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CONFERENCE REPORT

A research perspective towards a more complete biodiversity footprint: a report from the World Biodiversity Forum

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1 Introduction

The impact of human activities on biodiversity is increasingly putting at risk the capacity of nature to support human well-being (IPBES 2019). The recent Global Assessment of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) reiterated the importance of land- and sea-use changes, exploitation, climate change, pollution, and the introduction of invasive alien species as the major direct drivers of biodiversity loss and ecosystem degradation (Díaz et al. 2019). This assessment also highlighted the need to address the indirect drivers of biodiversity loss, such as unsustainable patterns of production and consumption (IPBES 2019). Acknowledging the importance of understanding the biodiversity impacts of products and supply chains, the life cycle assessment (LCA) community has been devoted to improving how biodiversity is incorporated in LCA. To date, few operational life cycle impact assessment (LCIA) methods exist that account for biodiversity impacts (Crenna et al. 2020). However, more and more private and public actors are asking for appropriate methods, models, and indicators to perform biodiversity footprint of products. At EU level, this need has been recently reinforced in the biodiversity strategy (EC 2020a) by the inclusion of environmental footprint as an approach to support the assessment of biodiversity impacts due to business activities and supply chains.

There are still a number of open issues that need to be addressed in what concerns the more systematic and comprehensive inclusion of biodiversity in LCA (Curran et al.

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2011, 2016; Winter et al. 2017; Crenna et al. 2020). Two questions are of fundamental importance: (1) what aspect of biodiversity should be assessed; (2) what aspects should be better modeled to guarantee that LCA can distinguish between production processes with varying severity of impacts on biodiversity. The potentially disappeared fraction of species (PDF) has been the most commonly used indicator of 'biodiversity impact' in LCA (Crenna et al. 2020). However, the complexity and multidimensionality of biodiversity cannot be fully captured in a single indicator (Purvis 2020; Rounsevell et al. 2020). Within the LCA community, many studies have highlighted that inclusion of multiple biodiversity indicators in LCA would allow for a more comprehensive representation of the biodiversity impacts of products and supply chains (Curran et al. 2016; Winter et al. 2017; Woods et al. 2018; Crenna et al. 2020). When discussing potential improvements of LCIA methods, another consideration that needs to be made is to what extent aspects of the production processes known to have a significant impact on biodiversity are considered (for example, land use management practices or the spatial pattern of the landscape).

2 LCA at the World Biodiversity Forum

The inaugural World Biodiversity Forum (WBF) was held in February 2020, in Davos, Switzerland, with the mission to advance integrative biodiversity research and to facilitate the interaction between all stakeholders relevant to biodiversity (including corporate, governmental, non-governmental, non-profit, academic educators, and other parties). Its ultimate aim was to support and accelerate transformative approaches ranging from fundamental research to implementation.

This manuscript reports the outcomes of a workshop held at the WBF, entitled "Assessment of biodiversity impacts from supply chains: challenges and way forward". The objective of this workshop was to bring together the biodiversity conservation community and the LCA community in order to discuss pragmatic approaches that can improve our understanding on how biodiversity impact assessments are done in LCA. The participants were divided into two groups to discuss two questions:

1. What are the important aspects to consider when assessing biodiversity impacts of supply chains?

2. Which biodiversity indicators from the conservation domain can be adopted in LCA?

The next sections present the rationale for each question as well as the main outcomes and conclusions reached by the participants.

3 Aspects to consider when assessing biodiversity impacts of supply chains

The main goals of LCA are to identify hotspots of environmental impacts in supply chains and to perform comparative assessments between different product options (Hellweg and Canals 2014). For comparison of the biodiversity impacts of alternative products or production processes, it is essential that LCIA focuses on the aspects that are known to have an influence on biodiversity impacts. Among other factors that could be relevant for biodiversity, the discussion was focused on two main aspects of supply chains that need to be considered to better understand impacts on biodiversity: (1) transparency of supply chains and (2) land management regimes.

In global supply chains, there is often a lack of transparency concerning the place where products are sourced. While spatially explicit information of land cover and land use change can be quantified through remote sensing, this information is currently not linked to information on specific commodities or on the supply chain actors connected to those places (Gardner et al. 2019). Having specific information on the place of origin is essential to properly quantify biodiversity impacts of products and supply chains. For example, agricultural activities are likely to have a higher impact in areas with highly threatened or sensitive ecosystems, high levels of endemism, or in pristine areas (Martins and Pereira 2017; Newbold et al. 2020). Recent advances in the LCA community included highly regionalized LCIA methods, for example LC-Impact (Verones et al. 2020) or Impact World + (Bulle et al. 2019). However, to fully make use of these developments, more detailed spatial information at the inventory level is needed. (Escobar et al. 2020), recently developed a bottom-up LCA approach to improve the spatial resolution of the inventory data with information from the Trase project (https://trase.earth/) to quantify spatially explicit carbon footprints of agricultural products. Such an approach could potentially be useful for biodiversity footprinting.

