense forest of tall, straight eucalyptus trees with lush green foliage. The trees are arranged in a grid-like pattern, suggesting a managed plantation. The background is a soft, out-of-focus green.

From Forest to Paper: A Life Cycle Perspective on *Eucalyptus*-Based pulp and paper Products

Fernanda Leite Cunha, Isáira Leite & Lopes, Sarah Pulls, Rachel Cook, Justin Baker, Otávio Camargo Campoe



FOREST PRODUCTIVITY COOPERATIVE

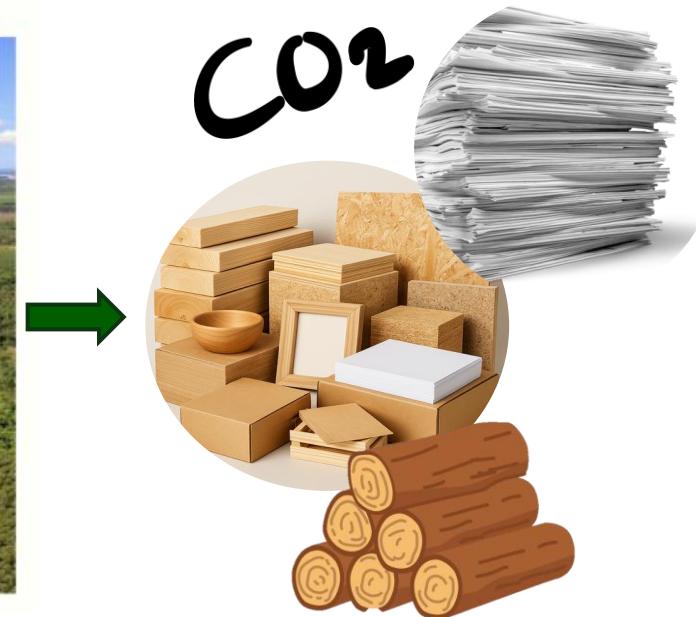
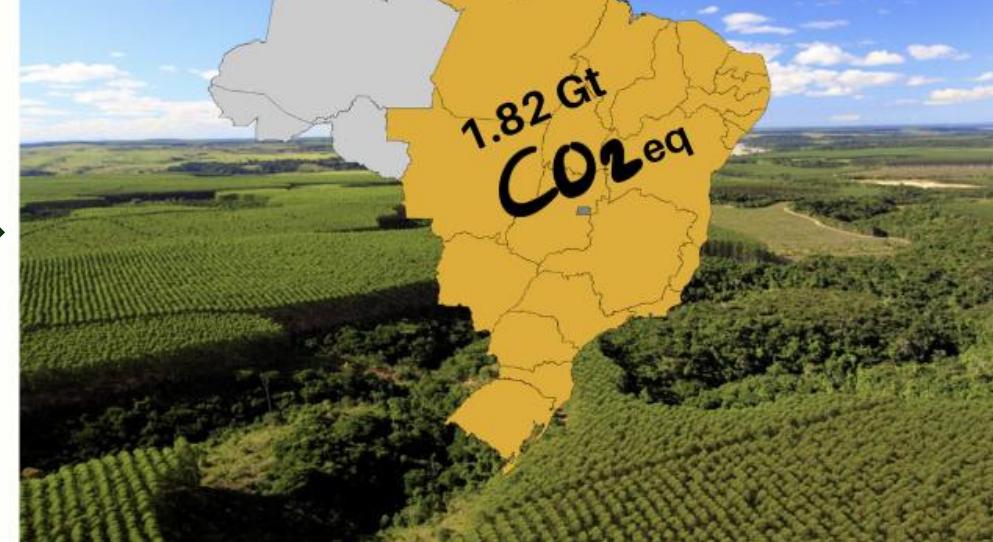


Forest Carbon Stock



$$\text{NEP} = \text{GPP} - \text{Rs} - \text{Rw} + \text{Rf}$$

19 months → NEP +
Strong drain of C₅anos ≈ 1.6 Mg C/ha/month



Hard Wood Products-HWP



335 megatons of CO₂ eq yr

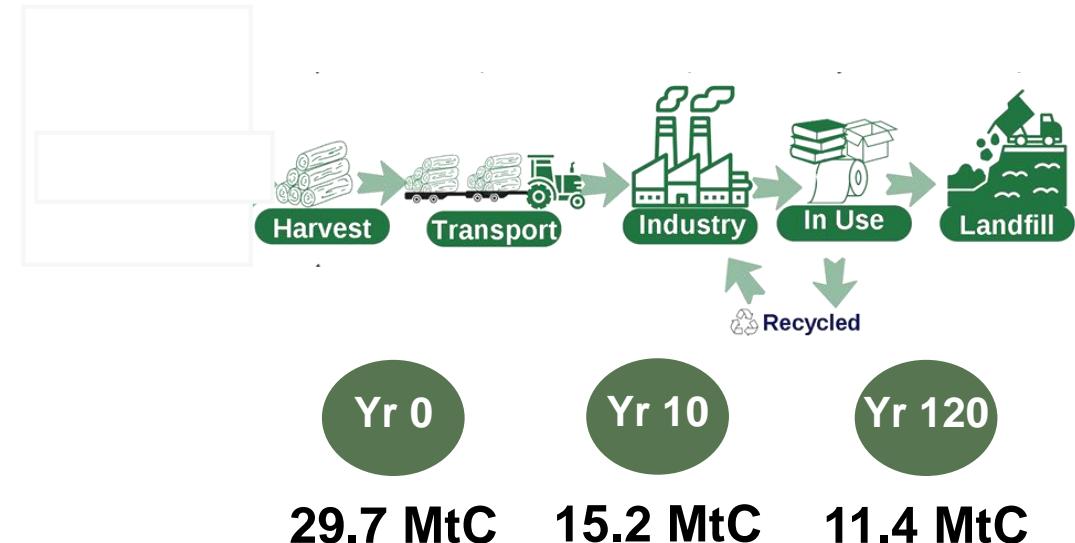
2015
(Johnston & Radeloff, 2019)

