Quantifying the ecosystem impacts of resource footprints

Francesca Verones*, Daniel Moran, Konstantin Stadler, Richard Wood
Industrial Ecology Programme, Norwegian University of Science and Technology NTNU, 7491 Trondheim, Norway

*presenting author

Summary
Multiregional input-output (MRIO) analyses quantify a consumer's resource footprint (e.g., for carbon emissions or water use) across the globe, taking into account production, trade and transformation steps along the supply chain. However, the spatially differentiated environmental consequences of these resource footprints have so far been poorly quantified due to the complexity of the relationships between resource use and environmental consequences. In order to provide such a measure of consequence, we combine for the first time an MRIO-based resource footprint approach with a novel life cycle impact assessment methodology called LC-Impact. By combining these two data sources we can measure the ecosystem consequences of resource footprints. The LC-Impact dataset features spatially differentiated measures of impact; an important trait given the widely varying environmental consequences of resource use throughout the world. We find that an account of the ecosystem consequences of resource footprints provides a quite different picture of consumers' global impacts.

Extended abstract
Consumption-based accounts (CBA) built using multiregional input-output (MRIO) accounts are used to calculate footprints of various resource uses across global production chains. MRIO accounts describe the trade and transformation steps linking production activity – where environmental impacts are directly exerted – to the consumers whose purchases ultimately drive those impacts. CBA footprints have been calculated for physical flows including carbon emissions, water use, raw material use, embodied air pollution, biodiversity impacts embodied in implicated commodities, as well as having been used to trace flows of goods with noteworthy social attributes, such as goods produced under unequal labour conditions, and conflict minerals.
However, mostly CBA analyses stop with the footprints of resource demand and do not take the next step of linking these measures of pressure to measures of actual impact. This is due to the complex link between resource demands and impacts which varies by the type of pressure and the location where that pressure is exerted. Water use provides a clear example of this. Consuming one m^3 of water in a dry ecosystem creates much different impacts than consuming the same volume in a humid ecosystem. This is recognized in the recently released ISO standard on water footprinting which defines a water footprint as a "metric(s) that quantifies the potential environmental impacts related to water" and is thus more than just a volumetric account of consumed water (ISO 14046 2014). The field of life cycle impact assessment (LCIA) aims to quantify the environmental impacts related to the resource use and emissions of a product or process throughout its entire life cycle. An LCIA account thus links the resource uses to environmental damage.
Since the consequences of resource use vary widely by location it is imperative that an approach for quantifying impact indicators recognizes spatial differentiation. An indicator may thus for example provide an estimate, spatially differentiated at the watershed level, of how many species would be impacted by a unit of water withdrawal from, or unit emission into, that watershed. Recently, there has been a lot of development in the spatially differentiated LCIA approaches that have been now combined in one global LCIA methodology: LC-Impact is a spatially-differentiated LCIA methodology that assesses environmental impacts on human health, ecosystem quality and resource depletion with 18 indicators (Huijbregts et al. 2014). Additionally, LC-Impact provides, if meaningful, factors for

environmental damages over different time horizons (up to 100 years, more than 100 years) and for different degrees of certainty for impacts, in order to enable practitioners to conduct sensitivity analyses. Here we combine results from MRIO-based resource footprint accounts with these indicators for ecosystem damage of LC-Impact in order to understand the ecosystem consequences of resource footprints. We use the recently updated EE MRIO EXIOBASE 2.0 as background system. EXIOBASE 2.0 exhibits a consistent sector classification of 163 industries/200 products with more than 300 environmental satellite accounts for the base year 2007. The high level of detail of EXIOBASE provides a unique possibility to investigate the impacts of products which exhibit a globally dispersed supply chain (Tukker et al. 2014). The relevant impact indicators from LC-Impact are climate change, terrestrial acidification, freshwater and marine eutrophication, ecotoxicity (freshwater, marine and terrestrial), land stress and water consumption. All of these indicators indicate the damage on ecosystems in terms of "potentially disappeared fraction of species" (PDF), per unit of resource stress, and include, if relevant, different degrees of spatial differentiation and levels of certainty. In this work we apply for the first time spatially-differentiated ecosystem damage metrics to global resource footprints of nations, enabling the tracking of damages to ecosystems throughout the global supply and production chains. As can be expected due to the large variability among environmental consequences of resource uses and the sensitivities in the factors due to time horizons and certainty of impacts, the results provide a quite different global map of footprint consequences than if footprints are assessed merely as physical flows. The results identify hotspots of ecosystem damage due to global resource use. Our results provide clear policy advices to focus on reducing environmental impacts at the identified hotspots. This ensures the most effective way to minimize ecosystem damages and thus contributes to well-being of people. The common approach to increase the spatial information within an EE IO framework is to disaggregate the whole IO table. Our study illustrates an alternative approach by incorporating spatial information in the characterization of country wide stressor accounts.

References

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