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Quantifying biodiversity footprints of Dutch economic sectors: A global supply-chain analysis

Harry C. Wilting*, Mark M.P. van Oorschot

PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands

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ABSTRACT

Economic sectors contribute to biodiversity loss via environmental pressures, such as land use and greenhouse gas (GHG) emissions, directly and via their supply chains. This study is the first that systematically quantifies supply-chain-related environmental pressures and terrestrial biodiversity losses in relation to sectoral production by presenting so-called biodiversity footprints for 47 sectors in the Dutch economy. The supply chains of the food and chemical sectors were investigated in more detail, by applying a structural path analysis. Mean Species Abundance (MSA) was used as a biodiversity indicator, representing the degree of ecosystem naturalness. Our results revealed that (i) the largest supply-chain-related biodiversity losses occur in land-intensive and energy-intensive sectors; (ii) sectors that produce primary resources, such as crops and livestock, showed the largest biodiversity footprint per EUR of output; (iii) for most sectors in the Dutch economy, more than 50% of the biodiversity losses related to their supply chains were being caused abroad; and (iv) more than 45% of the supply-chain-related losses caused by the food and chemical sectors occurred upstream of the direct suppliers. Our results imply that mitigation of GHG emissions as well as land-use-related options should be considered in sectoral strategies to protect global biodiversity. The results create a clear rational for not only improving sectoral production efficiency, but also for taking supply-chain responsibility. Supply-chain-related biodiversity losses often cannot be directly influenced by the sector, or occur in other countries. Additional strategies may be needed then to reduce global biodiversity losses.

1. Introduction

Current demand for food, wood, energy and water has negative consequences for global biodiversity, in general (Butchart et al., 2010), and animal species, in particular (Dirzo et al., 2014). Without further policy action biodiversity loss will continue under continuation of current trends in population and income growth (Tittensor et al., 2014). Newbold et al. (2015) predict further declines in global terrestrial biodiversity, in a business-as-usual land-use scenario, with losses concentrated in biodiverse but economically poor countries. Policy strategies averting biodiversity loss commonly focus on primary sectors, such as agriculture, mining and forestry, which directly drive biodiversity loss through habitat conversion (CBD, 2016). However, actors more downstream in the supply chains, such as companies in secondary and tertiary sectors, and consumers, can also play a role in mitigating biodiversity losses, by influencing primary sectors. By including biodiversity concerns in their decision-making processes and by taking responsibility for supply-chain impacts, they could move primary producers in a more biodiversity-friendly direction (Kok et al., 2014).

Several studies on the supply-chain-related impacts of consumption on biodiversity have been published in recent years. Lenzen et al. (2012) calculate consumption-based biodiversity losses, measured as the number of Red List species threatened, for 187 countries. Moran et al. (2016) apply a similar approach in investigating the biodiversity losses related to the supply chains of certain materials and products. Chaudhary et al. (2016) calculate the impacts of Swiss consumption on global biodiversity by including the relationship between impacts and land-related pressures. However, studies on the supply-chain-related consequences of economic sectors did not consider impacts on biodiversity yet. For instance, Foran et al. (2005) calculate the social, economic and environmental consequences of the supply chains of 135 sectors in the Australian economy, and Acquaye et al. (2017) analyse the environmental pressures in the supply chains of two heavy polluting industries, namely electricity and chemical industries, in several large economies. Where these studies focus on supply-chain

* Corresponding author.
E-mail address: Harry.Wilting@pbl.nl (H.C. Wilting).

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pressures of sectors, such as greenhouse gas emissions and land use, this paper goes a step further by presenting the combined impact these pressures have on global biodiversity loss, which can be interpreted as a biodiversity footprint by sector.

A growing interest in the impacts of Dutch economic activities on global biodiversity loss in combination with the lack of information on these impacts caused by sectors, led to the main research questions for this paper. How large are the supply-chain-related impacts of individual economic sectors on biodiversity? Where in the world and in which sectors do these impacts take place? And what environmental pressures are the most important? We answered these questions in two steps: (i) we created an overview of the biodiversity footprints of 47 Dutch economic sectors, including primary, secondary and tertiary sectors, covering all stages of production in the Dutch economy; (ii) we investigated the biodiversity footprints of two sectors that showed large footprints (the *food, beverages and tobacco* sector and the *chemicals and chemical products* sector), in more detail. The answers to the research questions revealed which sectors were responsible for most of the biodiversity loss, and supports Dutch policymakers and sector organisations on what mitigating measures should be taken, and what national and international policy tools could be used to stimulate such measures. Furthermore the answers support companies that feel a growing need to investigate and report on their supply chains impacts (see also section 1.1).