Climate Benefits

- Even temporary storage helps delay the peak of global warming.
- Creates a window to implement long-term climate solutions.
- HWP offset only ~1% of global GHG emissions (Matthews et al., 2023).
- HWP was accepted as part of a country's GHG reduction contributions (COP17, EPA)

Hard Wood Products-HWP

LobWise (1.0) Loblolly Wood Inventory, Storage, and Emissions



Pulp and paper Yr 0 → 18.9 million tC → 63%

Opportunities for improvement

- Parameterized only for **Pinus** in the southern US
- Model starts at harvest time
- Paper and pulp parameters and emissions (mil, recycled ...)
- Data managed in Excel-based system

Objective

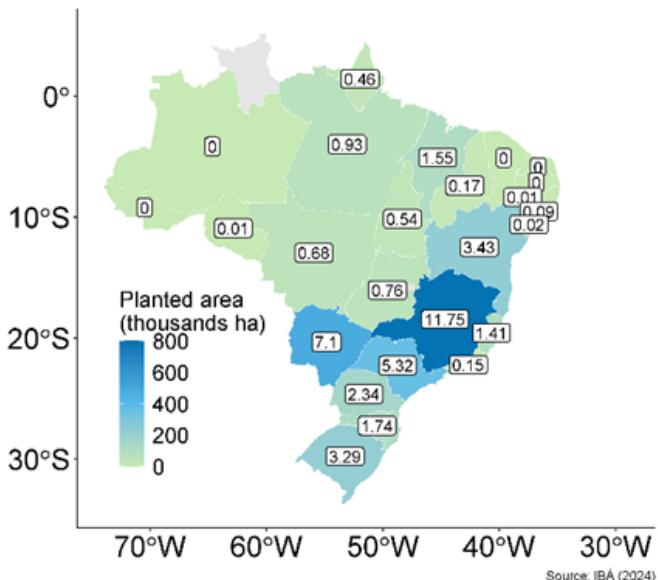
- Enhance the LobWise and adapt its parameters to reflect Brazilian forestry conditions and production systems.
- Provide a comprehensive analysis of C fluxes from paper and pulp products derived from *Eucalyptus* plantations in Brazil, assessing their contribution to atmospheric C removal.



Brazilian *Eucalyptus* Production



6 years rotations
Total green biomass : 41.7 Mt



Pulp and paper: 2.8 million ha 33 m³ ha⁻¹ yr⁻¹

The world's largest exporter of cellulose (75% pulp production)

Paper production: (80% remain in Brazil)



Miscellaneous Card paper
(0.05%) (6%)



neous Card paper
%) (6%)



Sanitar
(13%)



Print and Write (20%)

