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Climate impact assessment in life cycle assessments of forest products: implications of method choice for results and decision-making

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ABSTRACT

As life cycle assessments are often conducted to provide decision support, it is important that impact assessment methodology is consistent with the intended decision context. The currently most used climate impact assessment metric, the global warming potential, and how it is applied in life cycle assessments, has for example been criticised for insufficiently accounting for carbon sequestration, carbon stored in long-lived products and timing of emission. The aim of this study is to evaluate how practitioners assess the climate impact of forest products and the implications of method choice for results and decision-making.

To identify current common practices, we reviewed climate impact assessment practices in 101 life cycle assessments of forest products. We then applied identified common practices in case studies comparing the climate impact of a forest-based and a non-forest-based fuel and building, respectively, and compared the outcomes with outcomes of applying alternative, non-established practices.

Results indicate that current common practices exclude most of the dynamic features of carbon uptake and storage as well as the climate impact from indirect land use change, aerosols and changed albedo. The case studies demonstrate that the inclusion of such aspects could influence results considerably, both positively and negatively. Ignoring aspects could thus have important implications for the decision support. The product life cycle stages with greatest climate impact reduction potential might not be identified, product comparisons might favour the less preferable product and policy instruments might support the development and use of inefficient climate impact reduction strategies.

1. Introduction

Increased manufacturing of products from wood is often seen as a means of mitigating climate change and society's dependence on non-renewable resources. Life cycle assessment (LCA) can be used to support various types of decision-making in relation to the development of new products (Hetherington et al., 2014; Clancy et al., 2013; Sandin et al., 2014a) or policy-making (Bringezu et al., 2007; Gustavsson et al., 2006). However, there are shortcomings in established methodology and practices for assessing the climate impact of forest products in LCAs as they may not, for example, capture fully the dynamic nature of carbon flows in the forest from sowing to harvest and in the forest product life cycle from raw material extraction to disposal (Brandão et al., 2013; Lippke et al., 2011; McKechnie et al., 2011). Consequently, climate impact assessments of forest products may not be sufficiently accurate and robust to support the decision at hand. The purpose of

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this paper is to explore this problem. This is done by means of two research questions:

1. What are the current LCA practices for assessing the climate impact of forest products?
2. How do the results from LCAs of forest products change if the impact assessment accounts for more climate impact aspects than is the case in current common practices?

The approach used for answering the research questions is for the first one an analysis of LCAs of forest products published 1997–2013, and LCA case studies for the second one. We also discuss how different decision-making contexts of relevance to forest products are affected by potential shortcomings of current common practices.

Several analyses of methodology and practices in climate impact assessment have been published in recent years (Brandão et al., 2013; Pawelzik et al., 2013; Helin et al., 2013; Cherubini and Strømman, 2011; Cherubini et al., 2009; Petersen and Solberg, 2005). This study differs from these as the focus is on quantitative assessment of implications for LCA results and as it discusses implications of practices in different decision-making contexts, recognising that in many published LCAs there is a weak link between the decision-making context and methodological choices.

Before each research question is dealt with in separate sections, we first provide an overview of important aspects of climate impact assessment of forest products.

2. Background

An important aspect of climate impact assessment of forest products is the time perspective of the climate metric, i.e. the time period applied when calculating the effect of each emission pulse in terms of radiative forcing. The most commonly used metric to assess the contribution of greenhouse gases (GHG) is Global Warming Potential (GWP), and default time periods in different characterisation methods are 20, 100 and 500 years. The choice of time period influences the relative importance of different types of GHG emissions.

Another important aspect related to the temporal dimension of climate impact is the timing of GHG emissions and carbon sequestration. How this aspect should be handled is an issue for LCA in general but may be particularly pronounced for forest products since both GHG emissions (if forest biomass is used for long-lived products such as buildings, thereby delaying emissions) and carbon sequestration (as forests are relatively slow-growing) may occur over a long period of time. The potential risk of passing critical tipping points in the climate system, and the urgent impact mitigation this calls for also emphasises the need to somehow account for the timing of the climate impact (Jørgensen et al., 2014; Helin et al., 2013; Levasseur et al., 2010). The urgency can to some extent be addressed by selecting a short time period for the climate metric, such as 20 years, effectively ignoring the radiative forcing of GHGs 20 years after their release and assigning a relatively high importance to shorter-lived GHGs (e.g. methane). However, this still does not account for the timing of emissions. Discounting future emissions is one means of accounting for the timing, but then there is the challenge of determining a proper discount rate. Another means to account for the timing is to use dynamic characterisation methods, where the time period over which each emission pulse is integrated depends on when it occurs in the product life cycle (Levasseur et al., 2010).

