Characterization factors development at a land management practice level

Learnings from a forestry case study for land use impact assessment on climate change

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Introduction

○ **Context**: Methodological recommendations
  • **Scope**: LCA studies of energy generation from wood

○ **Scope of this presentation**
  • Focus on carbon sequestration & climate change
  • Feedback on land use CF development
Materials & Methods (1/3)

- Carbon stock description in forestry systems

**Stand-level approach**

**Landscape-level approach**

C stock

Time

C stock

Time
Materials & Methods (1/3)

- Carbon stock description in forestry systems

**Stand-level approach:**

- Most suitable approach for the land use framework
- Most suitable approach for distinguishing practices
Materials & Methods (2/3)

Carbon Sequestration potential → Climate Change

1st model considered: Müller-Wenk & Brandão (2010)

“Average stay” in air of fossil CO₂: 157 years
Materials & Methods (3/3)

Carbon Sequestration potential → Climate Change

2\textsuperscript{nd} model considered: \textit{Dynamic approach}

Transformation $\text{CF}_{\text{ref}\rightarrow\text{use}}$

Occupation CF

Defining \textbf{direct} and \textbf{avoided} processes
Materials & Methods (3/3)

Carbon Sequestration potential \(\rightarrow\) Climate Change

2\textsuperscript{nd} model considered: Dynamic approach

Deriving these \textbf{direct} and \textbf{avoided} processes into emission profiles
Materials & Methods (3/3)

Carbon Sequestration potential → Climate Change

2\textsuperscript{nd} model considered: *Dynamic approach*

Transformation $CF_{\text{ref→use}}$  
Occupation CF

**Obtaining CF by applying Time-Adjusted GWP to the resulting emission profiles**  
(Levasseur et al. 2010; Kendall 2012)
Data sources

○ Species considered

<table>
<thead>
<tr>
<th>Species</th>
<th>Management description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>Short Rotation Coppice, with or without residue harvesting</td>
</tr>
<tr>
<td>Birch then oak</td>
<td>Natural relaxation</td>
</tr>
</tbody>
</table>

Not presented here:
- Douglas-fir
- Chestnut

○ Carbon dynamics

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Eucalyptus</th>
<th>Natural relaxation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stemwood</td>
<td>Dendrometric model</td>
<td>Description from CNPF expert statements</td>
</tr>
<tr>
<td>Standing biomass &amp; roots</td>
<td>Expansion factors</td>
<td></td>
</tr>
<tr>
<td>Dead biomass</td>
<td>Exponential decay</td>
<td></td>
</tr>
<tr>
<td>Litter &amp; soil</td>
<td>Not considered due to lack of data</td>
<td></td>
</tr>
</tbody>
</table>
Real C dynamics & land use framework

Eucalyptus, transformation without to with residue harvesting

Average carbon stocks (without soil & litter)

- Previous land use: 73 tC / ha
- Land use under study: 64 tC / ha
- Carbon loss: 9 tC / ha
- Further land uses: Transitory effect

Time (years)

Average carbon stocks (without soil & litter)
Real C dynamics & land use framework

Eucalyptus, **transformation without to with residue harvesting**

- 153 tC / ha
- 200 yrs

**Transformation impact**

**Occupation impact**

Time (years)

Carbon stock (tC / ha)
Developing CF (1/4)

Dynamic approach

Müller-Wenk & Brandão (2010) proposal

+ 0.2-0.3 tCO$_2$-eq / ha / yr

+ 10-90%

Eucalyptus, with residue harvesting
Eucalyptus, without residue harvesting

Occupation CF (tCO2-eq / ha / yr)

Eucalyptus, from "with" to "without"
Eucalyptus, from "without" to "with"

Transformation CF (tCO2-eq / ha)
Developing CF (2/4)

- Everything at hand to calculate CF...

- But some questions raised

  - Matching real dynamics and framework modelling
    - Linear vs. real dynamic modelling
    - Temporal boundaries: historical vs. causal modelling
    - “No transformation time” assumption

- Developing CF for consequential approaches
Developing CF (3/4)

- **Real vs. linear dynamic modelling**

**Eucalyptus, occupation, without residue harvesting**

<table>
<thead>
<tr>
<th>Time (years)</th>
<th>Carbon stock (tC / ha)</th>
<th>Occupation CF (tCO2-eq / ha / yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>120</td>
<td>Dynamic approach</td>
</tr>
<tr>
<td>30</td>
<td>80</td>
<td>Müller-Wenk &amp; Brandão (2010) proposal</td>
</tr>
<tr>
<td>60</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>160</td>
<td></td>
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<td>210</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

- Real modelling vs. Linear modelling

Emission factor (COEF) = 0.037 x 3.7
Developing CF (4/4)

- **Historical vs. causal modelling**

  Eucalyptus, *occupation*, without residue harvesting

  **Historical “macro-level” modelling**

  **Causal “stand-level” modelling**

Historical modelling

Causal modelling

<table>
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<th>Occupation CF (tCO2-eq / ha / yr)</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>0.2</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>0.4</td>
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<td>1</td>
</tr>
<tr>
<td>60</td>
<td>120</td>
<td>1.2</td>
</tr>
<tr>
<td>70</td>
<td>140</td>
<td>1.4</td>
</tr>
</tbody>
</table>

- Historical approach
  - Dynamic approach

- Causal approach
  - Historical modelling
  - Causal modelling

- 5-fold increase in occupation CF
Take-home messages

- Land use framework **suitable** at a land management practice level

- A classical trade-off in LCA
    - Simple and easy to use method
  - Dynamic approach
    - More scientifically valid(?) but more challenging to apply

- Perspectives
  - Consequential modelling and land use framework
  - Integration of soil & litter
Thank you for your attention!

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