During the workshop, land management and land-use intensity were identified as essential elements needed to properly capture the biodiversity impacts of products and supply chains. These limitations have already been addressed in the literature (Lindner et al. 2019). Recent developments in the LCA field include characterization factors for the quantification of biodiversity impacts, which consider three levels of land use intensity (minimal, light, and intense use) (Chaudhary and Brooks 2018). Also, the development of a method able to capture the potential land occupation impacts of various forest management practices on biodiversity in boreal regions (Rossi et al. 2018) and the development of an integrated ecosystem services characterization model to assess the impact of land use changes on wild bees that contribute to pollination-dependent crop production (Othoniel et al. 2019). Overall, it was clear to all workshop participants that more clarity is needed in terms of the level of detail desired to include land management and use intensity in LCA and how these factors are responsive to changes in biodiversity measures.

A particularly relevant case where incorporation of land management and use intensity are necessary is the food production and biodiversity nexus (Seppelt et al. 2016). It is desirable that LCA is capable of taking into account changes in the management regimes at both the farm and landscape level. A relevant example in this case is the tradeoff of land sparing vs. land sharing and how it is considered in LCA. For this, LCA should also be able to consider what happens to the land left free because of intensification and the consequences of displacing production activities.

Another aspect to consider in LCA is the quantification of the relative effects of land management regimes on biodiversity patterns. Species respond idiosyncratically to both agricultural expansion and intensification, and while response data are available for thousands of species across the world (Luskin et al. 2017), most studies have focused on relatively few taxonomic groups (Luskin et al. 2017; Phalan 2018). While attempts have been made to extrapolate from these data (Phalan et al. 2014), there remain serious data gaps over the relative importance of habitat loss and subsequent agricultural intensification on many species. Nevertheless, many new data sources have become available either in databases—such as the PREDICTS database (Hudson et al. 2017)—or in the literature to investigate how biodiversity respond to changes in land use. For instance, a recent meta-analysis based on a literature review investigated how species richness responds to land use intensification (Beckmann et al. 2019). To better consider land management regimes in LCA would require to re-visit the proposed land use and land cover classification for life cycle inventories, verify its appropriateness to grasp changes in biodiversity impacts due to land management regimes, and to improve LCIA methods to better consider biodiversity response to different land management regimes.

4 Adoption of indicators from the biodiversity conservation domain into LCA

The aim of using a biodiversity indicator in LCA is to assess how biodiversity is impacted by a certain product along its supply chain. However, biodiversity is a multi-dimensional concept, and it has been recently argued that at least two complementary aspects must be taken into consideration when characterizing the impact on biodiversity (Purvis 2020). The first is ecosystem multifunctionality, i.e., the functioning of multiple ecosystem processes which are underpinned by local biodiversity, such as species with high local biomass or abundance (Grime 1998). Maintaining healthy multi-functional ecosystems permits—among others—to keep the ability of biodiversity to deliver a huge range of benefits to people (MA 2005; Díaz et al. 2018). The second is human-driven species extinction, i.e., the pruning of leaves in the tree of life, which currently threatens an estimated one million animal and plant species globally (Díaz et al. 2019). Using species extinction as a biodiversity indicator is relevant because it represents an irreversible loss, it is widely understood and easy to communicate (Rounsevell et al. 2020), and because preventing species extinction is morally the right thing to do (Soulé 1985). Ecosystem multifunctionality and species extinction are complementary in representing how biodiversity can be impacted (Purvis 2020). This is because, up to a certain extent, we can lose one benefit to people due to the reduction of ecosystem multifunctionality without any species extinction (i.e., the loss of a benefit due to the decline in the population of a species, which nonetheless remains extant) and vice-versa (i.e., the extinction of a species, which does not impact ecosystem multifunctionality).