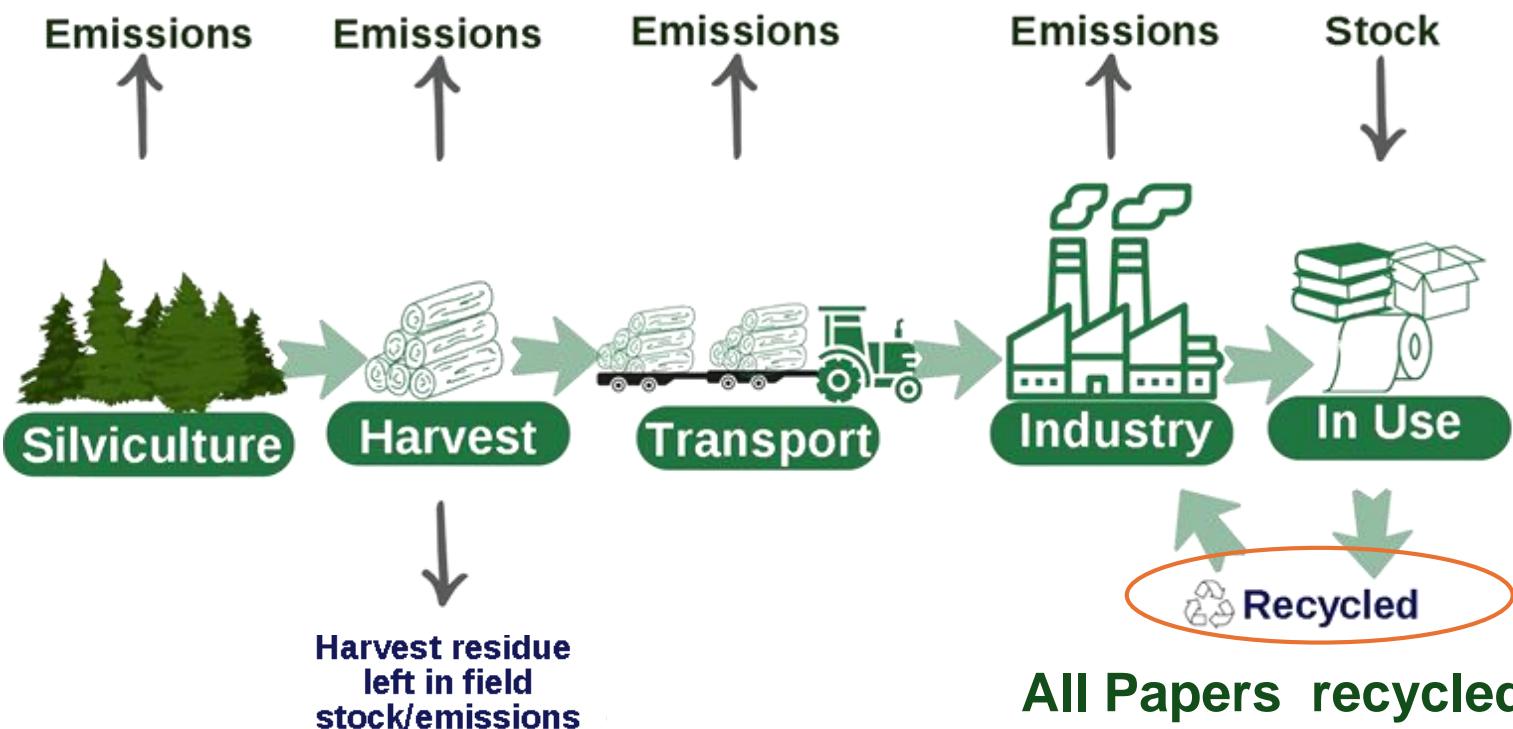


Packaging
(56%)



ForestWise 2.0

ForestWood Inventory, Storage, and Emissions



Emissions : GEE atmosfera_{rem} → Modelo do ciclo do C de Berna

ForestWise 2.0

ForestWood Inventory, Storage, and Emissions

Silviculture

Parameter= 0.0244 t CO₂ emitted/ t CO₂ final product



(1) soil preparation



(2) planting and replanting



(3) fertilizer application



(4) weed control



(5) ant control

ForestWise 2.0