Another time-related aspect of climate impact is the temporary storage of carbon in forest products, which prevents the carbon from being emitted as carbon dioxide to the atmosphere, while allowing regrowth of forest biomass (i.e. carbon sequestration) in the forest. It is argued that this causes a temporary reduction in radiative forcing, and there are several proposals on how this aspect can be captured in LCAs (Vogtländer et al., 2014; Levasseur et al., 2010; Moura-Costa and Wilson, 2000). On the other hand, research has also suggested that temporary carbon storage may not reduce climate impact as it lowers the carbon dioxide gradient between the atmosphere and potential carbon reservoirs (e.g. the oceans), thus reducing carbon dioxide removal from the atmosphere. When the temporarily stored carbon is released once again, the atmospheric carbon dioxide concentration is therefore, it is argued, higher than would have been the case without temporary storage (Kirschbaum, 2006). This view of temporary carbon storage has been criticised as it disregards the cumulative climate impact (Dornburg and Marland, 2008).

A related climate impact assessment aspect is the question of whether or not biogenic carbon dioxide emissions should be considered climate neutral and thus omitted when calculating climate impact potentials (Vogtländer et al., 2014; Garcia and Freire, 2014; Sjølie and Solberg, 2011). The climate neutrality of biogenic carbon dioxide is based on the assumption that forest products (and other bio-based products) are carbon neutral, i.e. that there is a balance between carbon sequestration at the forest level and the re-emission of this carbon at the product's end of life (EoL). This assumption has been questioned by some authors as the fate of carbon dioxide molecules emitted into the atmosphere is indifferent to its source (Gunn et al., 2012) or because excessive biomass harvesting may reduce carbon stocks (McKechnie et al., 2011; Johnson, 2009). Furthermore, even in cases where the carbon neutrality assumption is valid, this does not automatically imply climate neutrality as a temporal shift between emitted and sequestered carbon may contribute to a temporary increase in radiative forcing (Helin et al., 2013; Cherubini et al., 2011), just as an overlap of carbon stored in products and carbon sequestered at the forest level may reduce the radiative forcing (as discussed in the previous paragraph).

Another important aspect influencing the climate impact assessment of forest products is the handling of multifunctional EoL processes. For example, this issue arises because the energy content of non-energy forest products (e.g. building materials) is often utilised at the products' EoL for heat and/or power production. This creates a multifunctional process (waste handling and energy production) and thus an allocation problem, which can be resolved in many different ways (Sandin et al., 2015; International Organisation for Standardisation, 2006). In LCAs of buildings, the allocation problem can be solved by expanding the system being studied to encompass the avoided emissions of the displaced alternative energy system, often termed system expansion with substitution. The inclusion of a credit for such avoided emissions has been shown to significantly influence the climate impact of forest products (Sandin et al., 2014b; Perez-Garcia et al., 2005). The potential significance of the EoL credits for the forest products' climate impact is the reasons for why we, in the present paper, include it as an aspect of the climate impact assessment, although it is rather an aspect of the product system modelling (set in the goal and scope definition and affecting the life cycle inventory phase of an LCA).

LCAs that account for carbon exchanges in the forest have focused mostly on above-ground pools, while less attention has been paid to changes in the below-ground carbon stored in soil, due to land use (forestry) or land use change (afforestation, deforestation) (Helin et al., 2013). Carbon pools in the soil are especially large in boreal forests (Liski et al., 2006), and several authors have attempted to include the climate impact of soil carbon disturbances in LCA studies (e.g. Brandão et al., 2011; Repo et al., 2011;