From the indicators commonly applied in biodiversity conservation mentioned in our workshop discussion, we identified three indicators already used to report on global biodiversity change (GEO BON 2015) that can all potentially be incorporated into LCA in the short term. The Local Biodiversity Intactness Index (LBII, Scholes and Biggs 2005; Newbold et al. 2016) reports on the mean intactness of local species abundance of a large and diverse set of organisms, in a given geographical area, relative to their reference populations in undisturbed or non-intensively used land management states. The mean species abundance (MSA) is a metric conceptually similar to the LBII, reporting the abundance of species found in relation to a given pressure relative to its abundance found in an undisturbed situation (Schipper et al. 2020). Both LBII and MSA have already been used in modeling frameworks to investigate global integrated scenarios of biodiversity change in response to different environmental pressures (Newbold et al. 2016; Schipper et al. 2020; Leclère et al. 2020), and MSA has been coupled to LCA to measure business impacts on biodiversity (Lammerant 2018; Crenna et al. 2020). Because they are based on species abundances, LBII and MSA are good candidates to account for biodiversity impacts regarding ecosystem multifunctionality. Another useful biodiversity indicator is the Biodiversity Habitat Index (BHI, GEO BON 2015), which estimates the change in the proportion of collective biological diversity retained in any specified spatial unit as a function of habitat loss, fragmentation, and degradation across the unit, and which can be considered a proxy for local species extinctions. Quantifying BHI with global models of fine-scale species composition turnover across land uses (Di Marco et al. 2019) would allow capturing how land use changes translate into expected risk of local species loss in LCA. Such approaches nonetheless need to be scaled up to relate the local species extinctions they document to the global, irreversible species extinctions that should be taken into consideration when characterizing the impact on biodiversity. However, an unresolved issue is the large gaps in global data sets for many countries and regions.

LBII, MSA, and BHI are pragmatic options to improve the representation of biodiversity impacts in LCA, but other indicators may be developed in the longer term. Such developments could build on essential biodiversity variables (Pereira et al. 2013) to provide complementary measures for the assessments of impacts on biodiversity and should address the shortcomings of LBII, MSA, and/or BHI. First, these indicators aim to predict biodiversity change as a function of one or more anthropogenic pressures; yet, as those are species assemblage indicators, it is not possible to specifically relate the impact captured by these indicators to a list of affected species. Therefore, LCA might need to be complemented with biodiversity indicators able to preserve species identity (and extinction risk) or to species potentially affected. Ideally, and as has recently been demonstrated in a global scenario-based modeling effort, several complementary indicators are considered using an ensemble of biodiversity models (Leclère et al. 2020). Second, the selected indicators do not capture how environmental impacts affect species' physiology, dispersal, or their interactions with other organisms. A promising avenue to address these shortcomings is the recent development of mechanistic models for biodiversity (e.g., Bocedi et al. 2014; Harfoot et al. 2014; Cabral et al. 2017). In theory, the integration of biological processes into LCA has the potential to allow for understanding product and supply chain impacts on eco-evolutionary dynamics and should therefore deserve a strong research focus. It should be noted that these two shortcomings also hold true for PDF. Third, the LBII, MSA, and BHI indicators can currently only be measured for a limited number of realms and for a limited number of groups. Although there is some ongoing work to expand the coverage of these indicators, data and model developments are currently not sufficient neither to quantify those biodiversity indicators for the marine realm nor to consider soil biodiversity.

Beyond the development of new biodiversity indicators, workshop participants discussed another long-term issue in LCA. That is, how to translate the impact of a product on ecosystem multifunctionality and species extinction to a simple biodiversity indicators to be communicated, e.g., to policy makers and consumers. Solutions may span from represent either only the impact of the product on ecosystem multifunctionality, only the impact of the product on species extinction, or the impact of the product on both ecosystem multifunctionality and species extinction.

5 Conclusions

The discussions at the workshop at the World Biodiversity Forum have highlighted that it is imperative to strengthen cooperation between the LCA community and the biodiversity conservation community. This can potentially allow finding solutions to the main limitations of LCA in addressing biodiversity impacts in pragmatic and relevant way to support decision-making. In the workshop held at the WBF, it was clear that there is interest from the biodiversity and LCA community to engage, and the value added of doing so is understood by both communities. LCA as a method to measure the biodiversity footprints of production and consumption (Crenna et al. 2019; Marques et al. 2017) is becoming increasingly relevant in biodiversity-related policies and beyond, in particular with regard to agriculture and forestry, fisheries and international trade agreements, in reporting for 2030 Agenda for Sustainable Development (Sala and Castellani 2019), for product labeling and corporate performance (e.g. the Green claims initiative, EC 2020b), and in support to the assessment of financial instruments (e.g., the EU taxonomy initiative, EC 2020c). Increasing synergies between the LCA and the biodiversity conservation communities is essential to best inform the post 2020 biodiversity targets and policies, which also mention the mainstreaming of biodiversity impacts into production processes (CBD 2020; EC 2020a). The IPBES Global Assessment has clearly indicated that societies need transformative change to address biodiversity loss and ecosystem degradation (IPBES 2019), including the way we produce and consume, if we aim to bend the curve of biodiversity loss (Marques et al. 2019; Leclère et al. 2020). In fact, the European Biodiversity Strategy for 2030 (European Commission 2020) states that "biodiversity considerations need to be better integrated into public and business decision making at all levels". This implies that should biodiversity impact indicators improve as discussed in the workshop, the biodiversity footprint of products and companies might be measured more effectively and improve accordingly.

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