ForestWood Inventory, Storage, and Emissions

Scenarios analyzed for Harvest emissions

Parameter= 0.094 t CO₂ emitted/ t CO₂ final product

①



Harvester + Forwarder

②



Feller-Buncher + Skeeder

Scenarios analyzed for Transport emissions

Parameter= 0.0225 t CO₂ emitted/ t CO₂ final product



Tritrain
300 km round trip
66 m³

Results - C Stock and C Emissions

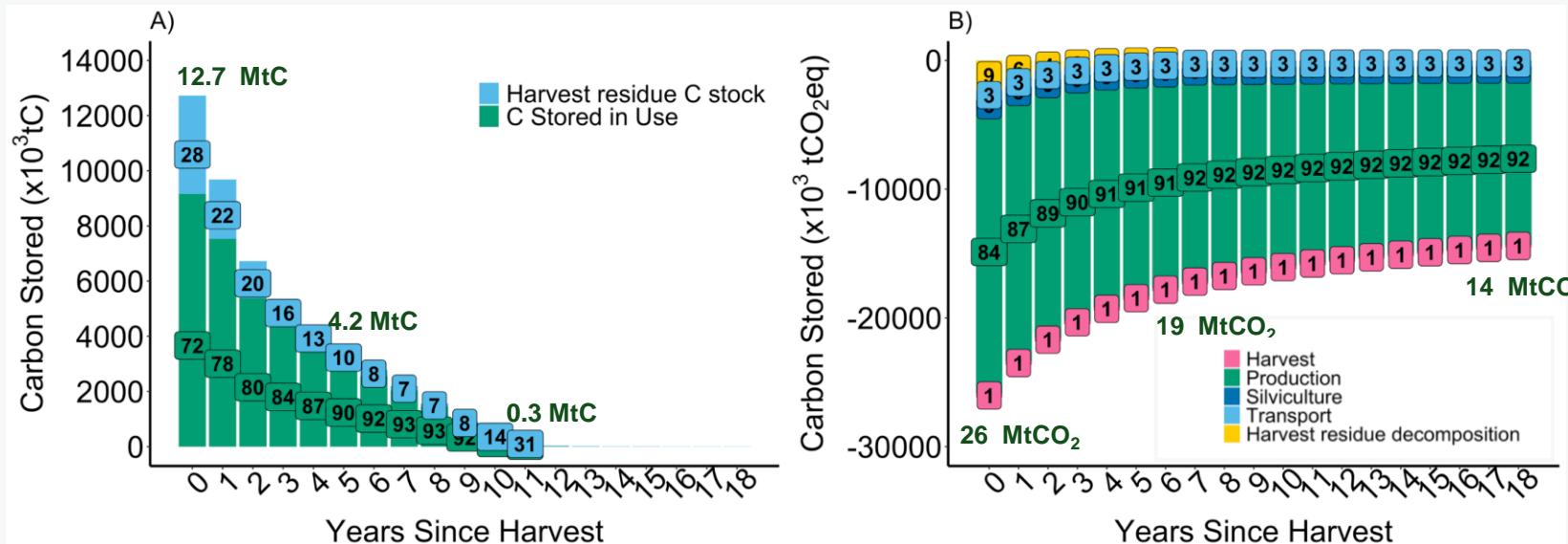


Fig. A) C stock. B) Greenhouse gas (GHG) emission pulses (t CO₂ eq) by type and source C