We used an environmentally extended multiregional input-output (EEMRIO) model to calculate the biodiversity footprints of Dutch economic sectors. EEMRIO models trace the flows of goods and services between sectors all over the world, and are appropriate for analysing the supply-chain-related environmental pressures of consumption activities (Wiedmann, 2009). Acquaye et al. (2017) applies an EEMRIO model to analyse the environmental pressures in the supply chains of two heavy polluting industries, but, to our knowledge, this study is the first to focus on the supply-chain impacts on biodiversity of all sectors in a country. We included multiple environmental pressures, such as land use, infrastructure and greenhouse gas (GHG) emissions, in our model, providing a more explicit relationship between local production processes and impacts on biodiversity, so that our model results would be more policy-relevant, as is argued by Spangenberg (2007). Hertwich (2012) also suggests to explicitly model the cause-effect relationships between environmental pressures and biodiversity loss in calculating biodiversity footprints.

We used Mean Species Abundance (MSA) as an indicator for biodiversity, since our focus was on connecting local biodiversity losses to sectoral activities. MSA is one of the various indices that were found relevant for measuring human impacts on biodiversity (Vačkář et al., 2012). The MSA indicator expresses the mean abundance of original (i.e. naturally occurring) species in a disturbed situation, relative to their abundance in undisturbed ecosystems, as a reflection of the degree to which an ecosystem is intact (Alkemade et al., 2009). In this way, the MSA indicator is providing an aggregate and sensitive measure of local biodiversity loss, based on multiple pressure factors. It is not a measure of extinction, as that only occurs on larger scales of space and time, nor can it easily be attributed to short-term activities of individual companies. It is more effective to base mitigation measures on early warning signals, to prevent the extinction of species, in the long term.

1.1. Use of sector footprints

Biodiversity footprint studies help to raise awareness among different stakeholders and may help to define mitigation strategies. Insights in biodiversity footprints of sectors, as calculated in this study, can support sector organisations with information for setting priorities and selecting relevant mitigation measures to reduce biodiversity losses, both within sectors and in their supply-chains. Especially processing and retail sectors have a key role in influencing both primary producers upstream and consumers downstream, as they have a central and strong position in supply chains. In the market transformation strategy of the World Wild Fund for Nature, these actors are the primary target for engagement, and this may leverage the effect of their interventions on priorities for conservation (WWF Market Transformation Initiative, 2012). Mainstreaming biodiversity concerns in sectors and reducing direct pressures are also explicit targets of the Convention on Biological Diversity (CBD, 2014). The Dutch Government can use this information to prioritise and target specific sectors for engaging in, for example, sector covenants on mitigation. Such a strategy can contribute to national or regional biodiversity targets for reducing the impacts of production and consumption, both within and outside the country.

Furthermore, sector footprints supply information on the average sector impacts that can be used as a general benchmark for individual company calculations. Wiedmann et al. (2009) apply such an approach by comparing the ecological footprint of a specific company in the recreational services sector to the average ecological footprint of that sector. When making corporate sustainability and impact reports, companies can apply data from sectoral studies to calculate their biodiversity footprint; for instance, by coupling the intensity of their impact on biodiversity (biodiversity loss per output in EUR) to their expenditures. Berners-Lee et al. (2011) implement such an approach for greenhouse gas (GHG) emissions in a tool to calculate the carbon footprint of small and medium-sized enterprises. Companies often calculate their supply-chain impacts with Life-Cycle Analysis (LCA) focusing on direct (on-site) pressures and pressures from direct suppliers, not including parts of the supply chain that are not directly visible (Lenzen, 2000). Data on sector footprints supply additional information for these calculations, providing the substantial part of the impact that is usually missing from LCAs of companies.

Finally, insights into the contribution, in the form of environmental pressures, by regions and sectors to supply-chain-related biodiversity losses can be used for policy prioritisation, and help sectors with their procurement strategies, and with taking responsibility for the supply-chain impacts. Three well-known types of mitigation strategies to decrease supply-chain impacts are (van Oorschot et al., 2012): (i) reduction in direct pressures from local production processes; (ii) reduction in resource use by any sector, through improved resource efficiency, and (iii) changes in the procurement patterns of the supply-chain sectors, or changes in the locations from which resources are obtained. The choice for one of these strategies depends on the types of pressures and the contributions of regions and sectors to the sector footprint. Sectors with large direct impact on biodiversity losses should focus on their own activities. The two other strategies help to reduce the losses further upstream in supply chains. The third strategy may also influence direct suppliers and suppliers further upstream to improve their processes.

2. Methodology and data

2.1. General approach

We based our analysis on an EEMRIO model that had been used, previously, in research on consumption-based biodiversity footprints (Wilting et al., 2017). We modified the model by excluding final consumers from the model equation, in order to focus on sector footprints. The model relates production of a specific sector via monetary flows of goods and services to production in sectors, all