C Balance (Stock-Emissions) : industry emissions

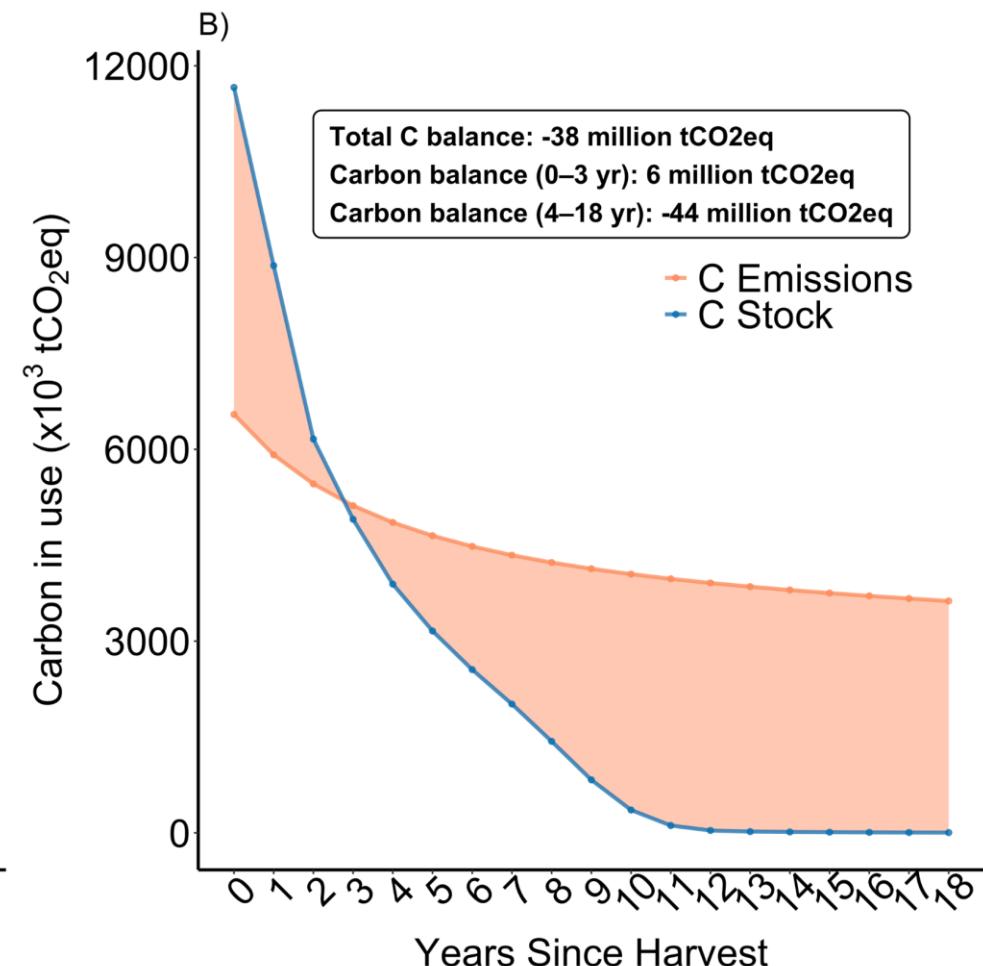
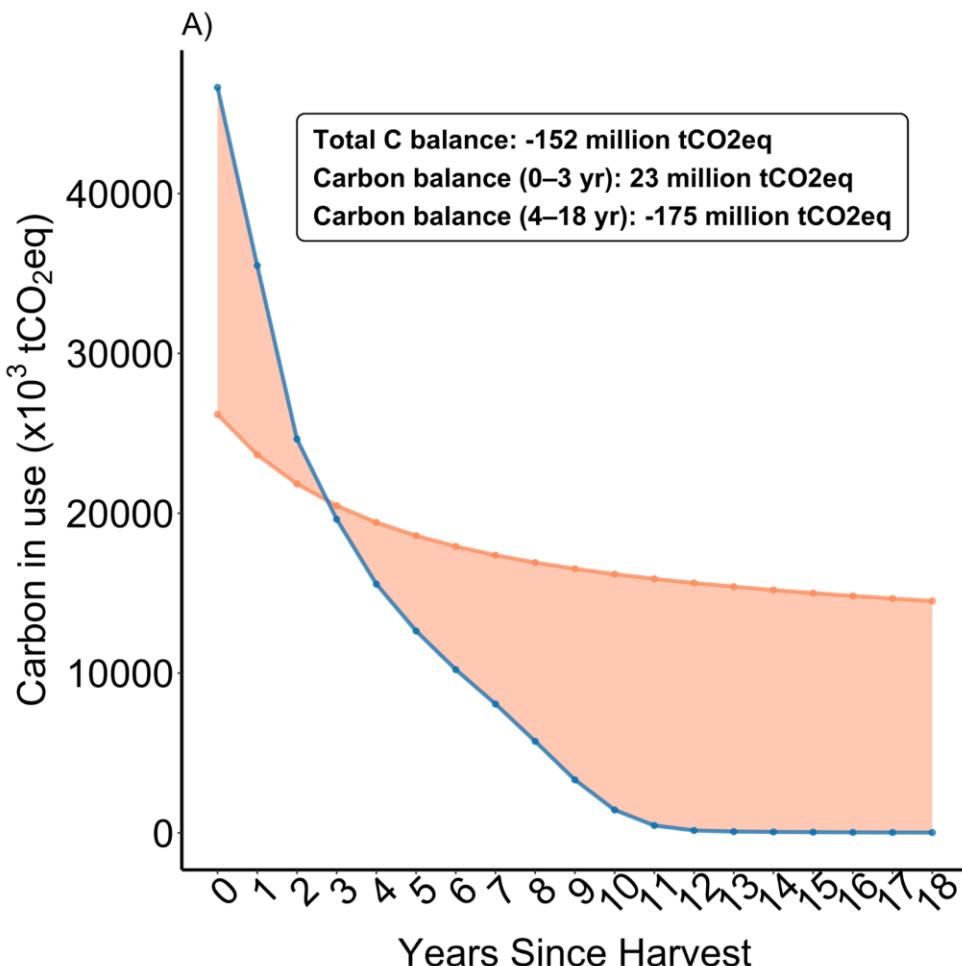


Fig. C emissions and stock associated with the life cycle of pulp and paper products over 18 years in Brazil. (A) total pulp production and (B) final paper products produced in Brazil (25%).

C Balance (Stock-Emissions) : no industry emissions

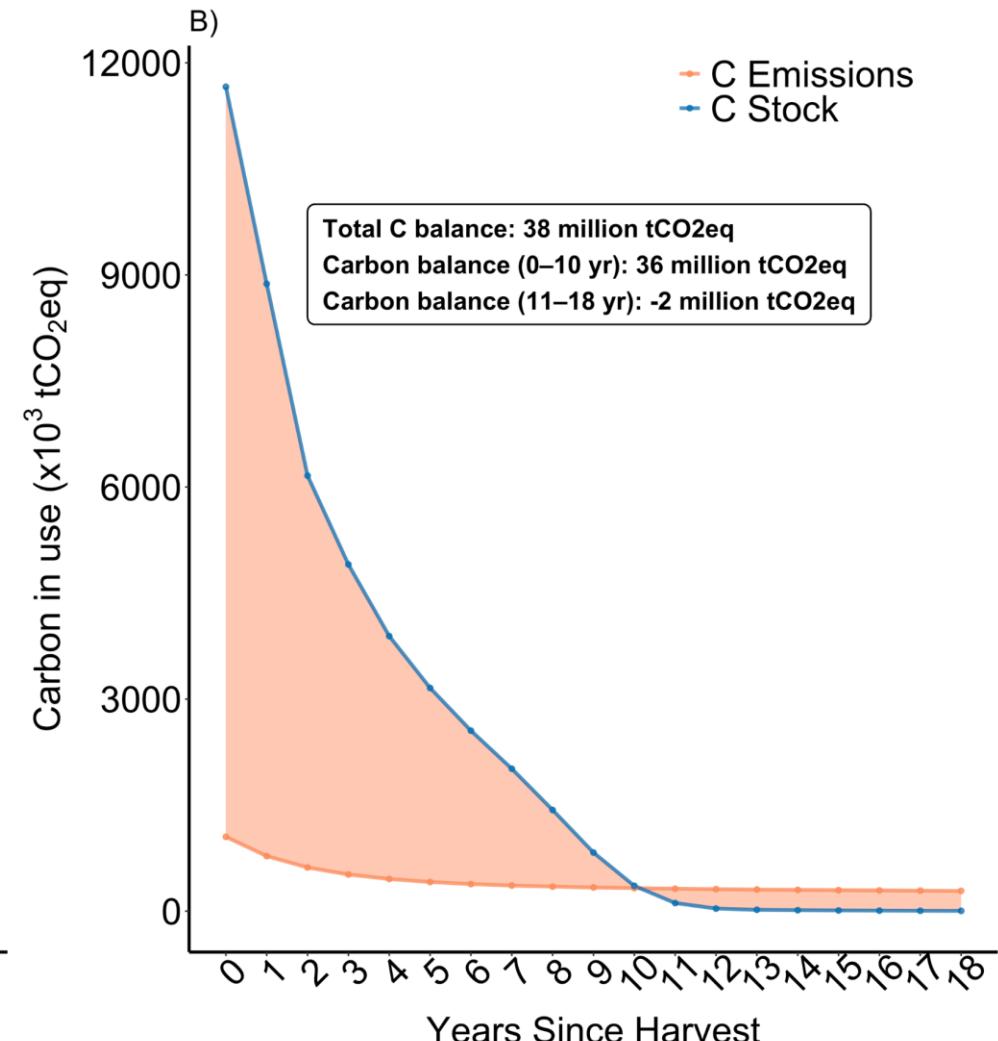
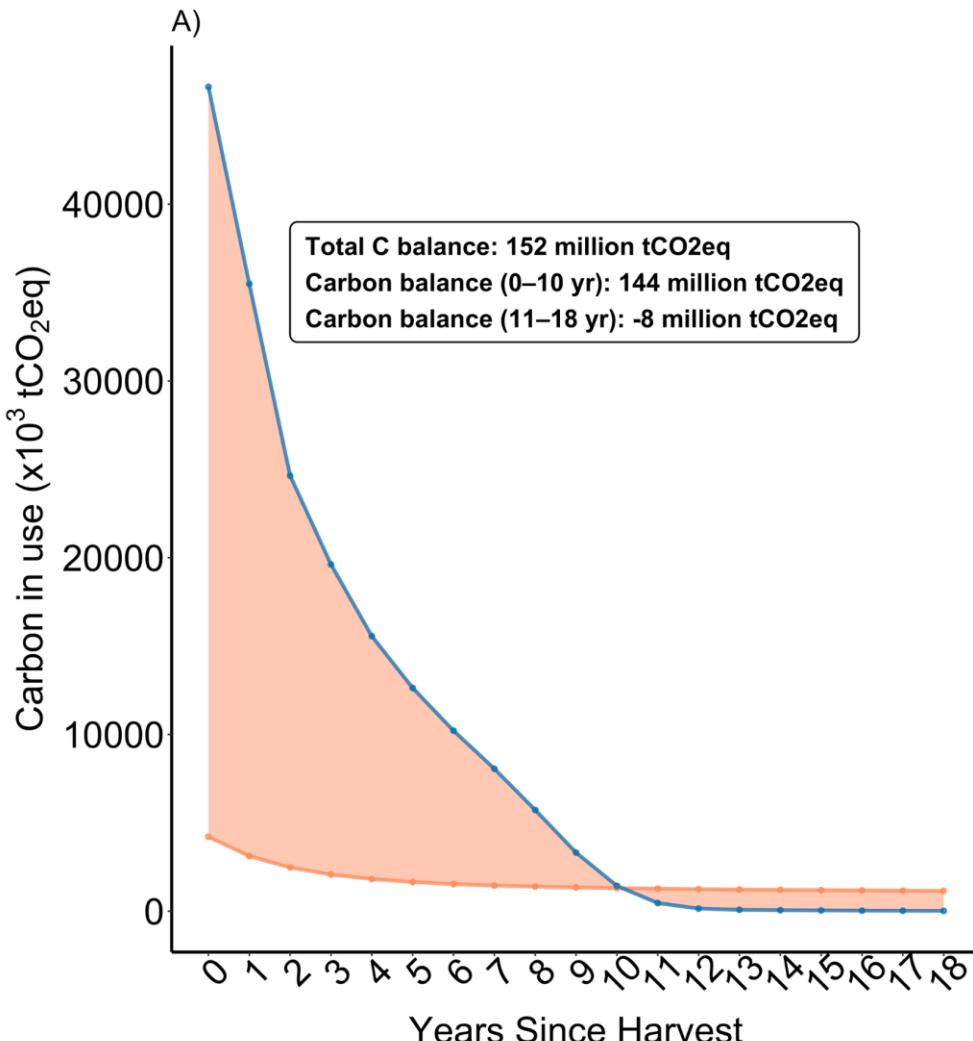
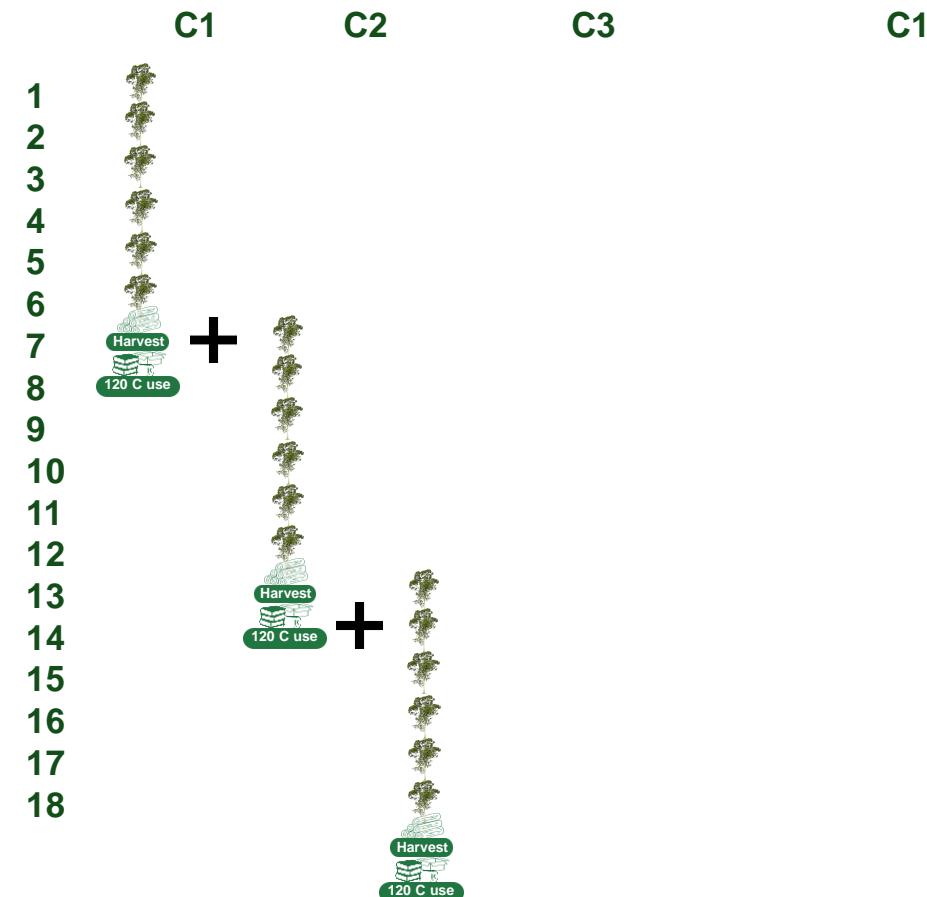
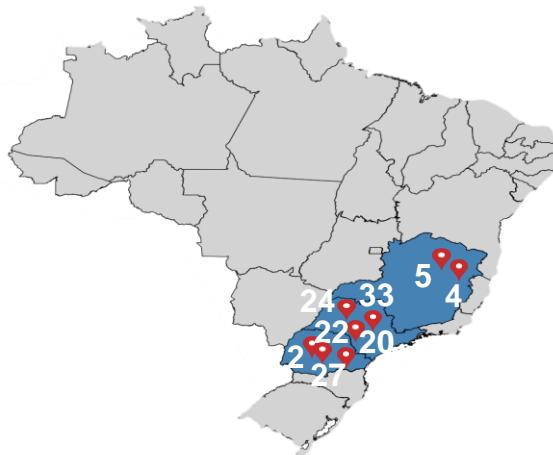
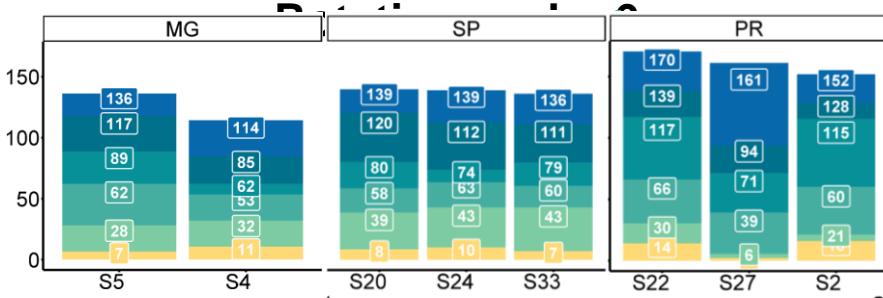


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Result- State level carbon footprint

Biomass + LCA (MG, SP, PR)

- Site: TECHS Experimental Network
- Species: *Eucalyptus urophylla* (A1)



Biomass + LCA

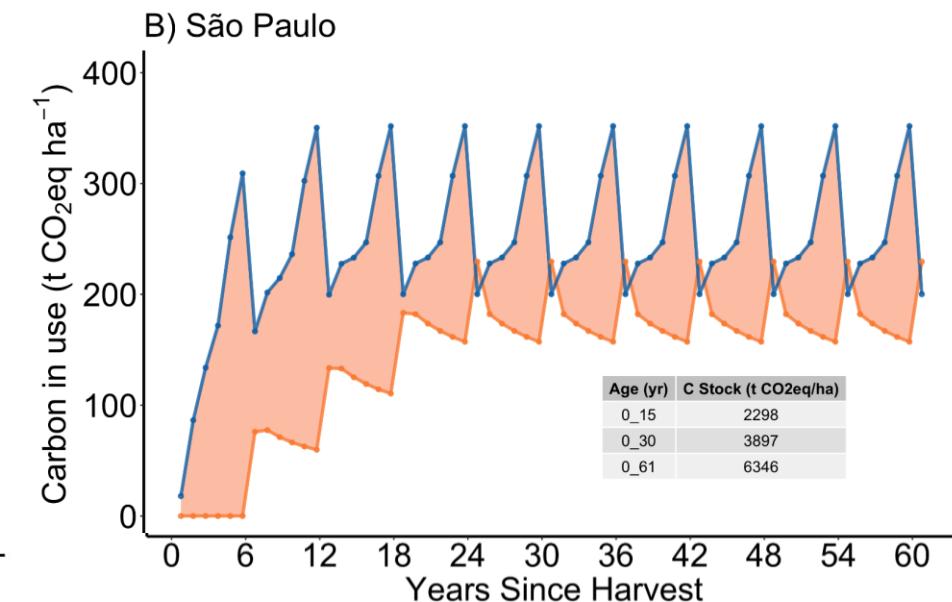
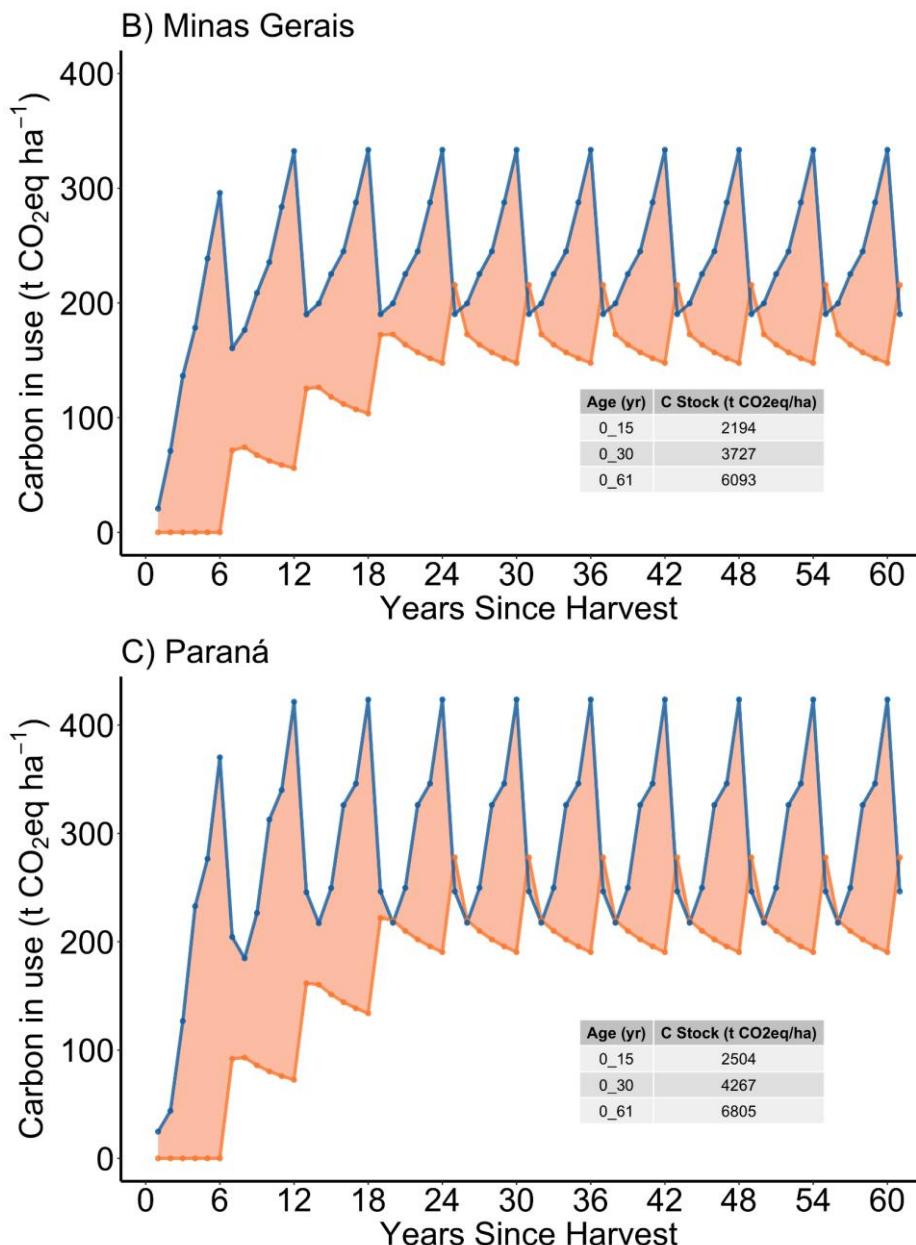
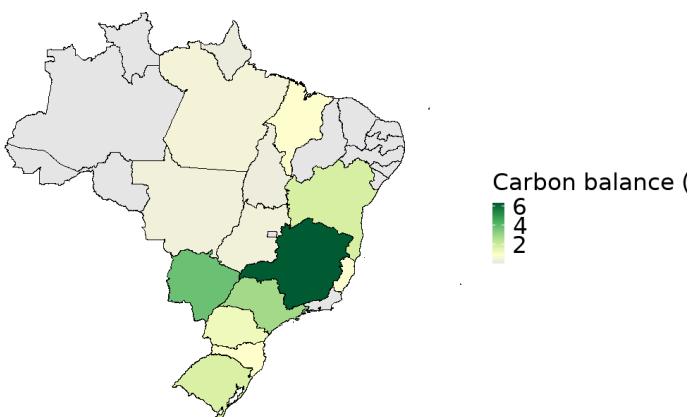


Fig. Cumulative C stock and emissions over 18 years for *Eucalyptus* plantations (1 ha) in the states of Minas Gerais, São Paulo and Paraná.

Conclusions

C balance



Industry emissions : + Balance until 3 yr
NO Industry emissions :
Total : 152 million tCO₂eq
Brazil: 38 million tCO₂eq

Emission pool



-Paper and pulp production – largest emitter
-More sustainable silviculture

LobWise implications



Green marketing
Sustainable industry
Management key decisions
National Carbon inventories



Thank you!



fernandaleitecunha@gmail.com

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FULBRIGHT